平成16年7月13日開示分

網機能情報提供対象装置に関する情報開示

- ユーザ網インタフェース -

フレッツ・ADSL技術開示資料

第3版

平成16年1月 東日本電信電話株式会社

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> 東 日 本 電 信 電 話 株 式 会 社 サービス開発部フレッツサービス推進室

> > adsl-tech@msd.east.ntt.co.jp

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版数	改訂年月	主な内容
第1版	2003年8月	・下り伝送速度の高速化
		(周波数帯域:138kHz~3.75MHz)
第2版	2003年11月	・下り伝送速度の高速化
		(周波数帯域:25kHz~3.75MHz)
		・上り伝送速度の高速化
		(周波数帯域:25kHz~276kHz)
第3版	2004年1月	・上り伝送速度の更なる高速化
		(周波数带域:25kHz~483kHz)
		・長延化
		(下りPSD mask:-28.5dBm/Hz peak)

改版履歴

<u>付属資料について</u>

付属資料番号	サービス化	下り信号	上り信号		過去の技術開示資料
(ページ)		使用帯域	使用帯域	シェ イ ピ ング	との関係
1	済	138k~3.75MHz	25k ~ 138kHz	なし	1、2版からの変更なし
(P5-P62)	(モア 40M)				
2	未定	25k~3.75MHz	25k ~ 276kHz	なし	2版の更新
(P63-P128)					
3	"	25k~3.75MHz	25k ~ 414Hz	あり	新規
(P129-P197)					
4	"	25k~3.75MHz	25k ~ 483kHz	なし	新規
(P198-P266)					
5	"	25k~2.2MHz	25k ~ 276kHz	なし	2版の更新
(P267-P332)					
6	"	25k~2.2MHz	25k ~ 414kHz	あり	新規
(P333-P401)					
7	11	25k~1.1MHz	25k ~ 276kHz	なし	新規
(P402-P464)		(長延化方式を含む)			

なお、本技術開示資料は、ITU-T勧告G.992.1の本文と合わせて技術参考情報とさせていただきます。

付属資料1

G.992.1 ANNEX Q PROPRIETARY EXTENSION TO G.992.1 ANNEX I

Attached is proposed text for G.992.1 Annex Q (Quad spectrum), a proprietary extension to G.992.1 Annex I to extend the data rate beyond 32 Mbit/s on short loops by way of:

- Increased bandwidth \rightarrow increased number of subcarriers, NSC=1024 (used subcarriers up to 869)
- Increased bit loading, beyond 15 bits/bin
- Extended framing \rightarrow S=1/2n, with support for n = 1 to 4

The attached text is the approved draft text for Annex I, marked up with revision control to show the changes necessary to support the additional functionality. Editorial changes such as replacing "Annex I" with "Annex Q" are not shown with revision control.

ANNEX Q

Specific requirements for an ADSL system to support data rates greater than 32 Mbit/s on short loops operating in the same cable as ISDN as defined in ITU-T Recommendation G.961 Appendix III

Q.1 Scope

This annex describes those specifications that are unique to an ADSL system coexisting in the same binder as TCM-ISDN as defined Recommendation G.961 Appendix III. The subclauses in this annex provide supplementary and replacement material to the clauses in the main body. The nature of the material is parenthetically indicated in the subclause heading. The modifications described in this annex allow a performance improvement from the ADSL system specified in Annex C for short loops in an environment coexisting with TCM-ISDN in the same cable. Specifically, this Annex specifies extensions to downstream bandwidth, framing modes, and maximum bit loading to support downstream data rates greater than 32 Mbit/s. This annex also defines those parameters of this ADSL system that have been left undefined in the main body of this Recommendation. It is recommended that ADSL system implementing Annex Q also implements Annex C.

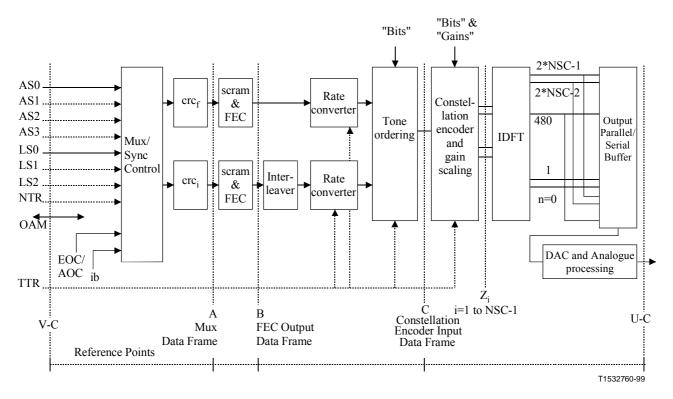
Q.2 Definitions

Bitmap-F _C	ATU-R transmitter bitmap under TCM-ISDN FEXT noise generated at ATU-C
Bitmap-F _R	ATU-C transmitter bitmap under TCM-ISDN FEXT noise generated at ATU-R
Bitmap-N _C	ATU-R transmitter bitmap under TCM-ISDN NEXT noise generated at ATU-C
Bitmap-N _R	ATU-C transmitter bitmap under TCM-ISDN NEXT noise generated at ATU-R
Dual Bitmap FEXT Bitmap	The Dual Bitmap method has dual bit rates under the FEXT and NEXT noise from TCM-ISDN Similar to the Dual Bitmap method however transmission only occurs during FEXT noise from TCM-ISDN
FEXT _C duration	TCM-ISDN FEXT duration at ATU-C estimated by the ATU-R
FEXT _C symbol	DMT symbol transmitted by ATU-R during TCM-ISDN FEXT
FEXT _R duration	TCM-ISDN FEXT duration at ATU-R estimated by the ATU-C
FEXT _R symbol	DMT symbol transmitted by ATU-C during TCM-ISDN FEXT
Hyperframe NEXT _C duration	5 Superframes structure which synchronized TTR TCM-ISDN NEXT duration at ATU-C estimated by the ATU-R
NEXT _C symbol	DMT symbol transmitted by ATU-R during TCM-ISDN NEXT
NEXT _R duration	TCM-ISDN NEXT duration at ATU-R estimated by the ATU-C
NEXT _R symbol	DMT symbol transmitted by ATU-C during TCM-ISDN NEXT
NSC NSWF	The highest subcarrier index that can be used for downstream transmission (i.e., the subcarrier index corresponding to the Nyquist frequency) For example, $NSC = 256$ for a downstream channel using the frequency band up to 1.104MHz; $NSC = 512$ for a downstream channel using the frequency band up to 2.208MHz. Sliding Window frame counter
Subframe	10 consecutive DMT symbols (except for sync symbols) according to TTR timing
TTR	TCM-ISDN Timing Reference
TTR _C	Timing reference used in ATU-C
TTR _R	Timing reference used in ATU-R
UI	Unit Interval

Q.3 Reference Models

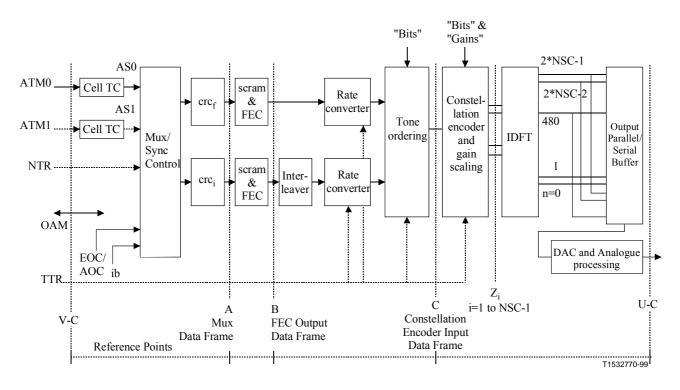
Q.3.1 ATU-C transmitter reference model (replaces figures in 5.1)

See Figure Q.1 and Figure Q.2.



NOTE - The TTR may be generated in ATU-C without being provided from the TCM-ISDN clock.

Figure Q.1/G.992.1 – ATU-C transmitter reference model for STM transport

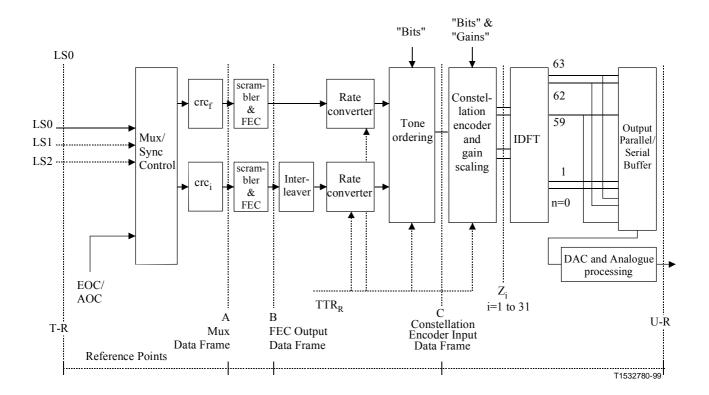


NOTE - The TTR may be generated in ATU-C without being provided from the TCM-ISDN clock.

Figure Q.2/G.992.1 – ATU-C transmitter reference model for ATM transport

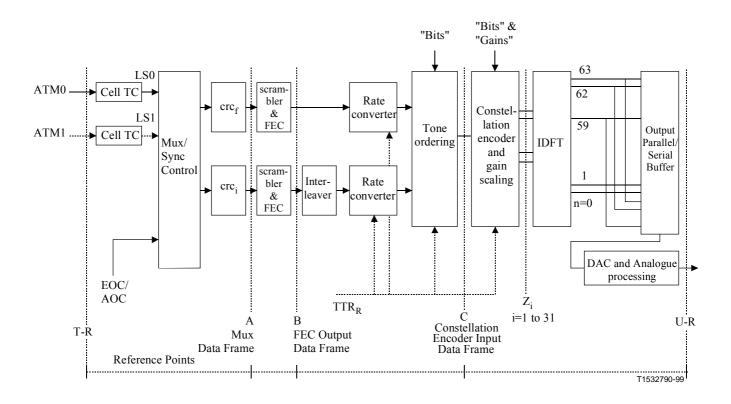
Q.3.2 ATU-R transmitter reference model (replaces figures in 5.2)

See Figure Q.3 and Figure Q.4.



NOTE – The TTR_R shall be generated in ATU-R from the received TTR_C signal, and it is locked to 690 periods of upstream sampling clock (276 kHz).

Figure Q.3/G.992.1 – ATU-R transmitter reference model for STM transport



NOTE – The TTR_R shall be generated in ATU-R from the received TTR_C signal, and it is locked to 690 periods of upstream sampling clock (276 kHz).



Q.3.3 ATU-C/R transmitter timing model (replacement for 5.3)

Q.3.3.1 TCM-ISDN crosstalk timing model (new)

Figure Q.5 shows the timing chart of the crosstalk from TCM-ISDN.

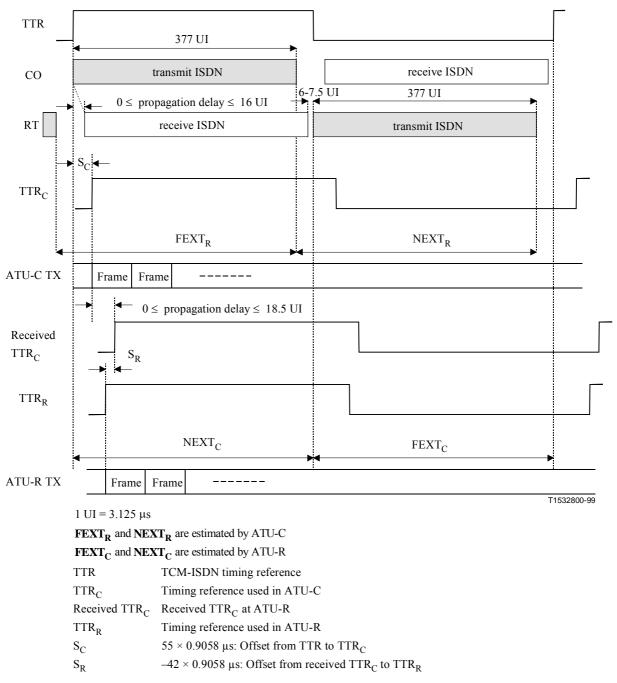


Figure Q.5/G.992.1 – Timing chart of the TCM-ISDN crosstalk

The data stream of TCM-ISDN is transmitted in TTR period. CO transmits the stream in the first half of the TTR period and RT transmits in the second half of the TTR period. ATU-C receives NEXT noise from the ISDN in the first half of the TTR period and FEXT noise from the ISDN in the second half of the TCM-ISDN period. On the other hand, ATU-R receives FEXT noise from the ISDN in the first half of the TTR period and NEXT noise from the ISDN in the second half of the TTR period.

As defined in Q.7.6.2 and Q.7.8.3, the ATU-C shall estimate the FEXT_R and NEXT_R duration at ATU-R, and the ATU-R shall estimate FEXT_C and NEXT_C duration at ATU-C taking propagation delay on the subscribe line into consideration.

The ATU-C shall transmit any symbols by synchronizing with the TTR_C . The ATU-R shall transmit any symbols synchronizing with the TTR_R generated from received TTR_C .

Q.3.3.2 Sliding window (new)

Figure Q.6 shows the timing chart of the transmission for the Annex Q downstream at ATU-C.

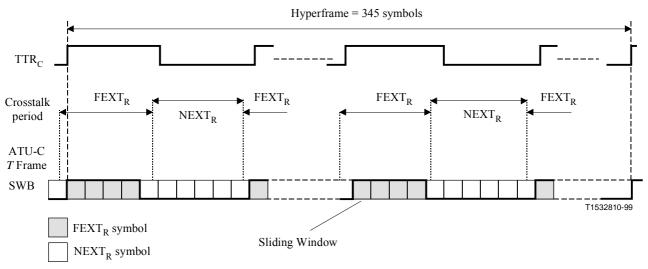


Figure Q.6/G.992.1 – Sliding window for downstream symbols

The Sliding Window defines the transmission symbols under the crosstalk noise environment synchronized to the period of TTR. The $\text{FEXT}_{C/R}$ symbol represents the symbol completely inside the $\text{FEXT}_{C/R}$ duration. The $\text{NEXT}_{C/R}$ symbol containing the $\text{NEXT}_{C/R}$ duration. Thus, there are more $\text{NEXT}_{C/R}$ symbols than $\text{FEXT}_{C/R}$ symbols.

The ATU-C decides which transmission symbol is FEXT_R or NEXT_R symbol according to the sliding window and transmits it with the corresponding bit table. Similarly, the ATU-R decides the transmission symbol is a FEXT_C or NEXT_C and transmits it with the corresponding bit table. Although the phase of the sliding window is asynchronous with $\text{TTR}_{C/R}$, the pattern is fixed to the 345 frames of the hyperframe.

Q.3.3.3 ATU-C Symbol Synchronization to TTR (new)

345 symbols are 34 cycles with cyclic prefix of TTR_C (or 32 cycles of TTR_C without cyclic prefix). This implies a PLL lock at the ATU-R.

Q.3.3.4 Dual Bitmap switching (new)

The ATU-C transmits FEXT_R symbols using Bitmap-F_R (in FEXT_R duration), and transmits NEXT_R symbols using Bitmap-N_R (in NEXT_R duration) according to the result of initialization. The ATU-R transmits FEXT_C symbols using Bitmap-F_C (in FEXT_C duration), and transmits NEXT_C symbols using Bitmap-N_C (in NEXT_C duration) in the same manner.

The ATU-C shall have the capability to disable Bitmap-N_C and Bitmap-N_R (see Q.4.5 and Q.5.3).

Q.3.3.5 Loop timing at ATU-R (new)

The phase relation between received symbol and transmitted symbol of ATU-R at the reference point U-R shall meet the phase tolerances as shown in Figure Q.7.

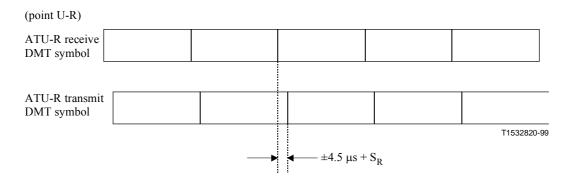
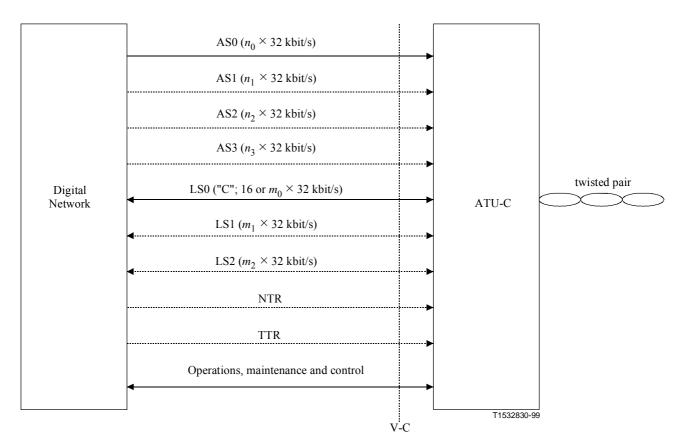


Figure Q.7/G.992.1 – Loop timing for ATU-R

- Q.4 ATU-C functional characteristics (pertains to clause 7)
- Q.4.1 STM transmission protocols specific functionality (pertains to 7.1)
- Q.4.1.1 ATU-C input and output V interface for STM transport (replaces figure in 7.1.1)

See Figure Q.8.



NOTE 1 – Optional bearer channels (both duplex and simplex) and features are shown with dotted lines. NOTE 2 – TTR may be generated in the ATU-C without being provided from the V-C reference point.

Figure Q.8/G.992.1 – ATU-C functional interfaces for STM transport at the V-C reference point

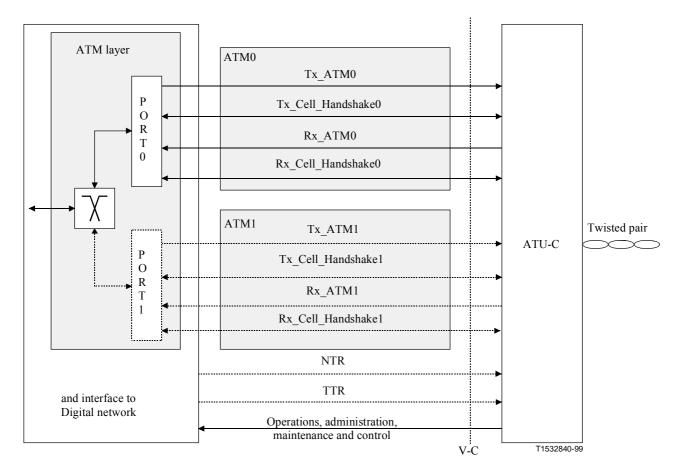
Q.4.1.2 Payload transfer delay (supplements 7.1.4)

Since Annex Q uses a rate converter, the maximum payload transfer delay is longer than specified values in 7.1.4. The additional one-way transfer delay due to the rate converters shall be less than 1.7 ms for fast data and 13 ms for interleaved data.

Q.4.2 ATM transmission protocols specific functionalities (pertains to 7.2)

Q.4.2.1 ATU-C Input and Output V interface for ATM transport (replaces figure in 7.2.1)

See Figure Q.9.



NOTE - TTR can be generated in the ATU-C without being provided from the V-C reference point.

Figure Q.9/G.992.1 – ATU-C functional interfaces to the ATM layer at the V-C reference point

Q.4.2.2 Payload transfer delay (supplements 7.2.2)

Since Annex Q uses a rate converter, the maximum payload transfer delay is longer than specified values in 7.2.2. The additional one-way transfer delay due to the rate converters shall be less than 1.7 ms for fast data and 13 ms for interleaved data.

Q.4.3 Framing (pertains to 7.4)

Q.4.3.1 Superframe structure (supplements 7.4.1.1)

Since the rate converter reorders the user data and overhead bit-level data to create hyperframes, the input data frames to the constellation encoder are different than those defined in 7.4.1.1.

Q.4.3.2 Hyperframe structure (replaces 7.4.1.3)

Annex Q uses the hyperframe structure shown in Figure Q.10. Figure Q.10 shows the phase relationship between the TTR_C and the hyperframe at the point U-C. Each hyperframe is composed of 5 superframes, which are numbered from 0 to 4. In order to indicate the boundary of the hyperframe, the inverse synch symbol is used for the 4th superframe (SPF#3), which is generated from a tone-by-tone 180-degree phase reversal of the synchronization symbol (see Q.4.7.1) except for the pilot tone.

The bit-level data stream from the rate-converter is extracted according to the size of Bitmap- F_R and Bitmap- N_R using the Sliding Window (see Q.3.3.2).

In order to make the bit rate to be a multiple of 32 kbit/s, the dummy bits are inserted at the end of hyperframe by the

rate converter (see Q.4.4.2). The hyperframe is composed of 345 DMT symbols, numbered from 0 to 344. Each symbol is assigned as $FEXT_R$ or $NEXT_R$ or $NEXT_R$ or $NEXT_R$ duration (see Q.2), and the following numerical formula gives the information which duration N_{dmt}-th DMT symbol belongs to at ATU-C transmitter (see Figure Q.11).

 $\begin{array}{ll} \mbox{For $N_{dmt} = 0, 1, ..., 344$} \\ S = 272 \ x \ N_{dmt} \ mod \ 2760$} \\ if \ \{ \ (S + 271 < a) \ or \ (S > a + b) \ \} & then \ FEXT_R \ symbol \\ else & then \ NEXT_R \ symbol \\ where \ a = 1243, \ b = 1461$ \\ \end{array}$

Thus, 128 DMT symbols are allocated in the FEXT_R duration, and 217 DMT symbols are allocated in the NEXT_R duration. The symbols are composed of:

FEXT _R symbol:				
Number of symbol using Bitmap-F _R	= 126			
Number of synch symbol	= 1			
Number of inverse synch symbol NEXT _R symbol:	= 1			
Number of symbol using Bitmap-N _R	= 214			
Number of synch symbol	= 3			

During FEXT Bitmap mode, the ATU-C shall transmit only the pilot tone in NEXT_R symbols.

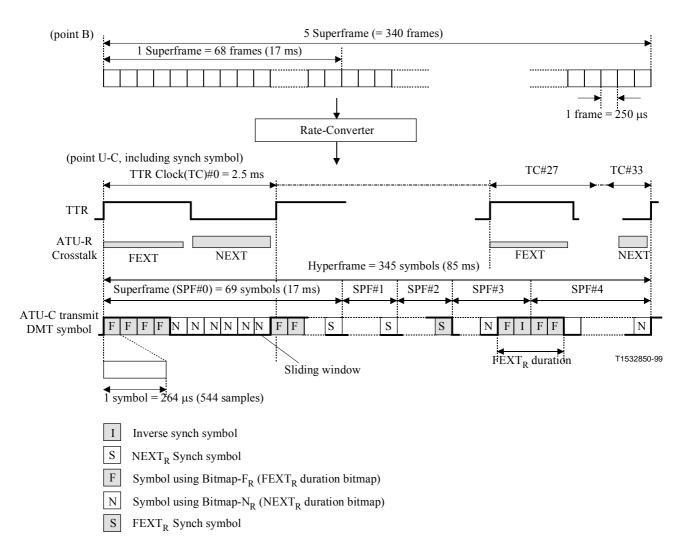


Figure Q.10/G.992.1 – Hyperframe structure for downstream

0	0 1 2	3	4	5		5 [,]	7	8	9
1	10 11 12	13	14	15	16	17	18	8 1	9
2	20 21 22	23	24	25	26	27	28	29	
3	30 31 32	33 3	34	35	36	37	38	39	40
4	41 42	43 44	I I	45	46	47	48	49	50
5	51 52 5	53 54		55	56	57	58	59	60
6	61 62 63	64	6	5 6	6	67	SS	69	70
7	71 72 73	74	75	76	5 7	7 7	8 7	79	80
8	81 82 83	84	85	86	87	88	89) 9	0
9	91 92 93	94	95	96	97	98	99	100	101
10	101 102 103	104 10)5	106	107	108	109	110	111
11	112 113 1	114 115	5	116	117	118	119	120	121
12		24 125			127	128	129	130	131
13	132 133 134		13						141
14	142 143 144	145	146						51
15	152 153 154	155	156		158				1
16	162 163 164		66	167	168	169	170	171	172
17	173 174	175 17		177	178	179	180	181	182
18		185 186		187	188	189	190	191	192
19		95 196			98		200	201	202
20	203 204 205		20						212
21	213 214 215	216	217			_	·		22
22	223 224 225	226	227		229				
23 24	233 234 235	236 2 246 24	37	238 248	239 249	240 250	241	242	243
24 25		240 24 256 257		248	249	260	260	262	263
23 26	264 265 26						271	272	273
20 27	274 ISS 276		27				·		283
28	284 285 286	287	288	<u> </u>	<u> </u>		<u> </u>	<u> </u>	93
20	294 295 296		298	299	300	301	302		- <u>-</u>
30	304 305 306		08	309	310	311	312	313	314
31		317 31		319	320	321	322	323	324
32		27 328			330	331	332	333	334
33	335 336 33						342	343	SS
	ISS Inverse synch syn	nbol S	S F	EXT _r Sy	/nch svm	ibol SS	T NEXT	Γ _R synch	symbol
	FEXT _R data symb			IEXT _R da	-				535330-00

Figure Q.11/G.992.1 – Symbol pattern in a hyperframe with cyclic prefix – Downstream

Q.4.3.3 Subframe Structure (replaces 7.4.1.4)

A subframe is 10 consecutive DMT symbols (except for synch symbols) as shown in Table Q.1. The 34 subframes form a hyperframe.

Subframe No.	DMT symbol No.	Note
0	0-9	
1	10-19	
2	20-29	
3	30-39	
4	40-49	
5	50-59	
6	60-70	#68 is Synch Symbol
7	71-80	
8	81-90	
9	91-100	
10	101-110	
11	111-120	
12	121-130	
13	131-141	#137 is Synch Symbol
14	142-151	
15	152-161	
16	162-171	
17	172-181	
18	182-191	
19	192-201	
20	202-212	#206 is Synch Symbol
21	213-222	
22	223-232	
23	233-242	
24	243-252	
25	253-262	
26	263-272	
27	273-283	#275 is Inverse Synch Symbol
28	284-293	
29	294-303	
30	304-313	
31	314-323	
32	324-333	
33	334-344	#344 is Synch Symbol

Table Q.1/G.992.1 – Subframe (downstream)

Q.4.3.4 Reduced overhead framing with merged fast and sync bytes (modifies 7.4.3.2)

In S=1/2n framing mode (see Q.4.9), there are n Sync bytes per symbol time. The contents of the Sync bytes is the same as in regular framing except that it repeats at n times the rate causing the superframe to be 68/n symbols in length. The contents of the sync bytes are shown in Table 7-6/G.992.1. In S=1/2n framing mode, "Frame Number" in column 1 in Table 7-6/G.992.1 is replaced by "Sync Byte Index Number".

As a result of the increase in superframe rate, the superframe contents is carried more frequently. For the case when N=2, the EOC and AOC bandwidth doubles, thereby transferring actual messages at twice the rate. The CRC byte is carried twice as frequently and therefore the maximum error rate rises from just over 58 per second to 117 per second. Where the duration of an error condition is measured, this needs to be taken into consideration. The indicator bits are also sent twice as often, which needs to be taken into consideration for statistics collection.

Q.4.4 Dual Bitmapping and Rate Conversion (replaces 7.15)

The functions of the rate converter (see Q.4.4.2), tone ordering (see Q.4.6), constellation encoding, and gain scaling shall use one of two bitmaps stored in the ATU. This method is called the dual bitmap.

Q.4.4.1 Dual Bitmap (new)

The Dual Bitmap method has individual bit rates under the FEXT and NEXT noise, and this needs an additional bit and gain table, $\{b_i, g_i\}$, and ordered bit table, b'_i , for the tone ordering. The dual bitmaps are switched synchronized with the sliding window pattern of NEXT/FEXT symbols. The number of bits and the relative gains to be used for every tone are calculated in the bit loading algorithm during the initialization sequence, and transmitted in R-B&G.

Q.4.4.2 Rate Converter (new)

The rate converter buffering changes the data frame boundaries between the reference points B and C according to Bitmap- F_R , Bitmap- N_R and the Sliding Window. Two independent rate converters are prepared for fast data and interleaved data. The amount of fast and interleaved data in Bitmap- F_R and Bitmap- N_R shall be calculated with the following formulae and illustrated in Figure Q.12:

If $t_{Rf} \le n_{Rmax}$:

$$n_{Rf} = t_{Rf}$$

$$n_{Ri} = n_R - n_{Rf}$$

$$f_{Rf} = t_{Rf}$$

$$f_{Ri} = f_R - f_{Rf}$$

If $t_{Rf} > n_{Rmax}$:

$$n_{Rf} = n_{R \max}$$

$$n_{Ri} = 0$$

$$f_{Rf} = \begin{cases} f_{Rf4} = \left\lceil \frac{t_{Rf} \times 10 - n_{Rf} \times 6}{4} \right\rceil$$

$$f_{Rf3} = \left\lceil \frac{t_{Rf} \times 10 - n_{Rf} \times 7}{3} \right\rceil$$

$$f_{Ri} = \begin{cases} f_{Ri4} = f_R = f_{Rf4} \\ f_{Ri3} = f_R - f_{Rf3} \end{cases}$$

Where:

^t Rf	is the number of allocated bits in one frame for fast bytes at the reference point B.
t _{Ri}	is the number of allocated bits for interleaved bytes at the reference point B.
f_{Rf} and n_{Rf}	are the numbers of fast bits in Bitmap- F_R and Bitmap- N_R , respectively.
f _{Rf3}	is the number of fast bits in Bitmap- F_R if the subframe (see Q.4.3.3) contains 3 Bitmap- F_R except
f _{Rf4}	for synch symbols. is the number of fast bits in Bitmap- F_R if the subframe contains 4 Bitmap- F_R except for synch
f _{Ri} and n _{Ri} ⁿ R	symbols. are the numbers of interleaved bits in Bitmap- F_R and Bitmap- N_R , respectively. is the number of total bits in Bitmap- N_R , which is specified in the B&G tables.

During FEXT Bitmap mode, n_{Rf} and n_{Ri} are zero.

To convert the bit rate to be a multiple of 32 kbit/s, the dummy bits for fast data are inserted to the tail of each subframe, and the dummy bits for interleaved data are inserted to the end of the Hyperframe. The number of the dummy bits shall be as follows:

If $t_{Rf} \le n_{Rmax}$:

$$dummy_{Rf} = 0$$

$$dummy_{Ri} = (f_{Ri} \times 126 + n_{Ri} \times 214) - t_{Ri} \times 340$$

If $t_{Rf} > n_{Rmax}$:

$$dummy_{Rf 4} = (f_{Rf} \times 4 + n_{Rf} \times 6) - t_{Rf} \times 10$$

$$dummy_{Rf 3} = (f_{Rf} \times 3 + n_{Rf} \times 7) - t_{Rf} \times 10$$

$$dummy_{Ri} = (f_{Ri4} \times 96 + f_{Ri3} \times 30) - t_{Ri} \times 340$$

If the fast data buffer uses single latency only, additional dummy bits are inserted at the tail of each FEXT symbol in the 4 Bitmap- F_R constructed subframe. The number of additional dummy bits inserted at the tail of each FEXT symbol shall be as follows:

$$dummy_{SRf} = f_{Rf3} - f_{Rf4}$$

The receiver shall determine Bitmap- F_R and Bitmap- N_R so that $dummy_{Ri}$ is less than 126, $dummy_{Rf4}$ is less than 4 and $dummy_{Rf3}$ is less than 3 in the initialization sequence. At the receiver, the inserted dummy bits shall be removed.

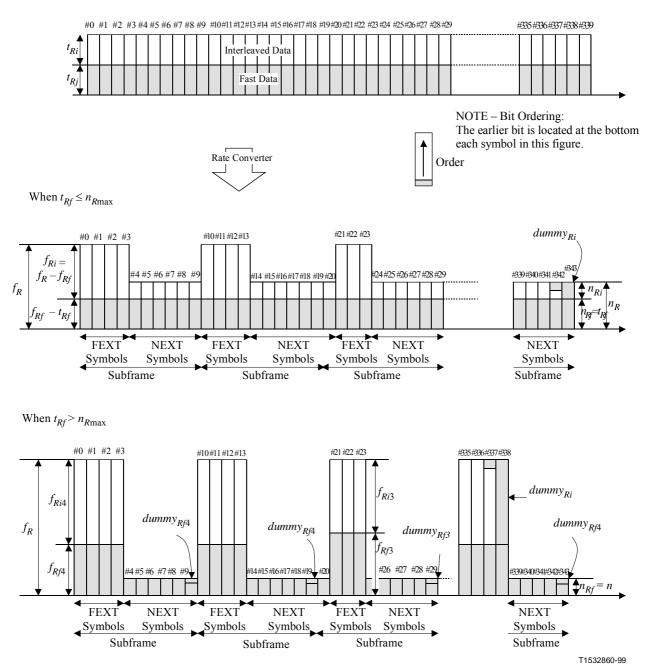


Figure Q.12/G.992.1 – Bit distribution for Rate Converter under Dual latency and Dual Bitmap mode

Q.4.5 FEXT Bitmapping (replaces 7.16)

The FEXT Bitmapping mode uses the Dual Bitmapping technique (Q.4.4) to transmit data only during FEXT. The ATU-C shall transmit only the pilot tone during the NEXT_R symbol. The ATU-R disables Bitmap-N_C and shall not transmit any signal during the NEXT_C symbol (see Figures Q.10 and Q.15).

Annex Q does not support the FEXT Bitmapping mode.

Q.4.6 Tone Ordering (replacement for 7.7)

A DMT time-domain signal has a high peak-to-average ratio (its amplitude distribution is almost Gaussian), and large values may be clipped by the digital-to-analogue converter. The error signal caused by clipping can be considered as an additive negative impulse for the time sample that was clipped. The clipping error power is almost equally distributed across all tones in the symbol in which clipping occurs. Clipping is therefore most likely to cause errors on those tones

that, in anticipation of a higher received SNR, have been assigned the largest number of bits (and therefore have the densest constellations). These occasional errors can be reliably corrected by the FEC coding if the tones with the largest number of bits have been assigned to the interleave buffer.

The numbers of bits and the relative gains in two bitmaps to be used for every tone are calculated in ATU-R receiver, and sent back to ATU-C according to a defined protocol (see 10.9.14). The pairs of numbers are typically stored, in ascending order of frequency or tone numbers *i*, in bit and gain tables for Bitmap- F_R and Bitmap- N_R .

For Bitmap- F_R , the "tone-ordered" encoding shall first assign f_{Rf} bits from the rate converter (see Q.4.4.2) to the tones with the smallest number of bits assigned to them, and the remaining f_{Ri} bits to the remaining tones. For Bitmap- N_R , it shall first assign n_{Rf} bits from the rate converter to the tones with the smallest number of bits assigned to them, and the remaining n_{Ri} bits to the remaining tones.

All tones shall be encoded with the number of bits assigned to them; one tone in each bitmap may therefore have a mixture of bits from the fast and interleaved buffers.

The ordered bit tables b'_{iF} and b'_{iN} shall be based on the original bit tables b_{iF} and b_{iN} as follows:

For k = 0 to 15 {

From the bit table, find the set of all *i* with the number of bits per tone $b_i = k$

Assign b_i to the ordered bit allocation table in ascending order of i

```
}
```

Two ordered bit tables for Bitmap- F_R and Bitmap- N_R shall be prepared. A complementary de-ordering procedure should be performed in ATU-R receiver. It is not necessary, however, to send the results of the ordering process to the receiver because the bit tables F_R and N_R were originally generated in ATU-R, and therefore those tables have all the information necessary to perform the de-ordering.

Q.4.7 Modulation (pertains to 7.11)

Q.4.7.1 Inverse Synchronization Symbol (replaces 7.11.4)

Except for the pilot tone, Inverse Synchronization symbol shall be generated from a tone-by-tone 180 degree phase reversal of Synchronization symbol (i.e. + maps to -, and - maps to +, for each of the 4-QAM signal constellation).

Q.4.7.2 Data subcarriers (modifies 7.11.1.1)

The channel analysis signal defined in 10.6.6 allows for a maximum of NSC-1 carriers (at frequencies $n\Delta f$, n = 1 to NSC-1) to be used.

Q.4.7.3 Nyquist frequency (modifies 7.11.1.3)

The carrier at the Nyquist frequency (#NSC) shall not be used for user data and shall be real valued; other possible uses are for further study.

Q.4.7.4 Modulation by the inverse discrete Fourier transform (replaces 7.11.2)

The modulating transform defines the relationship between the 2*NSC real values x_n and the Z_i :

$$x_n = \sum_{i=0}^{2^* NSC^{-1}} \exp\left(\frac{j\pi ni}{NSC}\right) Z_i \quad \text{for } n = 0 \text{ to } 2^* NSC - 1$$
(7-21)

The value of NSC shall be 1024 for this Annex. However, the PSD mask limits the highest used subcarrier index to 869.

The constellation encoder and gain scaling generate only NSC-1 complex values of Z_i . In order to generate real values of x_n , the input values (NSC-1 complex values plus zero at DC and one real value for Nyquist if used) shall be augmented so that the vector Z has Hermitian symmetry. That is,

 $Z_i = \text{conj}(Z'_{2*NSC-i})$ for i = NSC+1 to 2*NSC-1 (7-22)

Q.4.7.5 Synchronization symbol (modifies 7.11.3)

The synchronization symbol permits recovery of the frame boundary after micro-interruptions that might otherwise force retraining.

The data symbol rate, $f_{symb} = 4$ kHz, the carrier separation, $\Delta f = 4.3125$ kHz, and the IDFT size, N = 2*NSC, are such that a cyclic prefix of 15.625%*NSC samples could be used. That is, when NSC = 256, there are 40 samples in the cyclic prefix.

$$(512+40) \times 4.0 = 512 \times 4.3125 = 2208 \tag{7-23}$$

The cyclic prefix shall, however, be shortened to 12.5%*NSC samples, and a synchronization symbol (with a nominal length of NSC*2.125 samples) is inserted after every 68 data symbols. That is,

$$(2+0.125)*NSC \times 69 = (2+0.15625)*NSC \times 68$$
 (7-24)

The data pattern used in the synchronization symbol shall be the pseudo-random sequence PRD, (d_n , for n = 1 to 2*NSC) defined by:

$$d_n = 1$$
 for $n = 1$ to 9 (7-25)
 $d_n = d_{n-4} \oplus d_{n-9}$ for $n = 10$ to 2*NSC (7-26)

The first pair of bits (d_1 and d_2) shall be used for the DC and Nyquist subcarriers (the power assigned to them is zero, so the bits are effectively ignored); the first and second bits of subsequent pairs are then used to define the X_i and Y_i for i = 1 to NSC-1 as shown in Table 7-13.

The period of the PRD is only 511 bits, so d_{n+511} is equal to d_n . The d_1 - d_9 shall be re-initialized for each synchronization symbol, so each symbol uses the same data.

The two bits that modulate the pilot carrier, shall be overwritten by $\{0,0\}$: generating the $\{+,+\}$ constellation.

The minimum set of subcarriers to be used is the set used for data transmission (i.e. those for which $b_i > 0$); subcarriers for which $b_i = 0$ may be used at a reduced PSD as defined in transmit PSD paragraphs of Annexes A, B and C. The data modulated onto each subcarrier shall be as defined above; it shall not depend on which subcarriers are used.

Q.4.7.6 Cyclic prefix (replaces 7.12)

The last 12.5%*NSC samples of the output of the IDFT (x_n for n = 2*NSC-0.125*NSC to 2*NSC-1) shall be prepended to the block of 2*NSC samples and read out to the digital-to-analogue converter (DAC) in sequence. For example, when NSC=256, the subscripts, n, of the DAC samples in sequence are 480 ... 511, 0 ... 511.

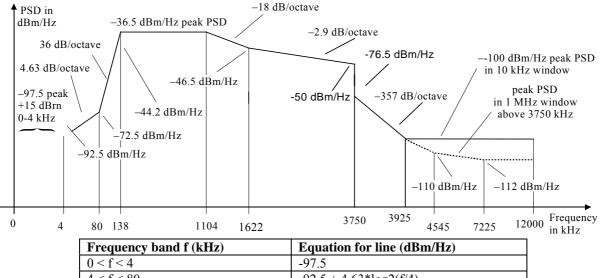
The cyclic prefix shall be used for all symbols beginning with the C-RATES1 segment of the initialization sequence, as defined in 10.6.2.

Q.4.8 ATU-C Downstream transmit spectral mask (replaces 7.14)

The downstream spectral mask of Annex Q is as specified in this section. Annex Q does not support overlapped spectrum. Therefore, C-MSG1 bit 16 shall be set to 0, and the PSD mask specified in § Q.4.8.1 shall be used.

Q.4.8.1 Downstream non-overlapped PSD mask definition

The non-overlapped PSD mask is defined with absolute peak values in Figure Q.13. The low frequency stop band is defined for frequencies below 138 kHz (tone 32); the high frequency stop band is defined at frequencies greater than 3750 kHz (tone 869). The in-band region of this PSD mask is the frequency band from 138 kHz to 3750 kHz.



0 < f < 4	-97.5
4 < f < 80	$-92.5 + 4.63 * \log 2(f/4)$
80 < f < 138	$-72.5 + 36 * \log 2(f/80)$
138 < f < 1104	-36.5
1104 < f < 1622	-36.5 - 18.0*log2(f/1104)
1622 < f < 3750	-46.5 - 2.9*log2(f/1622)
3750 < f < 3925	-76.5 - 357*log2(f/3750)
3925 < f < 12000	-100

Frequency (kHz)	PSD level (dBm/Hz)	Measurement BW
0	-97.5	100 Hz
4	-97.5	100 Hz
4	-92.5	100 Hz
10	interpolated	10 kHz
80	-72.5	10 kHz
138	-44.2	10 kHz
138	-36.5	10 kHz
1104	-36.5	10 kHz
1622	-46.5	10 kHz
3750	-50	10 kHz
3750	-76.5	10 kHz
3925 - 12000	-100	10 kHz

Additionally the PSD mask shall satisfy the following requirements:

Frequency (kHz)	PSD level (dBm/Hz)	Measurement BW
3925	-100	1 MHz
4545	-110	1 MHz
7225	-112	1 MHz
12000	-112	1 MHz

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. The breakpoints in the tables shall be connected by linear straight lines on a dB/log(f) plot.
- NOTE 3 MBW specifies the Measurement Bandwidth. The MBW specified for a certain breakpoint with frequency fi is applicable for all frequencies satisfying fi< $f \le fj$, where fj is the frequency of the next specified breakpoint.
- NOTE 4 The power in a 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency i.e. power in the [f, f + 1 MHz] window shall conform to the specification at frequency f.

- 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.

Figure Q.13: Non-overlapped Downstream Channel PSD Mask

Spectral Shaping of the In-Band Region defined in Q.4.8.2 and Transmit Signals with Limited Transmit Power defined in Q.4.8.3 shall be applied.

Q.4.8.2 Spectral Shaping of the In-Band Region of the PSD Spectrum

In order to shape the ATU-C PSD, frequency dependent gains, called spectral shaping values (ssv_i), shall be applied on each tone during initialization and showtime. The ssv_i values shall be represented with 1 bit before and 10 bits after the decimal point.

Table Q.2 defines the corner points for the nominal PSD shape of the inband region as gain in dB, i.e log_ssv_i . Log_ssv_i on other tones shall be linearly interpolated between corner points on a logarithmic scale for the gain (dB) and a linear scale for the frequency (Hz). Note that the corner points defined in Table Q.2 are relative values.

The spectral shaping values shall be converted from logarithmic scale $(log_ssv_i, dB values)$ to linear ssv_i values according to:

$$ssv_i = \frac{Round\left(1024 \times 10^{\frac{\log_s ssv_i}{20}}\right)}{1024}$$

These points are not passed at initialization for the nominal PSD shape but are provided here for reference. However, for additional spectral shaping (see Q.4.8.4), parameters are passed during G.994.1.

The combined accuracy of the process of linear interpolation of the log_ssvi values and the process of conversion to linear ssv_i values shall be strictly less than one half lsb of the 10 bit after the decimal point format of the linear ssvi values. No error shall be introduced when log_ssv_i equals 0dB or is interpolated between log_ssv_i values, which equal 0dB.

- NOTE 1: The above definition ensures that the maximum deviation between ssv_i values used by transmitter and receiver is one lsb.
- NOTE 2: The above needs an accuracy that is strictly < 1/2 lsb. An accuracy of = 1/2 lsb, will lead to inaccurate results.

Tone Index	$Log_ssv_i(dB)$	Comments
32	0	138 kHz defines the beginning of the inband region. No shaping is applied in
		the low stop band.
256	0	1104 kHz
376	-10	1622 kHz (-10 = -50 - Nominal PSD lowband)
869	-13.5	3750 kHz (-13.5 = -53.5 - Nominal_PSD_lowband)

Table Q.2:	Corner points f	or the non-overlapped nomin	nal in-band PSD shape.
------------	-----------------	-----------------------------	------------------------

The absolute values of the transmit PSD are obtained by scaling the relative shaping values with a NOMINAL_PSD_lowband, defined for the lower in-band frequencies. Note that the nominal in-band transmit PSD is frequency dependent. The NOMINAL_PSD_lowband is -40 dBm/Hz (flat from 138 kHz to 1104 kHz) for the non-overlapped spectrum.

NOTE 3: In-band PSD spectral shaping is applied prior to the IFFT.

NOTE 4: The value of MAXNOMATPds may be limited by regional regulations.

Q.4.8.3 Transmit Signals with Limited Transmit Power

For cases where the transmit signal must be limited to a maximum aggregate total power (e.g. $ATP_{dsmax} = +20 \text{ dBm}$), then

- a) During initialization the PSD transmit level is specified as an offset from the nominal value, i.e. (Nominal_PSD_lowband + ssvi x power cutback) dB, and all values of gi = 1 for the offset value x and power cutback. The value of x shall be the greater of 0 dB and (21.1 ATPdsmax) dB. For ATPdsmax = 20 dBm, the corresponding value of x shall be 1.1 dB.
- b) If bi>0, then valid range for gi is [-14.5 to +2.5+x] (dB);
 If bi>0, then gi shall be in the [g_{sync} 2.5 to g_{sync} + 2.5] (dB) range;
 If bi=0, then gi shall be equal to 0 (linear) or in the [-14.5 to g_{sync}] (dB) range;
 For G.992.1 annex Q, g_{sync} <= x dB

The g_i values shall be constrainted by following relation:

Constraint on g _i values	$\sum_{i=6}^{511} ssv_i^2 * g_i^2 \le \sum_{i=6}^{511} ssv_i^2$
-------------------------------------	---

Q.4.8.4 Additional inband spectral shaping

An ATU-R may request additional downstream inband spectral shaping by passing parameters to the ATU-C in a G.994.1 CLR, MP, or MS message. The ATU-C may select additional downstream inband spectral shaping by passing parameters to the ATU-R in a G.994.1 CL or MS message. Within the framework of G.994.1, the ATU-C has the ability to make the final decision on the downstream inband PSD shape to be used.

The additional inband spectral shaping parameters are listed in Q.7.2.2 and defined in Q.7.3. If the Additional inband spectral shaping Spar(2) bit is set to ONE in Table Q.6.2, its associated Npar(3) octets in Tables Q.6.2.1 to Q.6.2.1.5 define the inband spectral shape. If the additional inband spectral shaping Spar(2) bit is set to ZERO, its associated Npar(3) octets are not transmitted and the nominal inband PSD shape defined in Q.4.8.2 shall be used. These Npar(3) octets define the downstream PSD levels in the low band (between 138 and 1104 kHz), at 1622 kHz and at 3750 kHz. The PSD levels between 1104 kHz and 1622 kHz, and between 1622 kHz and 3750 kHz are linearly interpolated in log scale. The defined values are the PSD level in dB below the NOMINAL_PSD_lowband of -40dbm/Hz. For example, if all three values are set to 20 dB, the result will be a flat PSD of -60dbm/Hz. If the three values are set to 2 dB, 12 dB and 15.5 dB, the result is the PSD defined in Q.4.8.1 reduced by 2dB. In order not to violate the PSD mask defined in Q.4.8.1, the second value shall be no less than 10 dB and the third value shall be no less than 13.5 dB.

Q.4.8.5 Egress control

G.992.1 Annex Q equipment shall be able to reduce the PSD below -80 dBm/Hz for the Amateur radio bands between 1.81 MHz and 2.00 MHz, and between 3.5 MHz and 3.8 MHz. The ATU-C may apply additional spectral shaping as described in Q.4.8.4 to help achieve this requirement.

Q.4.9 Support of higher downstream bit rates with S = 1/2n (replaces 7.6.4)

With a rate of 4000 data frames per second and a maximum of 255 bytes (maximum RS codeword size) per data frame,

the ADSL downstream line rate is limited to approximately 8 Mbit/s per latency path. The line rate limit can be increased beyond this for the interleaved path by mapping 2n RS codewords into one FEC data frame (i.e. by using S = 1/2n in the interleaved path). S = 1/2n shall be used in the downstream direction only over bearer channel AS0.

For a selected value of $n \ge 1$, the K_I data bytes per interleaved mux data frame shall be packed into 2n RS codewords, split into n equal parts, each consisting of 2 consecutive RS codewords. This forces rate adaptation to occur in 32n kbit/s increments. Each of the n parts of the data frame shall begin with a sync byte and shall obey the rules defined in Table Q.3 for insertion of dummy bytes. The smallest value of n that can support the K_I data bytes shall be used.

Support of S = 1/2 (i.e., n=1), S = 1/4 (i.e., n=2), S = 1/6 (i.e., n=3), and S = 1/8 (i.e., n=4), is mandatory.

The resulting data frame structure shall be as shown in Figure Q.14.

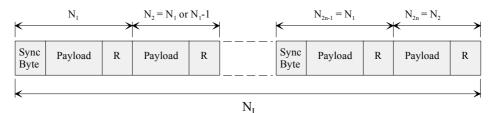


Figure Q.14 – Data frame for S = 1/2n mode

When K_I is divisible by 2n, the 2n codewords have the same length $N_{2i-1} = N_{2i} = (K_I/2n + R_I)$ for i = 1 to n, otherwise the odd numbered codewords are equal and are one byte longer than the even numbered codewords, i.e. $N_{2i-1} = (K_I + n)/2n + R_I$ bytes, and $N_{2i} = (K_I - n)/2n + R_I$ bytes for i = 1 to n. For the FEC output data frame, $N_I = \sum_{i=1}^n N_i$, with $N_I < 512n - 1$ bytes.

The convolutional interleaver requires all codewords to have the same odd length. To achieve the odd codeword length, insertion of dummy (not transmitted) bytes may be required. For S = 1/2n, the dummy byte addition to the odd numbered and/or even numbered codewords at the input of the interleaver shall be as in Table Q.3.

N _{2i-1}	N _{2i}	Dummy Byte Insertion Action
Odd	Odd	No action
Even	Even	Add one dummy byte at the beginning of all codewords
Odd	Even	Add one dummy byte at the beginning of each even numbered codeword
Even	Odd	Add one dummy byte at the beginning of each odd numbered codeword and two dummy bytes at the beginning of each even numbered codeword [the de-interleaver shall insert one dummy byte into the de-interleaver matrix on the first byte and the $(D + 1)$ th byte of the corresponding codeword to make the addressing work properly]

Table Q.3/G.992.1 –Dummy byte insertion at interleaver input for S = 1/2n

Q.5 ATU-R Functional Characteristics (pertains to clause 8)

Q.5.1 Framing (pertains to 8.4)

Q.5.1.1 Superframe structure (replaces 8.4.1.1)

The superframe structure of ATU-R transmitter is identical to that of ATU-C transmitter, as specified in Q.4.3.1.

Q.5.1.2 Hyperframe structure (replaces 8.4.1.3)

The hyperframe structure of ATU-R transmitter is functionally similar to that of ATU-C transmitter, except that the inverse synch symbol is used in the 1st superframe (SPF#0) (see Figure Q.15). The hyperframe is composed of 345 DMT symbols, numbered from 0 to 344. Each symbol is under $FEXT_C$ or $NEXT_C$ duration (see Q.5.3), and the following numerical formula gives the information which duration N_{dmt}-th DMT symbol belongs to at ATU-R transmitter (see Figure Q.16).

128 DMT symbols are allocated in the FEXT_{C} duration, and 217 DMT symbols are allocated in the NEXT_{C} duration. The symbols are composed of:

FEXT _C symbol:	
Number of symbol using Bitmap- F_{C}	= 126
Number of synch symbol	= 1
Number of inverse synch symbol	= 1
NEXT _C symbol:	
Number of symbol using Bitmap-N _C	= 214
Number of synch symbol	= 3

During FEXT Bitmapping mode, the ATU-R shall not transmit any signal.

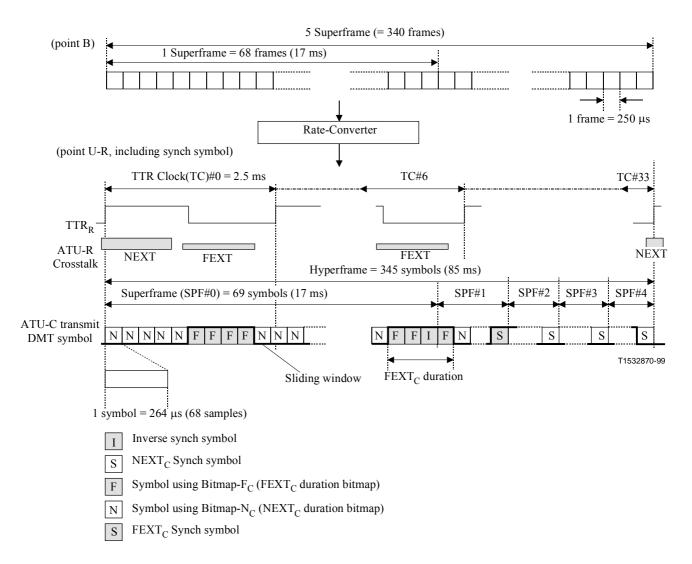


Figure Q.15/G.992.1 – Hyperframe structure for upstream

ттр	
TTR _R	
0	0 1 2 3 4 5 6 7 8 9
1	10 11 12 13 14 15 16 17 18 19
2	20 21 22 23 24 25 26 27 28 29
3	30 31 32 33 34 35 36 37 38 39 40
4	41 42 43 44 45 46 47 48 49 50
5	51 52 53 54 55 56 57 58 59 60
6	61 62 63 64 65 66 67 ISS 69 70
7	71 72 73 74 75 76 77 78 79 80
8	81 82 83 84 85 86 87 88 89 90
9	91 92 93 94 95 96 97 98 99 100 101
10	101 102 103 104 105 06 107 108 109 110 111
11	112 113 114 115 1 6 117 118 119 120 21
12	122 123 124 125 126 127 128 129 130 131
13	132 133 134 135 136 SS 138 139 140 141
14	142 143 144 145 146 147 148 149 150 151
15	152 153 154 155 156 157 158 159 160 161
16	162 163 164 165 166 167 168 169 170 171 172
17	173 174 175 176 77 178 179 180 181 82
18	183 184 185 186 187 188 189 190 191 92
19	193 194 195 196 197 198 199 200 201 202
20	203 204 205 SS 207 208 209 210 211 212
21	213 214 215 216 217 218 219 220 221 222
22	223 224 225 226 227 228 229 230 231 232
23	233 234 235 236 237 238 239 240 241 242 243
24	244 245 246 247 248 249 250 251 252 253
25	254 255 256 257 2 5 8 259 260 260 262 2 63
26	264 265 266 267 268 269 270 271 272 273
27	274 SS 276 277 278 279 280 281 282 283
28	284 285 286 287 288 289 290 291 292 293
29	294 295 296 297 298 299 300 301 302 303
30	304 305 306 307 308 309 310 311 312 313 314
31	<u>315</u> <u>316</u> <u>317</u> <u>318</u> <u>319</u> <u>320</u> <u>321</u> <u>322</u> <u>323</u> <u>324</u>
32	325 326 327 328 329 330 331 332 333 334
33	335 336 337 338 339 340 341 342 343 S5
	ISS Inverse synch symbol SS FEXT _R Synch symbol SS NEXT _R synch symbol
	FEXT _R data symbol NEXT _R data symbol T1535340-00

Figure Q.16/G.992.1 – Symbol pattern in a hyperframe with cyclic prefix – Upstream

Q.5.1.3 Subframe structure (replaces 8.4.1.4)

A subframe is 10 consecutive DMT symbols (except for synch symbols) as shown in Table Q.4. The 34 subframes form a hyperframe.

Subframe No.	DMT symbol No.	Note
0	0-9	
1	10-19	
2	20-29	
3	30-39	
4	40-49	
5	50-59	
6	60-70	#68 is Inverse Synch Symbol
7	71-80	
8	81-90	
9	91-100	
10	101-110	
11	111-120	
12	121-130	
13	131-141	#137 is Synch Symbol
14	142-151	
15	152-161	
16	162-171	
17	172-181	
18	182-191	
19	192-201	
20	202-212	#206 is Synch Symbol
21	213-222	
22	223-232	
23	233-242	
24	243-252	
25	253-262	
26	263-272	
27	273-283	#275 is Synch Symbol
28	284-293	
29	294-303	
30	304-313	
31	314-323	
32	324-333	
33	334-344	#344 is Synch Symbol

Table Q.4/G.992.1 – Subframe (upstream)

Q.5.2 Dual Bitmapping and rate conversion (replaces 8.15)

The function of the rate converter (see Q.5.2.2), tone ordering (see Q.5.4), constellation encoding, and gain scaling shall use one of two bitmaps stored in the ATU. This method is called the dual bitmap.

Q.5.2.1 Dual Bitmap (new)

The Dual Bitmap switching shall be the same as for the downstream data, specified in Q.4.4.1. The number of bits and the relative gains to be used for every tone are calculated in the bit loading algorithm during the initialization sequence, and transmitted in C-B&G.

Q.5.2.2 Rate Converter (new)

The rate converter buffering changes the data frame boundaries between the reference points B and C according to Bitmap- F_C , Bitmap- N_C and the Sliding Window. Two independent rate converters are prepared for fast data and interleaved data. The amounts of fast and interleaved data in Bitmap- F_C and Bitmap- N_C shall be calculated in the following formulae:

If $t_{Cf} \le n_{Cmax}$:

$$n_{Cf} = t_{Cf}$$
$$n_{Ci} = n_C - n_{Cf}$$
$$f_{Cf} = t_{Cf}$$
$$f_{Ci} = f_C - f_{Cf}$$

If $t_{Cf} > n_{Cmax}$:

$$n_{Cf} = n_{C \max}$$

$$n_{Ci} = 0$$

$$f_{Cf4} = \left[\frac{t_{Cf} \times 10 - n_{Cf} \times 6}{4}\right]$$

$$f_{Cf3} = \left[\frac{t_{Cf} \times 10 - n_{Cf} \times 7}{3}\right]$$

$$f_{Ci} = \begin{cases} f_{Ci4} = f_C - f_{C4} \\ f_{Ci3} = f_C - f_{Cf3} \end{cases}$$

Where:

^t Cf	is the number of allocated bits in one frame for fast bytes at the reference point B.
^t Ci	is the number of allocated bits for interleaved bytes at the reference point B.
f_{Cf} and n_{Cf}	are the numbers of fast bits in Bitmap- F_C and Bitmap- N_C , respectively.
fCf3	is the number of fast bits in Bitmap-F _C if the subframe (see Q.5.1.3) contains 3 Bitmap-F _C except
f _{Cf4}	for synch symbols. is the number of fast bits in Bitmap- F_C if the subframe contains 4 Bitmap- F_C except for synch
f_{Ci} and n_{Ci}	symbols. are the numbers of interleaved bits in Bitmap-F _C and Bitmap-N _C , respectively.
ⁿ C	is the number of total bits in Bitmap-N _C , which is specified in the B&G tables.
· · · · · · · · · · · ·	

During FEXT Bitmap mode, n_{Cf} and n_{Ci} are zero.

To convert the bit rate to be a multiple of 32 kbit/s, the dummy bits for fast data are inserted to the tail of each subframe, and the dummy bits for interleaved data are inserted to the end of the Hyperframe. The number of the dummy bits shall be as follows:

If $t_{Cf} \le n_{Cmax}$:

$$dummy_{Cf} = 0$$
$$dummy_{Ci} = (f_{Ci} \times 126 + n_{Ci} \times 214) - t_{Ci} \times 340$$

If $t_{Cf} > n_{Cmax}$:

$$dummy_{Cf 4} = (f_{Cf} \times 4 + n_{Cf} \times 6) - t_{Cf} \times 10$$

$$dummy_{Cf 3} = (f_{Cf} \times 3 + n_{Cf} \times 7) - t_{Cf} \times 10$$

$$dummy_{Ci} = (f_{Ci4} \times 96 + f_{Ci3} \times 30) - t_{Ci} \times 340$$

If the fast data buffer uses single latency only, additional dummy bits are inserted at the tail of each FEXT symbol in the 4 Bitmap- F_C constructed subframe. The number of additional dummy bits inserted at the tail of each FEXT symbol shall be as follows:

$$dummy_{SCf} = f_{Cf3} - f_{Cf4}$$

The receiver shall determine Bitmap-F_C and Bitmap-N_C so that $dummy_{Ci}$ is less than 126, $dummy_{Cf4}$ is less than 4 and $dummy_{Cf3}$ is less than 3 in the initialization sequence. At the receiver, the inserted dummy bits shall be removed.

Q.5.3 FEXT Bitmapping (replaces 8.16)

The FEXT Bitmapping mode uses the Dual Bitmapping technique (Q.4.4) to transmit data only during FEXT. The ATU-C shall transmit only the pilot tone during the NEXT_R symbol. The ATU-R disables Bitmap-N_C and shall not transmit any signal during the NEXT_C symbol (see Figures Q.10 and Q.15).

Annex Q does not support the FEXT Bitmapping mode.

Q.5.4 Tone Ordering (pertains to 8.7)

The tone ordering algorithm shall be the same as for the downstream data, specified in Q.4.4.

For Bitmap-F_C, the "tone-ordered" encoding shall first assign f_{Cf} bits from the rate converter (see Q.5.2.2) to the tones with the smallest number of bits assigned to them, and the remaining f_{Ci} bits to the remaining tones. For Bitmap-N_C, it shall first assign n_{Cf} bits from the rate converter to the tones with the smallest number of bits assigned to them, and the remaining n_{Ci} bits to the remaining tones. Two ordered bit tables for Bitmap-F_C and Bitmap-N_C shall be prepared.

Q.5.5 Modulation (pertains to 8.11)

Q.5.5.1 Inverse synchronization symbol (replaces 8.11.4)

Inverse Synchronization symbol shall be generated from a tone-by-tone 180 degree phase reversal of Synchronization symbol (i.e. + maps to -, and - maps to +, for each of the 4-QAM signal constellation).

Q.5.5.2 Gain scaling in synchronization symbol (new)

At initialization time, the sync symbol reference transmit PSD level shall be set at the nominal PSD level +10log(g_{sync}^2) dBm/Hz, with g_{sync}^2 defined as the average g_i^2 value over the used (i.e. $b_i > 0$) subcarriers in the NEXT or FEXT bitmap, whichever results in the highest average gain. The sync symbol reference transmit PSD shall not be updated with used subcarrier gain changes during SHOWTIME.

Q.5.6 ATU-R Upstream Transmit Spectral Mask (supplements 8.14)

The upstream spectral mask of Annex Q uses the same mask as Annex A.

Q.6 EOC Operation and Maintenance (pertains to clause 9)

Q.6.1 ADSL line related primitives (supplements 9.3.1)

Q.6.1.1 ADSL line related near-end defects (supplements 9.3.1.3)

Two near-end defects are further defined:

- *Loss-of-signal (LOS)*: The ADSL power shall be measured only in the FEXT_C duration at ATU-C, or only in the FEXT_R duration at ATU-R.
- Severely errored frame (SEF): A SEF defect occurs when the content of two consecutively received ADSL synchronization symbols in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-R, does not correlate with the expected content over a subset of the tones. An SEF defect terminates when the content of two consecutively received ADSL synchronization symbols in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-C, or in the FEXT_R duration at ATU-R, does not consecutively received ADSL synchronization symbols in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-R, correlate with the expected contents over the same subset. The correlation method, the selected subset of tones, and the threshold for declaring these defect conditions are implementation discretionary.

Q.6.1.2 ADSL line related far-end defects (supplements 9.3.1.4)

Loss-of-signal is further defined:

• Loss-of-signal (LOS): The ADSL power shall be measured only in the FEXT_C duration at ATU-C, or only in the FEXT_R duration at ATU-R.

Q.6.2 Test Parameters (supplements 9.5)

Q.6.2.1 Near-end test parameters (supplements 9.5.1)

The near-end primitives are further defined:

- *Attenuation (ATN)*: The received signal power shall be measured only in the FEXT_C duration at ATU-C, or only in the FEXT_R duration at ATU-R.
- *Signal-to-Noise ratio (SNR) margin*: During FEXT Bitmap mode, this primitive represents the snr margin in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-R.

Q.6.2.2 Far-end test parameters (supplements 9.5.2)

The far-end primitives are further defined:

- *Attenuation (ATN)*: The received signal power shall be measured only in the FEXT_C duration at ATU-C, or only in the FEXT_R duration at ATU-R.
- Signal-to-Noise ratio SNR margin: During FEXT Bitmap mode, this primitive represents the snr margin in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-R.

Q.6.3 Data registers in the ATU-R (supplements 9.2.4)

For the S=1/2n framing mode (see §Q.4.9), the downstream RS_I shall be the number of parity bytes per sync byte, i.e., $RS_I = R_I/(n^*S)$.

Q.7 Initialization (pertains to clause 10)

Q.7.1 Initialization with Hyperframe (replaces 10.1.5)

The exchange of messages between ATU-C and ATU-R should be performed in FEXT_{C} and FEXT_{R} . The DMT symbol has two symbol rates: one is 4.3125 kbaud for the symbol without a cyclic prefix, and the other is 4 x 69/68 kbaud for the symbol with a cyclic prefix. 32 times of the TTR has the same period as 345 times of the 4.3125 kbaud, and 34 times of the TTR is the same as 345 times of 4 x 69/68 kHz.

During FEXT Bitmap mode, the ATU-R shall not transmit any signal during the NEXT_C symbols duration and the ATU-C shall transmit only the pilot tone as the NEXT_R signal except:

- C-PILOT1 (C-PILOT1A) which is accompanied by a signal to allow the ATU-C to indicate the phase of TTR_C to the ATU-R (see Q.7.4.1);
- C-QUIETn where no signal is transmitted.

The ATU-C begins transmitting C-PILOT1 at the beginning of the hyperframe without cyclic prefix. The ATU-C informs the phase of the TTR_C to ATU-R during C-PILOT1. The ATU-R begins transmitting R-REVERB1 at the beginning of the hyperframe without cyclic prefix. The ATU-R performs the training of any receiver equalizer using this phase information of the TTR_R generated from received TTR_C .

From C-PILOT1 to C-SEGUE1, the following numerical formula gives the information which duration N_{dmt}-th DMT symbol belongs to at ATU-R (see Figure Q.17).

For $N_{dmt} = 0, 1, \dots 344$ $S = 256 \times N_{dmt} \mod 2760$ if { (S + 255 < a) or (S > a + b) } else where a = 1243, b = 1461

then FEXT_R symbols then NEXT_R symbols

In order to enter C-RATES1 at the beginning of the hyperframe with cyclic prefix, the number of symbols from C-PILOT1 to C-SEGUE1 shall be a multiple of 345 DMT symbols.

From R-REVERB1 to R-SEGUE1, the following numerical formula gives the information which duration N_{dmt}-th symbol belongs to at ATU-C (see Figure Q.18).

For $N_{dmt} = 0, 1, ..., 344$, $S = 256 \times N_{dmt} \mod 2760$ if { (S > a) and (S + 255 < a + b) } else then NEXT_C symbols where a = 1315, b = 1293

From C-RATES1 to C-SEGUE3, the number of symbols is a multiple of 345 DMT symbols. The following numerical formula gives the information which duration N_{dmt} -th DMT symbol belongs to. ATU-C transmits the message data in FEXT_R symbols (see Figure Q.11).

 $\label{eq:states} \begin{array}{l} \mbox{For $N_{dmt}=0, 1, ..., 344$} \\ S = 272 \ x \ N_{dmt} \ mod \ 2760$} \\ if \ \{ \ (S+271 \ge a) \ and \ (S \le a+b) \ \} \\ else \\ \mbox{then $NEXT_R$ symbols} \\ \mbox{then $FEXT_R$ symbols} \\ \mbox{where $a=1243$, $b=1461$} \end{array}$

The ATU-R enters R-REVERB3 at the beginning of the hyperframe with cyclic prefix, which is extracted from received signal. From R-REVERB3 to R-SEGUE5, the number of symbols is a multiple of 345 DMT symbols. The following numerical formula gives the information which duration N_{dmt} -th DMT symbol belongs to. ATU-R transmits the message data in FEXT_C symbols (see Figure Q.16).

For $N_{dmt} = 0, 1, ..., 344$ $S = 272 \times N_{dmt} \mod 2760$ if { (S > a) and (S + 271 < a + b) } then FEXT_C symbols else then NEXT_C symbols where a = 1315, b = 1293

TTR	_
1 1 1	٠(

R _C				7					
0	0 1 2	3	4	5	6	7	8	9	10
1		13 14	15	16	17	18	19	20	
2	22 23	24 25	26	27	28	29	30) 3	31
3	32 33 34	35 3	36 37	/ 38	3	9 4	0	41	42
4	43 44 45	46	47	48 4	19	50	51	52	53
5	54 55 5	6 57	58	59	60	61	62	63	64
6	65 66	67 68	69	70	71	72	73	7	4
7	75 76 77	78 79		81	82	83	8	4	85
8	86 87 88		90 9		2 9	93	94	95	96
9	97 98 99	100			103	104	105	106	107
10		10 111	112	113	114	115	116	117	
11	119 120	121 122		124	125	126	12	<u> </u>	28
12	129 130 131		33 134					38	139
13	140 141 142	143	E		I		148	149	150
14	151 152 15		155		157	158	159	160	161
15 16		164 165	166 6 177	167	168	169	170	17	
10	173 174 183 184 185	175 17 186 1	87 18	178 8 18	179 9 19			31 1 192	182 193
17	194 195 196					201	202	203	204
18	205 206 20		209	210	211	201	202	203	1
20	216 217	218 219		210	211	212	213		25
21	226 227 228		30 23						236
22	237 238 239			42 24			245	246	247
23	248 249 25		252	253	254	255	256	257	258
24		61 262	263	264	265	266	267	268	3 269
25	270 271	272 273	3 274	275	276	277	27	8 2	79
26	280 281 282	283 2	284 28	5 28	6 28	37 2	88	289	290
27	291 292 293	294	295	296 2	.97	298	299	300	301
28	302 303 30)4 305	306	307	308	309	310	311	312
29	313 314	315 316	317	318	319	320	321	32	.2
30	323 324 325	326 32			330) 33	1 3	32	333
31	334 335 336	337	338 3	39 34	40 3	41 3	342	343	344
	FEXT _R symb							Т	1535350-0

Figure Q.17/G.992.1 – Symbol pattern in a hyperframe without cyclic prefix – Downstream

TTP -	
TIND	

ſ																					ļ
×										Ľ											_
0	0		1	2		3		4		5		6	5	7		8	8		9	10	
1	11		12		13	1	4	1	15		16		17		18		19		20	21	l
2		22	23		24		25		26		27		28		29		3(3		_
3	32	33		34	3	5	36		3	7		38		39		40		41		42	
4	43	44		45		46		47		48		49		50		51		52		53	
5	54		55	50		57		58		5	9	6	50	6	51		62	Ļ	63	64	
6	6		66		67		68		69		70		71		72		73		74		
7		76	7		78		79		80		8		8		8	3	8	4	8	5	_
8	86	87		88		89	9	-	<u> </u>	91	_	92	╧	93		94		95		96	
9	97	9		99		100		101		102		10		10		10		10		107	
0	108		109		10	11		11	12		13		114	┷┯	115		116		117	118	3
1		19	120		121		122		123		124		12:		12		12		12		-
2	129	130	_	31	13		133		13	<u>.</u>		35		36	_	37		38		39	L
3	140	141		142		143		44		145		146		147		148		149		150	
4	151		52	15		154		15:		15		15		1:			59		60	161	12
5 6	162		163		.64		65		.66	i l	167		168	70	169		170	21	171	17	2
0 7	183	184	17	4 185	17:	5 86	176	7	17		17		17			30	18			32	Т
8	185	184		185		80 197		198		88 199		189 200		190 20		191 20		192 20	2	193 204	Т
。 9	205		206	20		20		20		-	10	_	211	_	1	_	2 213	_	214	215	
0	203		217		218		° 219	_	220		221		222	_	223		224		214	- <u>1</u>	
1		227	_	28	210		230		220			32	_	33		34		35		236	Г
2	239	238	_	239	_	240	_	, 41		242		243		244		245		246		247	Ц
3	248		<u>49</u>	250	_	251		252		25	3	25	54	25	55	-	56		57	258	5
4	259		260		61		62		63		264		265		266	<u> </u>	267	<u> </u>	268	269	
5		70	27		272	_	273		274	<u>. </u>	27		27		27	_	27			9	-
6	280	281		282		83	28	4	-	85	_	286	_	287	_	288		289		290	Т
7	291	29	2	293	┺	294		295		296	; 1	297	7	298	3	29	9	30	0	301	4
8	302		303	30	4	30		30			07	3	08		09	3	310		311	312	2
9	31	3	314	- :	315	13	316		317		318	T	319		320		321		322		_
0	323	324	32	25	32	6	327		32	<u></u>	32	_	33	30	-	31	_	32		33	
1	334	335		336	3	337	3	38		339		340		341		342		343		344	-
			C	ymbc ymbc						=									T1	5 35360	-00

Figure Q.18/G.992.1 – Symbol pattern in a hyperframe without cyclic prefix – Upstream

Q.7.2 Handshake – Non-standard information block (new)

This section defines the format of the G.994.1 non-standard information block to support Annex Q, and tabulates the parameters used by Annex Q. The use of these parameters is described in §Q.7.3 and §Q.7.4.

Q.7.2.1 Non-standard information block format (new)

Figure Q.19 defines the format of the non-standard information block.

8	7	6	5	4	3	2	1
		Non-stan		nation length	n = M + 6		
				intry code see Note 1)			
		Provid		ndor identifi see Note 2)	cation)		
		Ve		fic informati - Note 3)	on		

NOTE 1 – The value of this field shall be B5 00, the country code for USA

NOTE 2 – The value of this field shall be 43 45 4E 54, ASCII "CENT" for Centillium Communications

NOTE 3 – These octets are defined in Q.7.2.2. Formatting of these octets shall comply with the parsing rules defined in G.994.1 9.2.1 to 9.2.3

Figure Q.19 – Non-standard information block format

Q.7.2.2 Non-standard information block parameters (new)

The G.994.1 non-standard parameters for Annex Q are listed in Tables Q.5 to Q.6.2.1.2.5 below.

Bits								
8	7	6	5	4	3	2	1	NPar(1)s
х	х	х	х	х	х	х	1	Reserved for future use
х	х	х	х	х	х	1	х	Reserved for future use
х	х	Х	х	х	1	Х	х	Reserved for future use
х	х	Х	х	1	х	х	х	Reserved for future use
х	х	Х	1	х	х	Х	х	Reserved for future use
х	х	1	х	х	х	Х	х	Reserved for future use
х	1	Х	х	х	х	х	х	Reserved for future use
x	0	0	0	0	0	0	0	No parameters in this octet

Table Q.6 – Non-standard information field – SPar(1) coding

Bits								
8	7	6	5	4	3	2	1	SPar(1)s
x	х	х	х	х	х	х	1	G.992.1 Annex Q
x	х	х	х	х	х	1	х	Reserved for future use
x	х	х	х	х	1	х	х	Reserved for future use
х	х	х	х	1	х	х	х	Reserved for future use
x	х	х	1	х	х	х	х	Reserved for future use
х	х	1	х	Х	х	х	х	Reserved for future use
х	1	х	х	Х	х	х	х	Reserved for future use
x	0	0	0	0	0	0	0	No parameters in this octet

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex Q NPar(2)s
х	х	х	Х	Х	Х	Х	1	$n_{\text{C-PILOT1}} = 64$
х	х	х	х	Х	Х	1	х	$n_{\text{C-PILOT1}} = 128$
х	х	х	Х	х	1	Х	х	$n_{\text{C-PILOT1}} = 256$
х	х	х	х	1	х	Х	х	Amateur radio notch – 1.8 MHz band
х	х	х	1	Х	Х	х	Х	Amateur radio notch – 3.5 MHz band
х	х	1	х	Х	Х	Х	Х	Reserved for future use
Х	х	0	0	0	0	0	0	No parameters in this octet

Table Q.6.1 – Non-standard information field – G.992.1 Annex Q NPar(2) coding

Table Q.6.2 – Non-standard information field – G.992.1 Annex Q SPar(2) coding

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex Q SPar(2)s
x	Х	х	х	Х	Х	Х	1	Additional inband spectral shaping
х	х	х	х	х	х	1	х	Reserved for future use
х	х	х	х	х	1	Х	х	Reserved for future use
х	х	х	х	1	х	х	х	Reserved for future use
х	х	х	1	х	х	х	х	Reserved for future use
х	х	1	х	х	Х	х	х	Reserved for future use
х	х	0	0	0	0	0	0	No parameters in this octet

Table Q.6.2.1 - Non-standard information field - G.992.1 Annex Q Npar(3) coding Octet 1

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex Q Npar(3)s Octet 1
X	Х					Х	х	NOMINAL_PSD_lowband (bits 8 & 7)
х	Х	х	Х	Х	Х			Reserved for future use

Table Q.6.2.1.1 - Non-standard information field - G.992.1 Annex Q Npar(3) coding Octet 2

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex Q Npar(3)s Octet 2
Х	х	х	х	Х	х	Х	х	NOMINAL_PSD_lowband (bits 6 to 1)

Table Q.6.2.1.2 – Non-standard information field – G.992.1 Annex Q Npar(3) coding Octet 3

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex Q Npar(3)s Octet 3
Х	х					х	х	PSD level at 1622 kHz (bits 8 & 7)
Х	х	х	х	Х	Х			Reserved for future use

Table Q.6.2.1.3 – Non-standard information field – G.992.1 Annex Q Npar(3) coding Octet 4

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex Q Npar(3)s Octet 4
X	х	х	х	Х	Х	х	Х	PSD level at 1622 kHz (bits 6 to 1)

Table Q.6.2.1.4 – Non-standard information field – G.992.1 Annex Q Npar(3) coding Octet 5

1	Bits								
	8	7	6	5	4	3	2	1	G.992.1 Annex Q Npar(3)s Octet 5
	х	х					Х	х	PSD level at 3750 kHz (bits 8 & 7)
	x	х	х	х	Х	Х			Reserved for future use

Table Q.6.2.1.5 – Non-standard information field – G.992.1 Annex Q Npar(3) coding Octet 6

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex Q Npar(3)s Octet 6
Х	X	x	Х	Х	Х	Х	Х	PSD level at 3750 kHz (bits 6 to 1)

Q.7.3 Handshake – Parameter definitions (supplements 10.2)

Q.7.3.1 Handshake – ATU-C (supplements 10.2)

Q.7.3.1.1 CL messages (supplements 10.2.1)

See Table Q.7.

Table Q.7/G.992.1 – ATU-C CL message	e NPar(2) bit definitions for Annex Q
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NSF parameter	Definition

G.992.1 Annex Q	If set to ONE, this Spar(1) bit indicates that the ATU-C is configured to support G.992.1 Annex Q.
ⁿ C-PILOT1 ⁼⁶⁴	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 64.
ⁿ C-PILOT1 ⁼¹²⁸	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 128.
ⁿ C-PILOT1 ⁼²⁵⁶	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 256.
Amateur radio notch – 1.8 MHz band	If set to ONE, this Npar(2) bit indicates that the ATU-C is configured to reduce its transmit power between 1.81 and 2.0 MHz to ≤ -80 dBm.
Amateur radio notch – 3.5 MHz band	If set to ONE, this Npar(2) bit indicates that the ATU-C is configured to reduce its transmit power between 3.5 and 3.8 MHz to ≤ -80 dBm.
Additional inband spectral shaping	If set to ONE, this Spar(2) bit indicates that the ATU-C is configured to apply additional downstream inband spectral shaping as defined by the values of REDUCED_PSD_lowband, PSD level at 1622 kHz, and PSD level at 3750 kHz
REDUCED_PSD_ lowband	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-C is configured to use in the passband below 1104 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz.
PSD level at 1622 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-C is configured to use at 1622 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs between the REDUCED_PSD_lowband level at 1104 kHz and the PSD level at 1622 kHz.
PSD level at 3750 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-C is configured to use at 3750 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs between the PSD level at 1622 kHz and the PSD level at 3750 kHz.

Q.7.3.1.2 MS messages (supplements 10.2.2)

See Table Q.8.

Table Q.8/G.992.1 -	- ATU-C MS message	NPar(2) bit de	efinitions for Annex Q
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NSF bit	Definition
0.0001.4	
G.992.1 Annex Q	If set to ONE, this Spar(1) bit indicates that the ATU-C is selecting G.992.1 Annex Q.
ⁿ C-PILOT1 ⁼⁶⁴	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 64 (Note 1).
ⁿ C-PILOT1 ⁼¹²⁸	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 128 (Note 1).
ⁿ C-PILOT1 ⁼²⁵⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 256 (Note 1).
Amateur radio notch – 1.8 MHz band	If set to ONE, this Npar(2) bit indicates that the ATU-C shall reduce its transmit power between 1.81 and 2.0 MHz to ≤ -80 dBm.
Amateur radio notch – 3.5 MHz band	If set to ONE, this Npar(2) bit indicates that the ATU-C shall reduce its transmit power between 3.5 and 3.8 MHz to ≤ -80 dBm.

A 1 1	
Additional inband	If set to ONE, this Spar(2) bit indicates that the ATU-C shall apply additional downstream
spectral shaping	inband spectral shaping as defined by the values of REDUCED_PSD_lowband, PSD level at
	1622 kHz, and PSD level at 3750 kHz
REDUCED PSD	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-C
_lowband	shall apply in the passband below 1104 kHz. It is coded in steps of 0.125dB relative to
	NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz;
	00001101 means -41.625 dBm/Hz.
PSD level at 1622	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-C
kHz	shall apply at 1622 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband
	(-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625
	dBm/Hz. The PSD level shall be linearly interpolated in dBs between the
	REDUCED_PSD_lowband level at 1104 kHz and the PSD level at 1622 kHz.
PSD level at 3750	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-C
kHz	shall apply at 3750 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband
	(-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625
	dBm/Hz. The PSD level shall be linearly interpolated in dBs between the PSD level at 1622
	kHz and the PSD level at 3750 kHz.
Note 1: One and only	y one pilot tone bit shall be set in an MS message.

Q.7.3.2 Handshake – ATU-R (supplements 10.3)

Q.7.3.2.1 CLR messages (supplements 10.3.1)

See Table Q.9.

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NSF bit	Definition
G.992.1 Annex Q	If set to ONE, this Spar(1) bit indicates that the ATU-R is configured to support G.992.1 Annex Q.
ⁿ C-PILOT1 ⁼⁶⁴	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 64.
ⁿ C-PILOT1 ⁼¹²⁸	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 128.
ⁿ C-PILOT1 ⁼²⁵⁶	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 256.
Amateur radio notch – 1.8 MHz band	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports the 1.8 MHz Amateur radio band notch.
Amateur radio notch – 3.5 MHz band	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports the 3.5 MHz Amateur radio band notch.
Additional inband spectral shaping	If set to ONE, this Spar(2) bit indicates that the ATU-R wishes to have additional downstream inband spectral shaping applied as defined by the values of REDUCED_PSD_lowband, PSD level at 1622 kHz, and PSD level at 3750 kHz
REDUCED_PSD _lowband	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R wishes to have applied in the passband below 1104 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz.
PSD level at 1622 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R wishes to have applied at 1622 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs between the REDUCED_PSD_lowband level at 1104 kHz and the PSD level at 1622 kHz.

Table Q.9/G.992.1 – ATU-R CLR message NPar(2) bit definitions for Annex Q

PSD level at 3750	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R
kHz	wishes to have applied at 3750 kHz. It is coded in steps of 0.125dB relative to
	NOMINAL PSD lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz;
	00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs
	between the PSD level at 1622 kHz and the PSD level at 3750 kHz.

Q.7.3.2.2 MS messages (supplements 10.3.2)

Table Q.10.

Table Q.10/G.992.1 – ATU-R MS message NPar(2) bit definitions for Annex Q

NSF bit	Definition			
G.992.1 Annex Q	If set to ONE, this Spar(1) bit indicates that the ATU-R is selecting G.992.1 Annex Q.			
ⁿ C-PILOT1 ⁼⁶⁴	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is selecting the pilot tone on subcarrier 64 (Note 1).			
ⁿ C-PILOT1 ⁼¹²⁸	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is selecting the pilot tone on subcarrier 128 (Note 1).			
ⁿ C-PILOT1 ⁼²⁵⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is selecting the pilot tone on subcarrier 256 (Note 1).			
Amateur radio notch – 1.8 MHz band	This selection shall only be performed by the ATU-C. Therefore, this Npar(2) bit shall either be set to the same value as in a previous CL message or set to ONE.			
Amateur radio notch – 3.5 MHz band	This selection shall only be performed by the ATU-C. Therefore, this Npar(2) bit shall either be set to the same value as in a previous CL message or set to ONE.			
Additional inband spectral shaping	If set to ONE, this Spar(2) bit indicates that the ATU-R is selecting additional downstream inband spectral shaping as defined by the values of REDUCED_PSD_lowband, PSD level at 1622 kHz, and PSD level at 3750 kHz			
REDUCED_PSD _lowband	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R wishes to have applied in the passband below 1104 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz.			
PSD level at 1622 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R wishes to have applied at 1622 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs between the REDUCED_PSD_lowband level at 1104 kHz and the PSD level at 1622 kHz.			
PSD level at 3750 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R wishes to have applied at 3750 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs between the PSD level at 1622 kHz and the PSD level at 3750 kHz.			
Note 1: One and on	ly one pilot tone bit shall be set in an MS message.			

Q.7.3.2.3 MP messages (new)

Table Q.11.

NSF bit	Definition			
G.992.1 Annex Q	If set to ONE, this Spar(1) bit indicates that the ATU-R is proposing G.992.1 Annex Q.			
ⁿ C-PILOT1 ⁼⁶⁴	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the pilot tone on subcarrier 64 (Note 1).			
ⁿ C-PILOT1 ⁼¹²⁸	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the pilot tone on subcarrier 128 (Note 1).			
ⁿ C-PILOT1 ⁼²⁵⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the pilot tone on subcarrier 256 (Note 1).			
Amateur radio notch – 1.8 MHz band	This selection shall only be performed by the ATU-C. Therefore, this Npar(2) bit shall either be set to the same value as in a previous CL message or set to ONE.			
Amateur radio notch – 3.5 MHz band	This selection shall only be performed by the ATU-C. Therefore, this Npar(2) bit shall either be set to the same value as in a previous CL message or set to ONE.			
Additional inband spectral shaping	If set to ONE, this Spar(2) bit indicates that the ATU-R is proposing additional downstream inband spectral shaping as defined by the values of REDUCED_PSD_lowband, PSD level at 1622 kHz, and PSD level at 3750 kHz			
REDUCED_PSD_ lowband	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R wishes to have applied in the passband below 1104 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz.			
PSD level at 1622 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R wishes to have applied at 1622 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs between the REDUCED_PSD_lowband level at 1104 kHz and the PSD level at 1622 kHz.			
PSD level at 3750 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R wishes to have applied at 3750 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs between the PSD level at 1622 kHz and the PSD level at 3750 kHz.			
note 1: More than o	ne pilot tone bit may be set in an MP message.			

Table Q.11/G.992.1 – ATU-R MS message NPar(2) bit definitions for Annex Q

Q.7.4 Transceiver Training – ATU-C (supplements 10.4)

During transceiver training from C-REVERB1 to C-SEGUE1 except C-PILOTn and C-QUIETn, the ATU-C shall transmit both $FEXT_R$ and $NEXT_R$ symbols when Bitmap-N_R is enabled (Dual Bitmap mode), and shall not transmit the $NEXT_R$ symbols except pilot tone when Bitmap-N_R is disabled (FEXT Bitmap mode). The duration of each state is defined as Figure Q.24.

Q.7.4.1 C-PILOT1 (supplements 10.4.2)

The ATU-C shall start the N_{SWF} (sliding window frame) counter from 0 immediately after entering C-PILOT1, and increment the N_{SWF} counter modulo 345 after transmission of each DMT symbol. According to the sliding window function and this counter, the ATU-C decides to transmit all of the subsequent symbols in either FEXT_R or NEXT_R symbols (for example, see Figures Q.11, Q.17 and Q.22).

C-PILOT1 has two signals.

The first signal is the pilot tone, a single frequency sinusoid at $f_{C-PILOT1}$ defined as:

$$X_{k} = \begin{cases} 0, \quad k \neq n_{C-PILOT1}, \ 0 \leq k \leq NSC \\ A_{C-PILOT1}, \quad k = n_{C-PILOT1} \end{cases}$$

The frequency of the pilot tone shall be selected from one of the following choices during G.994.1 as:

- 1. $f_{\text{C-PILOT1}} = 276 \text{ kHz} (n_{\text{C-PILOT1}} = 64).$
- 2. $f_{\text{C-PILOT1}} = 552 \text{ kHz} (n_{\text{C-PILOT1}} = 128).$
- 3. $f_{\text{C-PILOT1}} = 1104 \text{ kHz} (n_{\text{C-PILOT1}} = 256).$

The second signal is the TTR indication signal used to transmit $NEXT_R/FEXT_R$ information. The ATU-R can detect the phase information of the TTR_C from this signal. The TTR indication signal shall be selected during G.994.1 as:

A48 signal -the constellation encoding of the 48th carrier with 2-bit constellation as follows:

(+, +) to indicate a FEXT_R symbol;

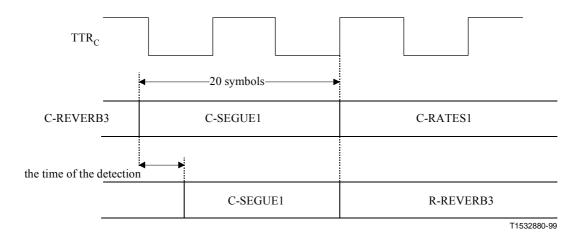
(+, -) to indicate a NEXT_R symbol.

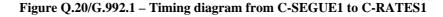
Q.7.4.2 C-PILOT1A (supplements 10.4.3)

C-PILOT1A has two signals and it is the same transmitted signal as C-PILOT1 (C.7.4.1).

Q.7.4.3 C-REVERB3 (supplements 10.4.11)

In order to synchronize the first symbol of C-RATES1 with the beginning of the hyperframe and to inform the entering timing of C-RATES1 to the ATU-R, the first symbol of C-SEGUE1 shall be transmitted inside of the FEXT_R duration as shown in Figure Q.20. Therefore, the duration of C-REVERB3 is 3628 DMT symbols.





Q.7.4.4 C-REVERB1 (replaces 10.4.5)

C-REVERB1 is a signal that allows the ATU-C and ATU-R receiver to adjust its automatic gain control (AGC) to an appropriate level. The data pattern used in C-REVERB1 shall be the pseudo-random downstream sequence (PRD), d_n for n = 1 to 2*NSC, defined in Q.4.7.5 and repeated here for convenience:

$d_n = 1$	for $n = 1$ to 9	(10-1)
$d_n = d_{n-4} \oplus d_{n-9}$	for $n = 10$ to 2*NSC	

The bits shall be used as follows: the first pair of bits $(d_1 \text{ and } d_2)$ is used for the DC and Nyquist subcarriers (the power assigned to them is, of course, zero, so the bits are effectively ignored); then the first and second bits of subsequent pairs are used to define the X_i and Y_i for i = 1 to NSC-1 as defined in Table 7-13.

The period of PRD is only 511 bits, so d_{n+511} is equal to d_n . The bits d_1 to d_9 shall be re-initialized for each symbol, so each symbol of C-REVERB1 is identical.

The two bits that modulate the pilot carrier shall be overwritten by $\{0,0\}$: generating the $\{+,+\}$ constellation.

The duration of C-REVERB1 is 512 (repeating) symbols without cyclic prefix.

Q.7.5 Transceiver Training – ATU-R (supplements 10.5)

During transceiver training from R-REVERB1 to R-SEGUE1 except R-QUIETn, the ATU-R shall transmit both $FEXT_C$ and $NEXT_C$ symbols when Bitmap-N_C is enabled (Dual Bitmap mode) and shall not transmit $NEXT_C$ symbols when Bitmap-N_C is disabled (FEXT Bitmap mode). The duration of each state is defined as Figure Q.24.

Q.7.5.1 **R-QUIET2** (supplements 10.5.1)

The ATU-R enters R-REVERB1 after it completes timing recovery and Hyperframe synchronization from C-PILOT1/C-PILOT1A.

Q.7.5.2 R-REVERB1 (supplements 10.5.2)

The data pattern used in R-REVERB1 is the pseudo-random upstream sequence PRU defined in 8.11.3 and repeated here for convenience:

$$\begin{cases} d_n = 1 & \text{for } n = 1 \text{ to } 6 \\ d_n = d_{n-5} & \oplus d_{n-6} & \text{for } n = 7 \text{ to } 64 \end{cases}$$
(C.10-1)

The ATU-R shall start its N_{SWF} counter immediately after entering R-REVERB1, and then increment the N_{SWF} counter with modulo 345 from 0 when it transmits each DMT symbol. The ATU-C and ATU-R shall have the same value since hyperframe alignment between the ATU-C and ATU-R shall be maintained. According to the sliding window and this counter, the ATU-R decides to transmit all of the subsequent symbols in either the FEXT_C or the NEXT_C symbol.

Q.7.5.3 R-QUIET3 (replaces 10.5.3)

The final symbol of R-QUIET3 accommodates the frame alignment of the transmitter to that of the receiver. It may be shortened by any number of samples. The maximum duration of R-QUIET3 is 6145 DMT symbols.

Q.7.5.4 R-REVERB2 (supplements 10.5.5)

After ATU-R detects C-SEGUE1, the ATU-R enters R-SEGUE1. The maximum duration of R-REVERB2 is 3643 DMT symbols.

Q.7.6 Channel analysis (ATU-C) (supplements 10.6)

ATU-C shall transmit only $FEXT_R$ symbols, and shall not transmit the $NEXT_R$ symbols except the pilot tone from C-RATES1 to C-CRC2. During C-MEDLEY, the ATU-C shall transmit both $FEXT_R$ and $NEXT_R$ symbols when Bitmap-N_R is enabled (Dual Bitmap mode). The ATU-C shall not transmit $NEXT_R$ symbols except the pilot tone, when Bitmap-N_R is disabled (FEXT Bitmap mode). The duration of each state is defined in Figure Q.24.

Q.7.6.1 C-SEGUE1 (supplements 10.6.1)

The duration of C-SEGUE1 is 20 symbols in order that the first symbol of C-SEGUE1 shall be inside of the FEXT_R duration.

Q.7.6.2 C-MEDLEY (replaces 10.6.6)

C-MEDLEY is a wideband pseudo-random signal used for estimation at the ATU-R of the downstream SNR. The data to be transmitted are derived from the pseudo-random sequence, PRD, and modulated as defined in 10.4.5. In contrast to C-REVERB1, however, the cyclic prefix is used and the data sequence continues from one symbol to the next (i.e. d_1 to d_9 are not re-initialized for each symbol); since PRD is of length 511, and 2*NSC bits are used for each symbol, the subcarrier vector for C-MEDLEY therefore changes from one symbol period to the next. The pilot subcarrier is overwritten by the (+,+) signal constellation. C-MEDLEY is transmitted for 16 384 symbol periods. Following C-MEDLEY the ATU-C shall enter the state C-REVERB4.

Basically, the definition of C-MEDLEY is as given above, except for the duration of the SNR estimation at ATU-R for the downstream. With the periodical noise of TCM-ISDN, SNR also changes in the same cycle, as shown in Figure Q.21. The ATU-C transmits the signal in both of $NEXT_R$ and $FEXT_R$ symbols, and the ATU-R estimates two SNRs from the received $NEXT_R$ and $FEXT_R$ symbols, respectively, as defined in Figure Q.22.

The following formula gives the information that received N_{dmt}-th DMT symbol belongs to:

For $N_{dmt} = 0, 1, ..., 344$ $S = 272 \times N_{dmt} \mod 2760$ if { (S + 271 < a) or (S > d) } if { (S > b) and (S + 271 < c) } where a = 1243, b = 1403, c = 2613, d = 2704 then symbol for estimation of NEXT_R SNR

When Bitmap-N_R is disabled (FEXT Bitmap mode), ATU-C shall transmit only the pilot tone as NEXT_R symbol. The number of bits of NEXT_R shall be no more than the number of bits of FEXT_R.

NOTE - At the transmitter, the PRD sequence generator is either always updated or always stopped during $NEXT_R$ symbol when Bitmap-N_R is disabled (FEXT Bitmap mode). The receiver should be able to support both modes of transmitter operation.

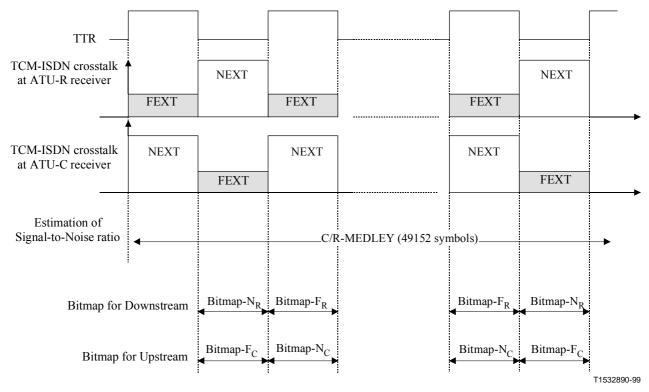


Figure Q.21/G.992.1 – Estimation of periodic Signal-to-Noise Ratio

TTR _C	
0	
1	
2	
3	30 31 32 33 34 35 36 36 37 39 40
4	41 42 43 44 45 46 47 48 49 50
5	51 52 53 54 55 56 57 58 59 60
6	61 62 63 64 65 66 67 58 70 70
7	71 72 73 74 75 76 76 80
8	81 82 83 84 85 36 87 88 89 99
9	91 92 93 94 95 96 97 98 99 100 101
10	101 102 103 104 105 106 107 108 109 111
11	112 113 114 115 116 117 120 121
12	122 123 124 125 26 27 78 129 131
13	132 133 134 135 136 137 138 139 141
14	142 143 144 145 146 147 148 149 151
15	152 153 154 155 156 157 158 159
16	162 163 164 165 166 167 168 169 170 172
17	173 174 175 176 177 178 179 188 182
18	183 184 185 186 187 188 189 199 192 102 104 105 106 107 100
19	193 194 195 196 197 198 1999 200 201 202
20 21	203 204 205 206 207 208 209 213 212
21	213 214 215 216 217 218 229 223 222 223 224 225 226 227 228 229 233
22	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$
23 24	233 234 235 237 238 249 238 249 253 244 245 246 247 248 249 258 253
25	244 245 246 246 246 260 262 263 254 255 256 257 258 259 269 262 263
26	264 265 266 267 268 269 279 277 273
27	274 275 276 277 278 279 288 288 283
28	284 285 286 287 288 289 299 299 299 293
29	294 295 296 297 298 299 300 300 300 300 300 300 300 300 300 3
30	304 305 306 307 308 309 334 334 332 333 314
31	315 316 317 318 319 324 324 324 324
32	325 326 327 328 329 336 333 332 333 334
33	335 336 337 338 339 340 344 342 343 344
	Symbol for estimation of FEXT _R S/N Symbol not used for S/N estimation
	Symbol for estimation of NEXT _R S/N T1535370-00

Figure Q.22/G.992.1 – Symbol pattern in a hyperframe for S/N estimation – Downstream

Q.7.6.3 C-RATES1 (supplements 10.6.2)

In order to support data rates greater than 32 Mbit/s, the B_I field has 11 bits. The RRSI fields shall use the same extended syntax as defined in Q.7.9.4 for C-RATES-RA.

For the S=1/2n framing mode (see §Q.4.9), the downstream RS_I shall be the number of parity bytes per sync byte, i.e., $RS_I = R_I/(n^*S)$.

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Table Q.12/G.992.1 – Assignment of 48 bits of C-MSG1			
Suffix(ces) of <i>m_i</i> (Note 1)	Parameter (Note 3)		
47-44	Minimum required downstream SNR margin at initialization (Note 2)		
43-18	Reserved for future use		
17	Trellis coding option		
16	Overlapped spectrum option (Note 4)		
15	Unused (shall be set to "1")		
14-12	Reserved for future use		
11	NTR		
10-9	Framing mode		
8-6	Transmit PSD during initialization		
5	Reserved		
4-0	Maximum numbers of bits per subcarrier supported		
NOTE 1 – Within the separate fields	the least significant bits have the lowest subscripts.		
NOTE 2 – A positive number of dB;			
NOTE 3 – All reserved bits shall be	set to "0".		
NOTE $4 -$ The initialization sequence allows for interworking of overlapped and non-overlapped spectrum			

Q.7.6.4 C-MSG1 (supplements 10.6.4)

T 11 0 10/0 000 1

NOTE 4 – The initialization sequence allows for interworking of overlapped and non-overlapped spectrum implementations. Therefore, this indication is for information only.

Q.7.6.4.1 Maximum numbers of bits per subcarrier supported – Bits 4-0 (replaces 10.6.4.8)

The N_{downmax} (transmit) capability shall be binary encoded onto $\{m_4, ..., m_0\}$ (e.g. $10001_2 = 17$). The maximum number of bits for the upstream data, N_{upmax} , that the ATU-C receiver can support need not be signalled to the ATU-R; it will be implicit in the bits and gains message, C-B&G, which is transmitted after channel analysis.

Q.7.7 Channel analysis (ATU-R) (supplements 10.7)

From R-RATES1 to R-CRC2, the ATU-R shall transmit only the $FEXT_C$ symbols and shall not transmit the $NEXT_C$ symbols. In R-SEGUE2 and R-MEDLEY, the ATU-R shall transmit both $FEXT_C$ and $NEXT_C$ symbols when Bitmap-N_C is enabled (Dual Bitmap mode) and shall not transmit $NEXT_C$ symbols when Bitmap-N_C is disabled (FEXT Bitmap mode). The duration of each state is defined in Figure Q.24.

Q.7.8 R-SEGUE1 (supplements 10.7.1)

The maximum duration of R-SEGUE1 is 14 symbols (see Figure Q.20).

Q.7.8.1 R-REVERB3 (supplements 10.7.2)

The ATU-R shall start R-REVERB3 aligned with the beginning of a Hyperframe.

Q.7.8.2 **R-SEGUE2** (supplements 10.7.3)

The duration of R-SEGUE2 is 13 symbols.

Q.7.8.3 R-MEDLEY (supplements 10.7.8)

Basically, the definition of R-MEDLEY is the same as 10.7.8, except for the duration of the SNR estimation at ATU-C for the upstream. With the periodical noise of TCM-ISDN, SNR also changes in the same cycle, as shown in Figure Q.21. ATU-R shall transmit the signal in both of NEXT_C and FEXT_C symbols, and ATU-C shall estimate two SNRs from the received NEXT_C and FEXT_C symbols, respectively, as defined in Figure Q.23.

The following numerical formula gives the information that received N_{dmt}-th DMT symbol belongs to:

For $N_{dmt} = 0, 1, ..., 344$ $S = 272 \times N_{dmt} \mod 2760$ if { (S > b) and (S + 271 < c) } if { (S + 271 < a) } where a = 1148, b = 1315, c = 2608

then symbol for estimation of FEXT_{C} SNR then symbol for estimation of NEXT_{C} SNR

When Bitmap-N_C is disabled (FEXT Bitmap mode), the ATU-R shall not transmit NEXT_C symbol. The number of bits of NEXT_C shall be no more than the number of bits of FEXT_C.

NOTE - At the transmitter, the PRD sequence generator is either always updated or always stopped during $NEXT_R$ symbol when Bitmap-N_R is disabled (FEXT Bitmap mode). The receiver should be able to support both modes of transmitter operation.

TTR _R _	
0	
1	
2	20 22 25 26 27 28 29
3	30 32 33 34 35 36 37 38 39 40 44 45 46 47 48 49 50
5	43 43 44 45 46 47 48 49 50 55 54 55 56 57 58 59 60
6	34 35 36 37 38 39 60 63 62 63 64 65 66 67 68 69 70
7	71 75 76 77 78 79 80
8	81 83 84 85 86 87 88 89 90
9	91 92 93 94 95 96 97 98 99 100 101
10	101 105 106 107 108 109 110 111
11	
12	127 128 129 130 131
13	<i>132 134 135</i> 136 137 138 139 140 14
14	142 143 145 146 147 148 149 150 151
15	152 333 344 355 156 157 158 159 160 161
16	162 63 64 65 165 167 168 169 170 171 172
17	176 77 178 179 180 181 182
18	183 184 185 186 187 188 189 190 191 92
19	193 194 195 196 19 198 199 200 201 202
20	203 204 205 206 207 208 209 210 211 212
21	213 214 215 217 218 219 220 221 222
22	223 227 228 229 230 231 232
23	233 234 235 238 239 240 241 242 243
24 25	244 245 246 247 248 249 250 251 252 253
25 26	254 255 257 238 259 260 260 262 263 264 265 265 268 269 270 271 272 273
26 27	203 203 203 203 211 212 213 234 235 235 278 279 280 281 282 283
27	284 285 286 287 288 289 290 291 292 293
20	294 295 296 297 298 299 300 301 302 303
30	304 305 306 308 309 310 311 312 313 314
31	<u>313</u> 316 317 318 319 320 321 322 323 324
32	325 326 327 328 329 330 331 332 333 34
33	335 336 337 338 339 340 341 342 343 344
	T1535290-00
	Symbol for estimation of FEXT _C S/N Symbol not used for S/N estimation
	Symbol for estimation of NEXT _C S/N

Figure Q.23/G.992.1 – Symbol pattern in a hyperframe for S/N estimation – Upstream

Q.7.8.4 R-MSG1 (supplements 10.7.6)

Suffix(ces) of m_i (Note 1)	Parameter (Note 2)		
47-18	Reserved for future use		
17	Trellis coding option		
16	Overlapped spectrum option (Note 3)		
15	Unused (shall be set to "1")		
14	Support of $S = 1/2$ mode (see Q.4.9) (Note 4)		
13	Support of dual latency downstream		
12	Support of dual latency upstream		
11	Network Timing Reference		
10, 9	Framing mode		
8-5	Reserved for future use		
4-0	Maximum numbers of bits per subcarrier supported		
NOTE 1 – Within the separate fields t	he least significant bits have the lowest subscripts.		
NOTE 2 – All reserved bits shall be se	et to "0".		
NOTE 3 – The initialization sequence	allows for interworking of overlapped and non-overlapped spectrum		
implementations. Therefore, this indication is for information only.			

Table Q.13/G.992.1 – Assignment of 48 bits of R-MSG1

NOTE 4 – Since the S=1/2 mode is mandatory for Annex Q, a modem supporting Annex Q shall set this bit to binary ONE.

Q.7.8.4.1 Maximum numbers of bits per subcarrier supported – Bits 4-0 (replaces 10.7.6.6)

The N_{upmax} (transmit) capability is encoded onto $\{m_4, ..., m_0\}$ with a conventional binary representation (e.g. $10001_2 = 17$).

Q.7.9 Exchange – ATU-C (supplements 10.8)

During C-RATESn, C-MSGn, C-B&G, and C-CRCn, the ATU-C shall transmit the FEXT_R symbol. In the other signals, the ATU-C shall transmit both FEXT_R and NEXT_R symbols when Bitmap-N_R is enabled (Dual Bitmap mode), and shall not transmit the NEXT_R symbols except pilot tone when Bitmap-N_R is disabled (FEXT Bitmap mode). The duration of each state is defined in Figure Q.25.

Q.7.9.1 C-MSG2 (supplements 10.8.9)

 $n_{1C-MSG2} = 43$ $n_{2C-MSG2} = 91$

Q.7.9.1.1 Total number of bits per symbol supported (supplements 10.8.9.3)

The maximum number of bits per symbol is defined at the reference point B, that is calculated from the FEXT_C and NEXT_C downstream channel performance (e.g. if the maximum numbers of bits that can be supported in FEXT_C and NEXT_C symbols are 111 and 88 {Total number of bits per symbol supported} = $(111 \times 126 + 88 \times 214)/340 = 96)$.

NOTE – The number of symbols per hyperframe is 340. The number of FEXT symbols is 126. The number of NEXT symbols is 214.

Q.7.9.2 C-B&G (replaces 10.8.13)

C-B&G shall be used to transmit to the ATU-R the bits and gains information, Bitmap-F_C { b_1 , g_1 , b_2 , g_2 , ... b_{31} , g_{31} }, and Bitmap-N_C { b_{33} , g_{33} , b_{34} , g_{34} , ..., b_{63} , g_{63} }, that are to be used on the upstream carriers. b_i of Bitmap-F_C indicates the number of bits to be coded by ATU-R transmitter onto the *i* th upstream carrier in FEXT_C symbols; g_i of Bitmap-F_C indicates the scale factor, relative to the gain that was used for that carrier during the transmission of R-MEDLEY, that shall be applied to the *i* th upstream carrier in NEXT_C symbols. Similarly, b_i of Bitmap-N_C indicates the scale factor that shall be applied to the (*i* – 32) th upstream carrier in NEXT_C symbols.

Because no bits or energy will be transmitted at DC or one-half the sampling rate, b_0 , g_0 , b_{32} , g_{32} , b_{64} , and g_{64} are all presumed to be zero and shall not be transmitted.

Each b_i shall be represented as an unsigned 5-bit integer, with valid b_i s lying in the range of zero to N_{upmax} , the maximum number of bits that the ATU-R is prepared to modulate onto any subcarrier, which is communicated in R-MSG1.

Each g_i shall be represented as an unsigned 11-bit fixed-point quantity, with the binary point assumed just to the right of

the third most significant bit. For example, a g_i with binary representation (most significant bit listed first) 001.01000000₂ would instruct the ATU-R to scale the constellation for carrier *i*, by a gain factor of 1.25, so that the power in that carrier shall be 1.94 dB higher than it was during R-MEDLEY.

For subcarriers on which no data are to be transmitted, and the receiver will never allocate bits (e.g. out-of-band subcarriers) both b_i and g_i shall be set to zero (00000₂ and 00000000 000₂, respectively). For subcarriers on which no data are to be currently transmitted, but the receiver may allocate bits later (e.g. as a result of an SNR improvement), the b_i shall be set to zero and the g_i to a value in the 0.19 to 1.33 range (000.00110000₂ to 001.0101010₁).

The C-B&G information shall be mapped in a 992-bit (124 byte) message *m* defined by:

$$m = \{m_{991}, m_{990}, \dots, m_1, m_0\} = \{g_{63}, b_{63}, \dots, g_{33}, b_{33}, g_{31}, b_{31}, \dots, g_1, b_1\},$$
(C.10-2)

with the MSB of b_i and g_i in the higher *m* index and m_0 being transmitted first. The message *m* shall be transmitted in 124 symbols, using the transmission method as described in 10.8.9.

When Bitmap-N_C is disabled (FEXT Bitmap mode), b_i and g_i of Bitmap-N_C shall be set to zero.

Q.7.9.3 C-SEGUE3 (replaces 10.8.16)

The duration of C-SEGUE3 is 18 symbols. Following C-SEGUE3, the ATU-C completes the initialization and enters C-SHOWTIME. In C-SHOWTIME, ATU-C shall transmit the signal using Bitmap- F_R and Bitmap- N_R with the sliding window.

When Bitmap-N_R is disabled (FEXT Bitmap mode), ATU-C shall transmit only the pilot tone as NEXT_R symbols.

	→ bits →							
fields	7	6	5	4	3	2	1	0
RS _F	$B_{10}(AS0)$	0	value of RS _F					
			MSB LSB					
RSI	$B_8(AS0)$	$B_9(AS0)$	value of RS _I					
			MSB LSB					
S	I9	I ₈	value of S					
			MSB LSB					
Ι	I ₇	I ₆	I ₅	I_4	I ₃	I ₂	I ₁	I ₀
FS(LS2)	value of FS(LS2) set to $\{0000000_2\}$							

Table Q.14/G.992.1 – RRSI fields of C-RATES-RA

The RS_I field has been extended to include bit B₉ of B_I (AS0) in bit 6, and The RS_F field has been extended to include the most significant bit B₁₀ of B_I (AS0) in bit 7, B_I (AS0) being the number of payload bytes in the AS0 bearer channel in the downstream interleave buffer. This is to support the higher data rates for the S=1/4, S=1/6 and S=1/8 modes.

The S field shall be coded $\{100100_2\}$ to indicate S=1/4, $\{100110_2\}$ to indicate S=1/6, and $\{101000_2\}$ to indicate S=1/8.

For the S=1/2n framing mode (see §Q.4.9), the downstream RS_I shall be the number of parity bytes per sync byte, i.e., $RS_I = R_I/(n^*S)$.

Q.7.10 Exchange – ATU-R (supplements 10.9)

ATU-R shall transmit only the FEXT_{C} symbols in R-MSGn, R-RATESn, R-B&G, R-CRCn. In other signals, the ATU-R shall transmit both FEXT_{C} and NEXT_{C} symbols when Bitmap-N_C is enabled (Dual Bitmap mode) and shall not transmit NEXT_{C} symbols when Bitmap-N_C is disabled (FEXT Bitmap mode). The duration of each state is defined in Figure Q.25.

Q.7.10.1 R-MSG-RA (supplements 10.9.2)

Replace Table 10-15 with Table Q.15.

Suffix(ces) of m _i	Parameter		
(Note)	All reserved bits shall be set to 0		
79-72	Reserved for ITU-T		
71 - 70	Extension to number of RS payload bytes, K		
69, 68	Extension to number of tones carrying data (ncloaded)		
67-56	B _{fast-max}		
55-49	Number of RS overhead bytes, (R)		
48-40	Number of RS payload bytes, K		
39-32	Number of tones carrying data (ncloaded)		
31-25	Estimated average loop attenuation		
24-21	Coding gain		
20-16	Performance margin with selected rate option		
15 - 14	Extension to total number of bits per DMT symbol, B _{max}		
13-12	Maximum Interleave Depth		
11-0	Total number of bits per DMT symbol, B _{max}		
NOTE – Within the sep	arate fields the least significant bits have the lowest subscripts.		

Table Q.15/G.992.1 – Assignment of 80 bits of R-MSG-RA (Annex Q)

Q.7.10.1.1 Total number of bits supported (B_{max}) (replaces 10.9.2.8)

This parameter shall be defined as in R-MSG2, see Q.7.9.1.

Q.7.10.1.2 B_{fast-max} (new)

 $B_{fast-max}$ is the maximum number of bits of the fast buffer for fast data transmitted on the condition that the bits of the fast data can be equally assigned to all FEXT-symbols and NEXT-symbols.

Fast Buffered Data Bfast-max is tf.

Q.7.10.2 R-MSG2 (supplements 10.9.8)

Suffix(ces) of m _i (Note 1)	1) Parameter (Note 2)		
31-25	Estimated average loop attenuation		
24-21	Reserved for future use		
20-16	Performance margin with selected rate option		
15 - 14	Extension to total number of bits per DMT symbol, B _{max}		
13-12	Reserved for future use		
11-0	Total number of bits per DMT symbol, B _{max}		
NOTE 1 – Within the separate fi	elds the least significant bits have the lowest subscripts.		
NOTE 2 – All reserved bits shall be set to "0".			

Table Q.16/G.992.1 – Assignment of 32 bits of R-MSG2

 $N_{1R-MSG2} = 10$ $N_{2R-MSG2} = 20$

Q.7.10.2.1 Total number of bits per symbol supported (supplements 10.9.8.3)

The maximum number of bits per symbol that the downstream channel can support is encoded into bits 15, 14 and 11 - 0.

The maximum number of bits per symbol is defined at the reference point B, that is calculated from the FEXT_R and NEXT_R downstream channel performance. For example, if the maximum numbers of bits that can be supported in FEXT_R and NEXT_R symbols are 111 and 88, the total number of bits per symbol supported is $(111 \times 126 + 88 \times 214)/340 = 96$.

NOTE – The number of symbols per hyperframe is 340, the number of FEXT symbols is 126, and the number of NEXT symbols is 214.

Q.7.10.3 R-B&G (replaces 10.9.14)

The purpose of R-B&G is to transmit to ATU-C the bits and gains information, Bitmap-F_R { b_1 , g_1 , b_2 , g_2 , ..., b_{NSC-1} , g_{NSC-1} }, and Bitmap-N_R { b_{NSC+1} , g_{NSC+1} , b_{NSC+2} , g_{NSC+2} , ..., $b_{2*NSC-1}$, $g_{2*NSC-1}$ }, to be used on the downstream subcarriers. b_i of Bitmap-F_R indicates the number of bits to be coded by ATU-C transmitter onto the *i* th downstream subcarrier in FEXT_R symbols; g_i of Bitmap-F_R indicates the scale factor that shall be applied to the *i* th downstream subcarrier in FEXT_R symbols, relative to the gain that was used for that carrier during the transmission of C-MEDLEY. Similarly, b_i of Bitmap-N_R indicates the number of bits onto the (*i* – NSC) th downstream carrier in NEXT_R symbols; g_i of Bitmap-N_R indicates the scale factor that shall be applied to the (*i* – NSC) th downstream carrier in NEXT_R symbols. Because no bits or energy will be transmitted at DC or one-half the sampling rate, b_0 , g_0 , b_{NSC} , g_{NSC} , b_{2*NSC} , and g_{2*NSC} are all presumed to be zero, and are not transmitted. When subcarrier 64 is reserved as the pilot tone, b_{64} and b_{NSC+64} , shall be set to 0, g_{128} and $g_{NSC+128}$ shall be set to g_{sync} . The value g_{sync} represents the gain scaling applied to the sync symbol.

Each b_i is represented as an unsigned 5-bit integer, with valid b_i lying in the range of zero to N_{downmax} , the maximum number of bits that the ATU-C is prepared to modulate onto any subcarrier, which is communicated in C-MSG1.

Each g_i is represented as an unsigned 11-bit fixed-point quantity, with the binary point assumed just to the right of the third most significant bit. For example, a g_i with binary representation (most significant bit listed first) 001.010000002 would instruct the ATU-C to scale the constellation for carrier *i* by a gain factor of 1.25, so that the power in that carrier shall be 1.94 dB higher than it was during C-MEDLEY.

For subcarriers on which no data are to be transmitted, and the receiver will never allocate bits (e.g. out-of-band subcarriers) both b_i and g_i shall be set to zero (00000₂ and 0000000 000₂, respectively). For subcarriers on which no data are to be currently transmitted, but the receiver may allocate bits later (e.g. as a result of an SNR improvement), the b_i shall be set to zero and the g_i to a value in the 0.19 to 1.33 range (000.00110000₂ to 001.0101010₁).

The R-B&G information shall be mapped in a (2*NSC-2)*16-bit ((2*NSC-2)*2 byte) message *m* defined by:

 $m = \{m_{(2*NSC-2)*16-1}, m_{(2*NSC-2)*16-2}, ..., m_1, m_0\} = \{g_{2*NSC-1}, b_{2*NSC-1}, ..., g_{NSC+1}, b_{NSC+1}, g_{NSC+1}, b_{NSC+1}, g_{NSC+1}, ..., g_{1}, b_1\},$ (Q.10-3)

with the MSB of b_i and g_i in the higher *m* index and m_0 being transmitted first. The message *m* shall be transmitted in (2*NSC-2)*2 symbols, using the transmission method as described in 10.9.8.

When Bitmap-N_R is disabled (FEXT Bitmap mode), b_i and g_i of Bitmap-N_R shall be set to zero.

Q.7.10.4 R-SEGUE5 (replaces 10.9.17)

The duration of R-SEGUE5 is 13 symbols. Following R-SEGUE-5, ATU-R completes the initialization and enters R-SHOWTIME. In R-SHOWTIME, ATU-R shall transmit the signal using Bitmap- F_C and Bitmap- N_C with the sliding window.

When Bitmap-N_C is disabled (FEXT Bitmap mode), ATU-R shall not transmit NEXT_C symbols.

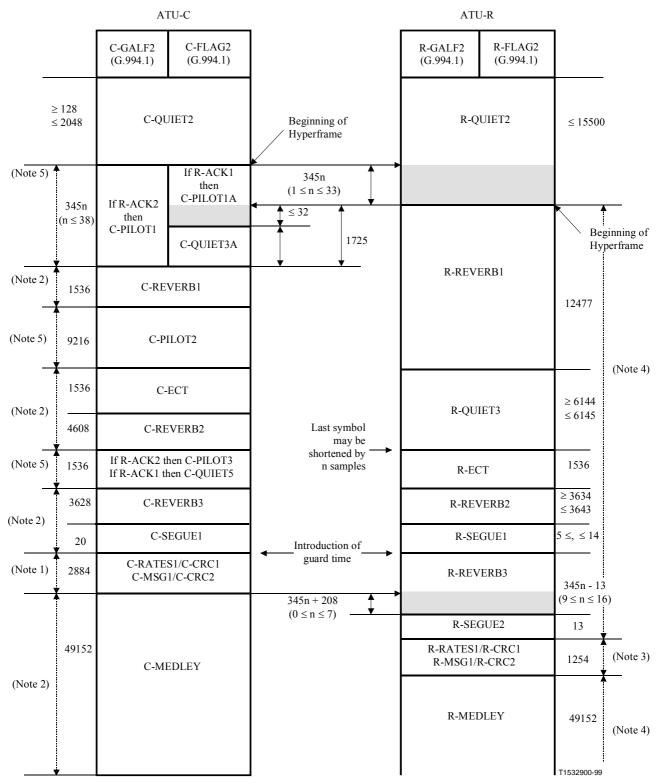
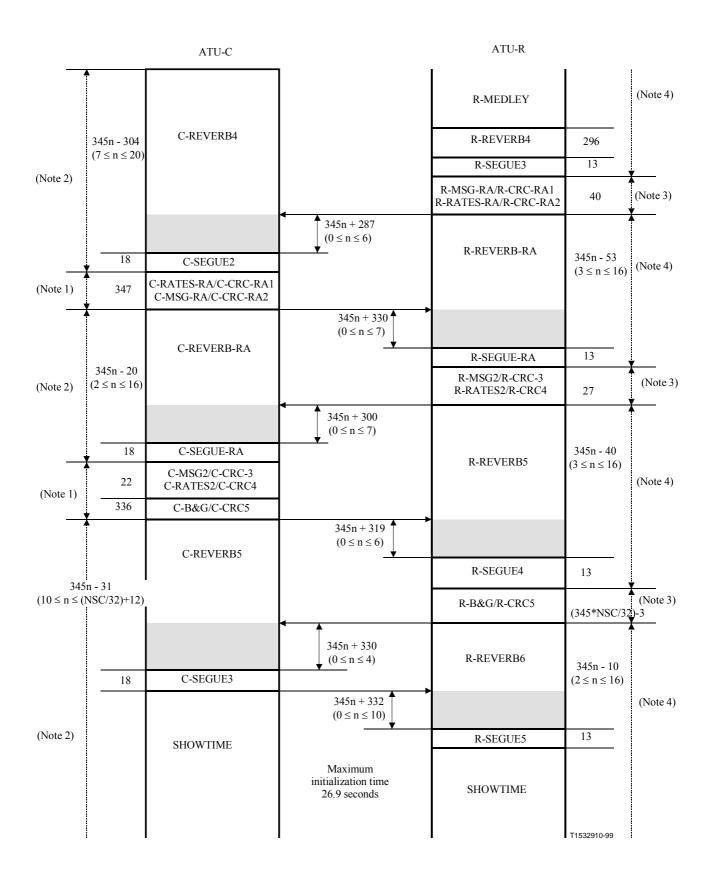
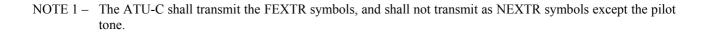


Figure Q.24/G.992.1 – Timing diagram of the initialization sequence – Part 1





- NOTE 2 The ATU-C shall transmit both FEXTR and NEXTR symbols, when Bitmap-NR is enabled (Dual Bitmap mode). ATU-C shall not transmit the NEXTR symbols except pilot tone, when Bitmap-NR is disabled (FEXT Bitmap mode).
- NOTE 3 The ATU-R shall transmit the FEXTC symbols, and shall not transmit the NEXTC symbols.
- NOTE 4 The ATU-R shall transmit both FEXTC symbols, when Bitmap-NC is enabled (Dual Bitmap mode). ATU-R shall not transmit NEXTC symbols, when Bitmap-NC is disabled (FEXT Bitmap mode).
- NOTE 5 The ATU-C shall transmit both FEXTR and NEXTR symbols.

Figure Q.25/G.992.1 – Timing diagram of the initialization sequence – Part 2

Q.8 AOC On-line adaptation and reconfiguration (pertains to clause 11)

Q.8.1.1 Bit swap request (replaces 11.2.3)

The receiver shall initiate a bit swap by sending a bit swap request to the transmitter via the AOC channel. This request tells the transmitter which subcarriers are to be modified. The format of the request is shown in Table Q.17.

Message header	Message field 1-4			
$\{11111111_2\}$	Bitmap index	Subchannel	Command	Subchannel
(8 bits)	(1 bit)	index – bits 10	(5 bits)	index – bits 8
(0 0113)		& 9		to 1
		(2 bits)		(8 bits)

Table Q.17/G.992.1 – Format o	f the bit swap	request message
-------------------------------	----------------	-----------------

The request shall comprise nine bytes as follows:

- an AOC message header consisting of 8 binary ones;
- message fields 1-4, each of which consists of a one-bit bitmap index, subchannel index bits 10 & 9, and a five-bit command followed by bits 8 to 1 of the subchannel index. One-bit bitmap index, subchannel index bits 10 & 9, and valid five-bit commands for the bit swap message shall be as shown in Table Q.18. In Table Q.18, the MSB for the bit swap request command represents the Bitmap index. For downstream data, Bitmap index equals 0 indicates Bitmap-F_R, and Bitmap index equals 1 indicates Bitmap-N_R. Similarly for upstream data, Bitmap index equals 0 indicates Bitmap-F_C, and 1 indicates Bitmap-N_C. The next 2 bits are subchannel index bits 10 & 9. The ten-bit subchannel index is counted from low to high frequencies with the lowest frequency subcarrier having the number zero. The subcarrier index zero shall not be used;
- the bit swap between $\text{FEXT}_{C/R}$ symbols and $\text{NEXT}_{C/R}$ symbols is not allowed.

Value (8 bit)	Interpretation			
yzz000002	Do nothing			
yzz000012	Increase the number of allocated bits by one			
yzz000102	Decrease the number of allocated bits by one			
yzz000112	Increase the transmitted power by 1 dB			
yzz001002	Increase the transmitted power by 2 dB			
yzz001012	Increase the transmitted power by 3 dB			
yzz001102	Reduce the transmitted power by 1 dB			
yzz001112	Reduce the transmitted power by 2 dB			
yzz01xxx ₂	Reserved for vendor discretionary commands			
NOTE – y is "0" for FEX	$T_{C/R}$ symbols, and "1" for NEXT _{C/R} symbols of the Sliding Window.			
NOTE – subchannel index = zz_2 *256 + subchannel index value from lower 8 bit field				

Table Q.18/G.992.1 – Bit swap request command

The bit swap request message (i.e. header and message fields) shall be transmitted five consecutive times.

To avoid g_i divergence between ATU-C and ATU-R after several bit swaps, for a g_i update of Δ dB the new g_i value should be given by:

$$g_i' = (1/256) \times round(256 \times g_i \times 10 \exp(\Delta/20))$$
 (Q.11-1)

Q.8.1.2 Extended bit swap request (supplements 11.2.4)

The format of the extended bit swap request is shown in Table Q.19.

Message header	Message field 1-6			
$\{11111100_2\}$	Bitmap index	Subchannel	Command	Subchannel
(8 bits)	(1 bit)	index – bits 10	(5 bits)	index – bits 8
(0 0103)		& 9		to 1
		(2 bits)		(8 bits)

In the same manner as the bit swap request, each of the message fields of the extended bit swap request consists of one-bit bitmap index, a five-bit command followed by a related ten-bit subchannel index.

Q.8.1.3 Bit swap acknowledge (supplements 11.2.5)

The bit swap superframe counter number shall only indicate the last superframe (SPF#4) of a hyperframe.

The new bit and/or transmit power table(s) shall then take effect starting from the first frame (frame 0) of SPF#0 of a hyperframe.

If the bit swap superframe counter number contained in the received bit swap acknowledge message does not indicate SPF#4, then the new table(s) shall take effect starting from frame 0 of SPF#0 of the next hyperframe.

付属資料2

G.992.1 ANNEX Q-EU (REVISION 3.2) PROPRIETARY EXTENSION TO G.992.1 ANNEX I

This document defines G.992.1 Annex Q-EU (Quad spectrum downstream with extended upstream spectrum), a proprietary extension to G.992.1 Annex I to extend the data rate beyond 32 Mbit/s downstream and 2 Mbit/s upstream on short loops by way of:

- Increased downstream bandwidth → increased number of subcarriers, NSCds=1024 (used subcarriers up to 869)
- Increase upstream bandwidth \rightarrow increased number of subcarriers, NSCus=64
- Increased bit loading, beyond 15 bits/bin
- Extended framing \rightarrow S=1/2n, with support for n = 1 to 4

Due to the increase in upstream data rates, the upstream maximum interleave depth has been increased to 16. Support of this is mandatory.

The attached text is the approved text for Annex I, marked up with revision control to show the changes necessary to support the additional functionality.

Revision R3 has the following changes with respect to Revision R2:

- modified both downstream and upstream PSDs
- added support for overlapped spectrum
- added G.994.1 code points to support above changes

Revision 3.2 changes the following with respect to Revision 3.1:

- changes PRD and PRU polynomial for MEDLEY (REVERB is unchanged) by defining new PRD_m and PRU_m.
- removes HAM band notches from the PSD definitions to allow them to be disabled.
- makes upstream masks EU-36 to EU-64 optional for use with non-overlapped spectrum as well as overlapped spectrum, and adds associated downstream masks DS-36 to DS-60 for non-overlapped spectrum.
- added a new G.994.1 NPar(3) code point to indicate support for the optional EU masks with non-overlapped spectrum. Changed the bit assignments for the mode 1 upstream masks and mode 2 upstream masks from NPar(2) to NPar(3) within the extended upstream branch of the tree. Changed bit assignments for the EU-32 to EU-64 NPar(3) code points.
- Modified timing diagram for initialization in Figure Q.27(Text in C-B&G and R-REVERB5 has been changed. Update Figure Q.27)

ANNEX Q-EU

Specific requirements for an ADSL system to support downstream data rates greater than 32 Mbit/s and upstream data rates greater than 2 Mbit/s on short loops operating in the same cable as ISDN as defined in ITU-T Recommendation G.961 Appendix III

Q.1 Scope

This annex describes those specifications that are unique to an ADSL system coexisting in the same binder as TCM-ISDN as defined Recommendation G.961 Appendix III. The subclauses in this annex provide supplementary and replacement material to the clauses in the main body. The nature of the material is parenthetically indicated in the subclause heading. The modifications described in this annex allow a performance improvement from the ADSL system specified in Annex C for short loops in an environment coexisting with TCM-ISDN in the same cable. Specifically, this Annex specifies extensions to downstream and upstream bandwidth, framing modes, and maximum bit loading to support downstream data rates greater than 32 Mbit/s and upstream data rates greater than 2 Mbit/s. This annex also defines those parameters of this ADSL system that have been left undefined in the main body of this Recommendation. An ADSL system implementing Annex Q-EU shall support Annex Q. It is recommended that an ADSL system implementing Annex S I and C.

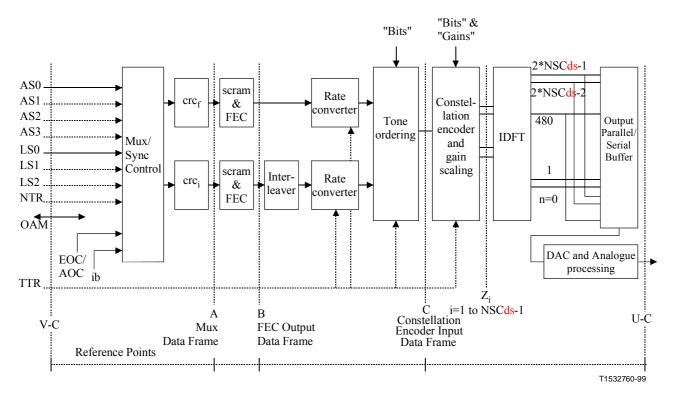
Q.2 Definitions

Bitmap-F _C ATU-R transmitter bitmap under TCM-ISDN FEXT noise generated at ATU-C	
Bitmap-F _R ATU-C transmitter bitmap under TCM-ISDN FEXT noise generated at ATU-R	
Bitmap-N _C ATU-R transmitter bitmap under TCM-ISDN NEXT noise generated at ATU-C	
Bitmap-N _R ATU-C transmitter bitmap under TCM-ISDN NEXT noise generated at ATU-R	
Dual BitmapThe Dual Bitmap method has dual bit rates under the FEXT and NEXT noise from TCM-ISDNFEXT BitmapSimilar to the Dual Bitmap method however transmission only occurs during FEXT noise from TCM-ISDN	
FEXT _C duration TCM-ISDN FEXT duration at ATU-C estimated by the ATU-R	
FEXT _C symbol DMT symbol transmitted by ATU-R during TCM-ISDN FEXT	
FEXT _R duration TCM-ISDN FEXT duration at ATU-R estimated by the ATU-C	
FEXT _R symbol DMT symbol transmitted by ATU-C during TCM-ISDN FEXT	
Hyperframe5 Superframes structure which synchronized TTRNEXT _C durationTCM-ISDN NEXT duration at ATU-C estimated by the ATU-R	
NEXT _C symbol DMT symbol transmitted by ATU-R during TCM-ISDN NEXT	
NEXT _R duration TCM-ISDN NEXT duration at ATU-R estimated by the ATU-C	
NEXT _R symbol DMT symbol transmitted by ATU-C during TCM-ISDN NEXT	
NSCds The highest subcarrier index that can be used for downstream transmission (i.e., the subcarrier index corresponding to the Nyquist frequency) For example, NSCds = 256 for a downstream channel using the frequency band up to 1.104MHz; NSCds = 512 for a downstream channel using the frequency band up to 2.208MHz.	n
NSCus The highest subcarrier index that can be used for upstream transmission (i.e., the subcarrie index corresponding to the Nyquist frequency) For example, NSCus = 64 for an upstream channel using the frequency band up to 276 kHz.	
N _{SWF} Sliding Window frame counter	
Subframe10 consecutive DMT symbols (except for sync symbols) according to TTR timingTTRTCM-ISDN Timing Reference	
TTR _C Timing reference used in ATU-C	
TTR _R Timing reference used in ATU-R	
UI Unit Interval	

Q.3 Reference Models

Q.3.1 ATU-C transmitter reference model (replaces figures in 5.1)

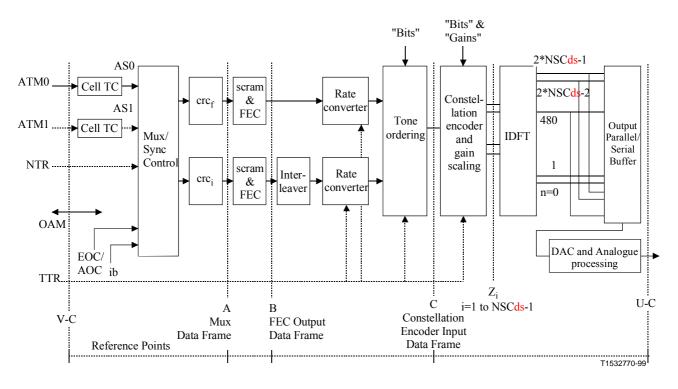
See Figure Q.1 and Figure Q.2.



NOTE - The TTR may be generated in ATU-C without being provided from the TCM-ISDN clock.

Figure Q.1/G.992.1 – ATU-C transmitter reference model for STM transport

Annex Q-EU does not currently support STM transport. It only supports ATM transport.

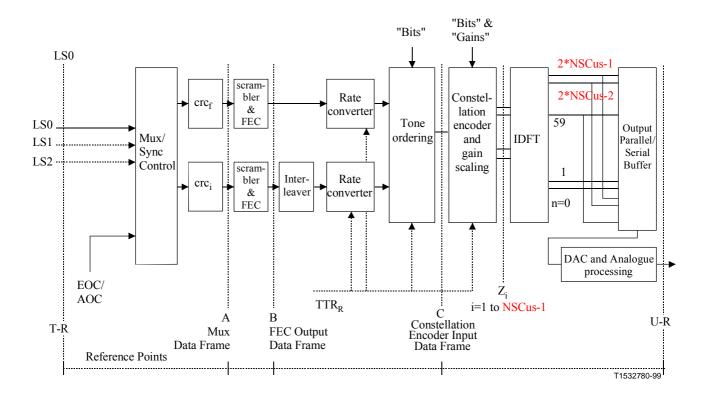


NOTE - The TTR may be generated in ATU-C without being provided from the TCM-ISDN clock.

Figure Q.2/G.992.1 – ATU-C transmitter reference model for ATM transport

Q.3.2 ATU-R transmitter reference model (replaces figures in 5.2)

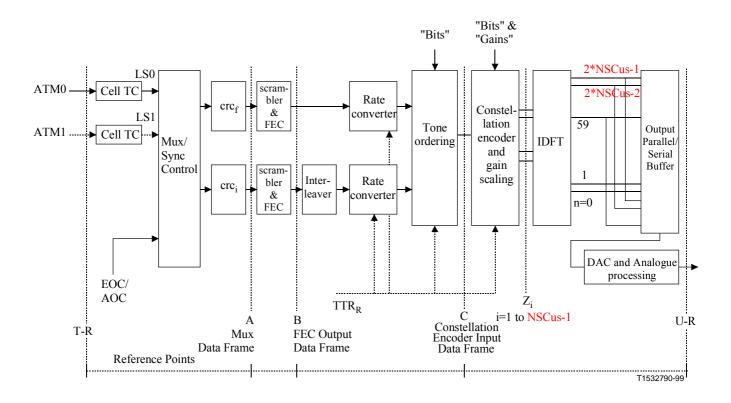
See Figure Q.3 and Figure Q.4.



NOTE – The TTR_R shall be generated in ATU-R from the received TTR_C signal, and it is locked to 690 periods of upstream sampling clock (1.104 MHz).

Figure Q.3/G.992.1 – ATU-R transmitter reference model for STM transport

Annex Q-EU does not currently support STM transport. It only supports ATM transport.



NOTE – The TTR_R shall be generated in ATU-R from the received TTR_C signal, and it is locked to 690 periods of upstream sampling clock (1.104 MHz).



Q.3.3 ATU-C/R transmitter timing model (replacement for 5.3)

Q.3.3.1 TCM-ISDN crosstalk timing model (new)

Figure Q.5 shows the timing chart of the crosstalk from TCM-ISDN.

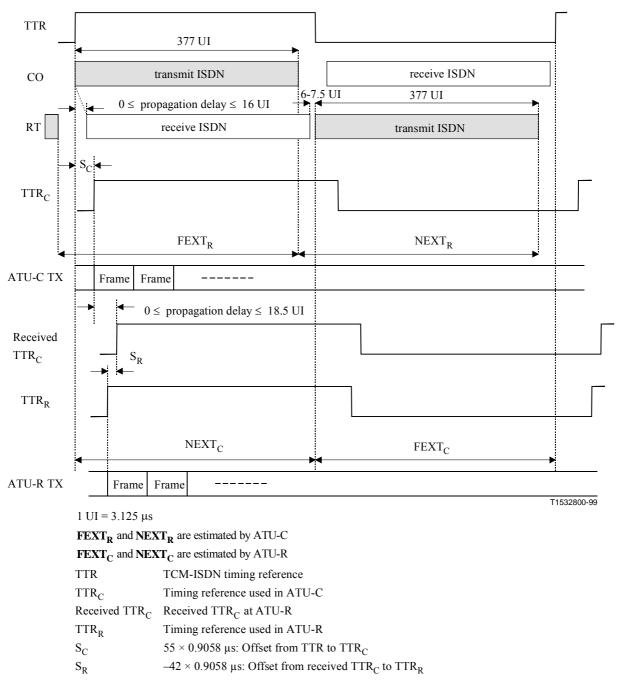


Figure Q.5/G.992.1 – Timing chart of the TCM-ISDN crosstalk

The data stream of TCM-ISDN is transmitted in TTR period. CO transmits the stream in the first half of the TTR period and RT transmits in the second half of the TTR period. ATU-C receives NEXT noise from the ISDN in the first half of the TTR period and FEXT noise from the ISDN in the second half of the TCM-ISDN period. On the other hand, ATU-R receives FEXT noise from the ISDN in the first half of the TTR period and NEXT noise from the ISDN in the second half of the TTR period.

As defined in Q.7.6.2 and Q.7.8.3, the ATU-C shall estimate the FEXT_R and NEXT_R duration at ATU-R, and the ATU-R shall estimate FEXT_C and NEXT_C duration at ATU-C taking propagation delay on the subscribe line into consideration.

The ATU-C shall transmit any symbols by synchronizing with the TTR_C . The ATU-R shall transmit any symbols synchronizing with the TTR_R generated from received TTR_C .

Q.3.3.2 Sliding window (new)

Figure Q.6 shows the timing chart of the transmission for the Annex Q-EU downstream at ATU-C.

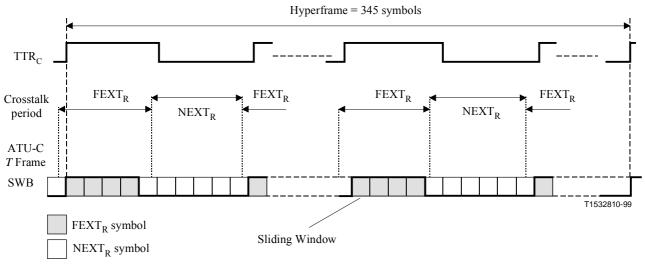


Figure Q.6/G.992.1 – Sliding window for downstream symbols

The Sliding Window defines the transmission symbols under the crosstalk noise environment synchronized to the period of TTR. The $\text{FEXT}_{C/R}$ symbol represents the symbol completely inside the $\text{FEXT}_{C/R}$ duration. The $\text{NEXT}_{C/R}$ symbol containing the $\text{NEXT}_{C/R}$ duration. Thus, there are more $\text{NEXT}_{C/R}$ symbols than $\text{FEXT}_{C/R}$ symbols.

The ATU-C decides which transmission symbol is FEXT_R or NEXT_R symbol according to the sliding window and transmits it with the corresponding bit table. Similarly, the ATU-R decides the transmission symbol is a FEXT_C or NEXT_C and transmits it with the corresponding bit table. Although the phase of the sliding window is asynchronous with $\text{TTR}_{C/R}$, the pattern is fixed to the 345 frames of the hyperframe.

Q.3.3.3 ATU-C Symbol Synchronization to TTR (new)

345 symbols are 34 cycles with cyclic prefix of TTR_C (or 32 cycles of TTR_C without cyclic prefix). This implies a PLL lock at the ATU-R.

Q.3.3.4 Dual Bitmap switching (new)

The ATU-C transmits FEXT_R symbols using Bitmap-F_R (in FEXT_R duration), and transmits NEXT_R symbols using Bitmap-N_R (in NEXT_R duration) according to the result of initialization. The ATU-R transmits FEXT_C symbols using Bitmap-F_C (in FEXT_C duration), and transmits NEXT_C symbols using Bitmap-N_C (in NEXT_C duration) in the same manner.

The ATU-C shall have the capability to disable Bitmap-N_C and Bitmap-N_R (see Q.4.5 and Q.5.3).

Q.3.3.5 Loop timing at ATU-R (new)

The phase relation between received symbol and transmitted symbol of ATU-R at the reference point U-R shall meet the phase tolerances as shown in Figure Q.7.

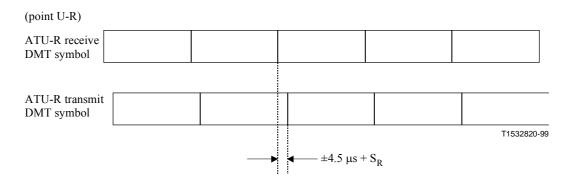
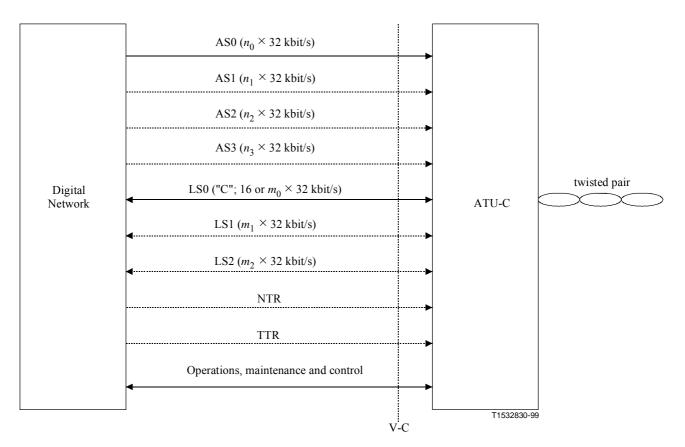


Figure Q.7/G.992.1 – Loop timing for ATU-R

- Q.4 ATU-C functional characteristics (pertains to clause 7)
- Q.4.1 STM transmission protocols specific functionality (pertains to 7.1)
- Q.4.1.1 ATU-C input and output V interface for STM transport (replaces figure in 7.1.1)

See Figure Q.8.



NOTE 1 – Optional bearer channels (both duplex and simplex) and features are shown with dotted lines. NOTE 2 – TTR may be generated in the ATU-C without being provided from the V-C reference point.

Figure Q.8/G.992.1 – ATU-C functional interfaces for STM transport at the V-C reference point

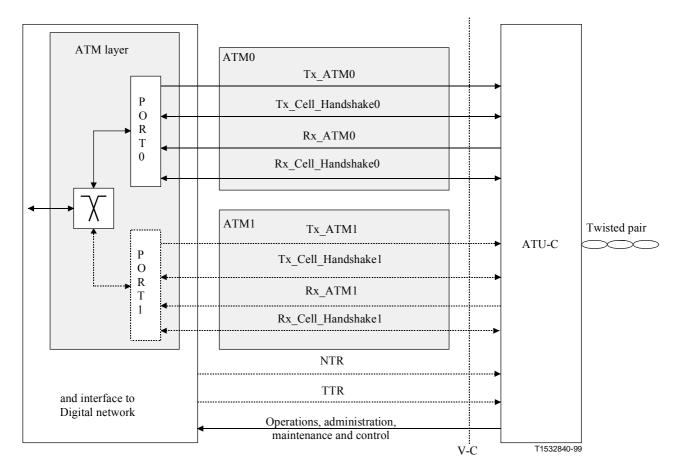
Q.4.1.2 Payload transfer delay (supplements 7.1.4)

Since Annex Q-EU uses a rate converter, the maximum payload transfer delay is longer than specified values in 7.1.4. The additional one-way transfer delay due to the rate converters shall be less than 1.7 ms for fast data and 13 ms for interleaved data.

Q.4.2 ATM transmission protocols specific functionalities (pertains to 7.2)

Q.4.2.1 ATU-C Input and Output V interface for ATM transport (replaces figure in 7.2.1)

See Figure Q.9.



NOTE - TTR can be generated in the ATU-C without being provided from the V-C reference point.

Figure Q.9/G.992.1 – ATU-C functional interfaces to the ATM layer at the V-C reference point

Q.4.2.2 Payload transfer delay (supplements 7.2.2)

Since Annex Q-EU uses a rate converter, the maximum payload transfer delay is longer than specified values in 7.2.2. The additional one-way transfer delay due to the rate converters shall be less than 1.7 ms for fast data and 13 ms for interleaved data.

Q.4.3 Framing (pertains to 7.4)

Q.4.3.1 Superframe structure (supplements 7.4.1.1)

Since the rate converter reorders the user data and overhead bit-level data to create hyperframes, the input data frames to the constellation encoder are different than those defined in 7.4.1.1.

Q.4.3.2 Hyperframe structure (replaces 7.4.1.3)

Annex Q-EU uses the hyperframe structure shown in Figure Q.10. Figure Q.10 shows the phase relationship between the TTR_C and the hyperframe at the point U-C. Each hyperframe is composed of 5 superframes, which are numbered from 0 to 4. In order to indicate the boundary of the hyperframe, the inverse synch symbol is used for the 4th superframe (SPF#3), which is generated from a tone-by-tone 180-degree phase reversal of the synchronization symbol (see Q.4.7.1) except for the pilot tone.

The bit-level data stream from the rate-converter is extracted according to the size of Bitmap- F_R and Bitmap- N_R using the Sliding Window (see Q.3.3.2).

In order to make the bit rate to be a multiple of 32 kbit/s, the dummy bits are inserted at the end of hyperframe by the

rate converter (see Q.4.4.2). The hyperframe is composed of 345 DMT symbols, numbered from 0 to 344. Each symbol is assigned as $FEXT_R$ or $NEXT_R$ or $NEXT_R$ or $NEXT_R$ duration (see Q.2), and the following numerical formula gives the information which duration N_{dmt}-th DMT symbol belongs to at ATU-C transmitter (see Figure Q.11).

 $\begin{array}{ll} \mbox{For $N_{dmt} = 0, 1, ..., 344$} \\ S = 272 \ x \ N_{dmt} \ mod \ 2760$} \\ if \ \{ \ (S + 271 < a) \ or \ (S > a + b) \ \} & then \ FEXT_R \ symbol \\ else & then \ NEXT_R \ symbol \\ where \ a = 1243, \ b = 1461 \\ \end{array}$

Thus, 128 DMT symbols are allocated in the FEXT_R duration, and 217 DMT symbols are allocated in the NEXT_R duration. The symbols are composed of:

FEXT _R symbol:	
Number of symbol using Bitmap-F _R	= 126
Number of synch symbol	= 1
Number of inverse synch symbol NEXT _R symbol:	= 1
Number of symbol using Bitmap-N _R	= 214
Number of synch symbol	= 3

During FEXT Bitmap mode, the ATU-C shall transmit only the pilot tone in NEXT_R symbols.

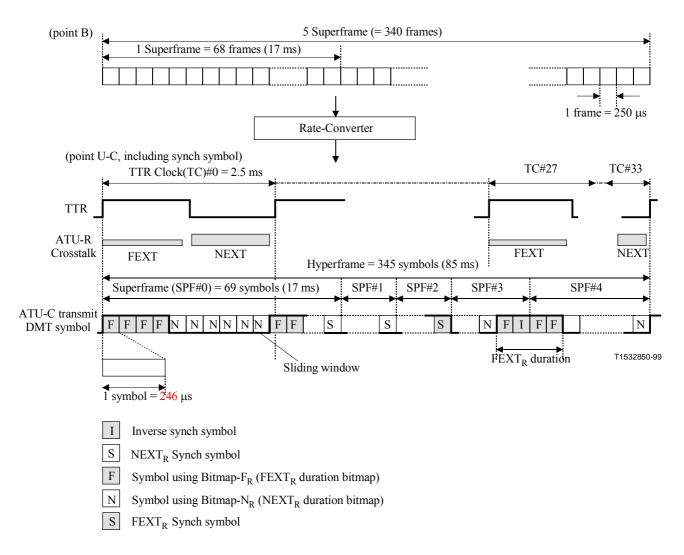


Figure Q.10/G.992.1 – Hyperframe structure for downstream

2									
0	0 1 2	3	4	5		6	7	8	9
1	10 11 12	13	14	15	16	5 17	7 18	3 1	9
2	20 21 22	23	24	25	26	27	28	29	
3	30 31 32	33 3	34	35	36	37	38	39	40
4	41 42	43 44	4	45	46	47	48	49	50
5	51 52 5	3 54		55	56	57	58	59	60
6	61 62 63	64	6	5 6	6	67	SS	69	70
7	71 72 73	74	75	76	7	7 7	8 7	9 8	30
8	81 82 83	84	85	86	87	88	89) 9()
9	91 92 93	94	95	96	97	98	99	100	101
10	101 102 103	104 10	05	106	107	108	109	110	111
11		14 11:		116	117	118	119	120	121
12	122 123 12				127	128	129	130	131
13	132 133 134	135	13						141
14	142 143 144	145	146						51
15	152 153 154	155	156		158				
16	162 163 164		166	167	168	169	170	171	172
17			76	177	178	179	180	181	182
18	183 184 1 193 194 19	85 180 5 196		187 97 1	188 98	189 199	190 200	191 201	192
19 20	203 204 205	5 196 SS	20		· · ·		· · ·		202
20	203 204 203 213 214 215	216	217	· · · ·		<u> </u>			212 22
21	213 214 213 223 224 225	226	227		229	·			
22	233 234 235		227	238	239	240	241	242	243
23		246 24		248	249	250	251	252	253
25		56 257		258	259	260	260	262	263
26	264 265 26					270	271	272	273
27	274 ISS 276	277	27		9 2	80 2	81 2	82 2	283
28	284 285 286	287	288	289	29	0 29	1 29	2 29)3
29	294 295 296	297	298	299	300	301	302	303	;
30	304 305 306	307 3	08	309	310	311	312	313	314
31	315 316 3	317 31	8	319	320	321	322	323	324
32	325 326 32	27 328	3	329	330	331	332	333	334
33	335 336 337	7 338	3	39 3	40	341	342	343	SS
	ISS Inverse synch sym	ibol S	SS F	EXT _r Sy	/nch syn	nbol SS	NEXT	Г _R synch	symbol
	FEXT _R data symbol	ol 🗌	N	IEXT _R da	ata symb	ol		T1	535330-00

Figure Q.11/G.992.1 – Symbol pattern in a hyperframe with cyclic prefix – Downstream

Q.4.3.3 Subframe Structure (replaces 7.4.1.4)

A subframe is 10 consecutive DMT symbols (except for synch symbols) as shown in Table Q.1. The 34 subframes form a hyperframe.

Subframe No.	DMT symbol No.	Note
0	0-9	
1	10-19	
2	20-29	
3	30-39	
4	40-49	
5	50-59	
6	60-70	#68 is Synch Symbol
7	71-80	
8	81-90	
9	91-100	
10	101-110	
11	111-120	
12	121-130	
13	131-141	#137 is Synch Symbol
14	142-151	
15	152-161	
16	162-171	
17	172-181	
18	182-191	
19	192-201	
20	202-212	#206 is Synch Symbol
21	213-222	
22	223-232	
23	233-242	
24	243-252	
25	253-262	
26	263-272	
27	273-283	#275 is Inverse Synch Symbol
28	284-293	
29	294-303	
30	304-313	
31	314-323	
32	324-333	
33	334-344	#344 is Synch Symbol

Table Q.1/G.992.1 – Subframe (downstream)

Q.4.3.4 Reduced overhead framing with merged fast and sync bytes (modifies 7.4.3.2)

In S=1/2n framing mode (see Q.4.9), there are n Sync bytes per symbol time. The contents of the Sync bytes is the same as in regular framing except that it repeats at n times the rate causing the superframe to be 68/n symbols in length. The contents of the sync bytes are shown in Table 7-6/G.992.1. In S=1/2n framing mode, "Frame Number" in column 1 in Table 7-6/G.992.1 is replaced by "Sync Byte Index Number".

As a result of the increase in superframe rate, the superframe contents is carried more frequently. For the case when N=2, the EOC and AOC bandwidth doubles, thereby transferring actual messages at twice the rate. The CRC byte is carried twice as frequently and therefore the maximum error rate rises from just over 58 per second to 117 per second. Where the duration of an error condition is measured, this needs to be taken into consideration. The indicator bits are also sent twice as often, which needs to be taken into consideration for statistics collection.

Q.4.4 Dual Bitmapping and Rate Conversion (replaces 7.15)

The functions of the rate converter (see Q.4.4.2), tone ordering (see Q.4.6), constellation encoding, and gain scaling shall use one of two bitmaps stored in the ATU. This method is called the dual bitmap.

Q.4.4.1 Dual Bitmap (new)

The Dual Bitmap method has individual bit rates under the FEXT and NEXT noise, and this needs an additional bit and gain table, $\{b_i, g_i\}$, and ordered bit table, b'_i , for the tone ordering. The dual bitmaps are switched synchronized with the sliding window pattern of NEXT/FEXT symbols. The number of bits and the relative gains to be used for every tone are calculated in the bit loading algorithm during the initialization sequence, and transmitted in R-B&G.

Q.4.4.2 Rate Converter (new)

The rate converter buffering changes the data frame boundaries between the reference points B and C according to Bitmap- F_R , Bitmap- N_R and the Sliding Window. Two independent rate converters are prepared for fast data and interleaved data. The amount of fast and interleaved data in Bitmap- F_R and Bitmap- N_R shall be calculated with the following formulae and illustrated in Figure Q.12:

If $t_{Rf} \le n_{Rmax}$:

$$n_{Rf} = t_{Rf}$$

$$n_{Ri} = n_R - n_{Rf}$$

$$f_{Rf} = t_{Rf}$$

$$f_{Ri} = f_R - f_{Rf}$$

If $t_{Rf} > n_{Rmax}$:

$$n_{Rf} = n_{R \max}$$

$$n_{Ri} = 0$$

$$f_{Rf} = \begin{cases} f_{Rf4} = \left\lceil \frac{t_{Rf} \times 10 - n_{Rf} \times 6}{4} \right\rceil$$

$$f_{Rf3} = \left\lceil \frac{t_{Rf} \times 10 - n_{Rf} \times 7}{3} \right\rceil$$

$$f_{Ri} = \begin{cases} f_{Ri4} = f_R = f_{Rf4} \\ f_{Ri3} = f_R - f_{Rf3} \end{cases}$$

Where:

^t Rf	is the number of allocated bits in one frame for fast bytes at the reference point B.
t _{Ri}	is the number of allocated bits for interleaved bytes at the reference point B.
f_{Rf} and n_{Rf}	are the numbers of fast bits in Bitmap- F_R and Bitmap- N_R , respectively.
f _{Rf3}	is the number of fast bits in Bitmap- F_R if the subframe (see Q.4.3.3) contains 3 Bitmap- F_R except
f _{Rf4}	for synch symbols. is the number of fast bits in Bitmap- F_R if the subframe contains 4 Bitmap- F_R except for synch
f _{Ri} and n _{Ri} ⁿ R	symbols. are the numbers of interleaved bits in Bitmap- F_R and Bitmap- N_R , respectively. is the number of total bits in Bitmap- N_R , which is specified in the B&G tables.

During FEXT Bitmap mode, n_{Rf} and n_{Ri} are zero.

To convert the bit rate to be a multiple of 32 kbit/s, the dummy bits for fast data are inserted to the tail of each subframe, and the dummy bits for interleaved data are inserted to the end of the Hyperframe. The number of the dummy bits shall be as follows:

If $t_{Rf} \le n_{Rmax}$:

$$dummy_{Rf} = 0$$

$$dummy_{Ri} = (f_{Ri} \times 126 + n_{Ri} \times 214) - t_{Ri} \times 340$$

If $t_{Rf} > n_{Rmax}$:

$$dummy_{Rf4} = (f_{Rf} \times 4 + n_{Rf} \times 6) - t_{Rf} \times 10$$

$$dummy_{Rf3} = (f_{Rf} \times 3 + n_{Rf} \times 7) - t_{Rf} \times 10$$

$$dummy_{Ri} = (f_{Ri4} \times 96 + f_{Ri3} \times 30) - t_{Ri} \times 340$$

If the fast data buffer uses single latency only, additional dummy bits are inserted at the tail of each FEXT symbol in the 4 Bitmap- F_R constructed subframe. The number of additional dummy bits inserted at the tail of each FEXT symbol shall be as follows:

$$dummy_{SRf} = f_{Rf3} - f_{Rf4}$$

The receiver shall determine Bitmap- F_R and Bitmap- N_R so that $dummy_{Ri}$ is less than 126, $dummy_{Rf4}$ is less than 4 and $dummy_{Rf3}$ is less than 3 in the initialization sequence. At the receiver, the inserted dummy bits shall be removed.

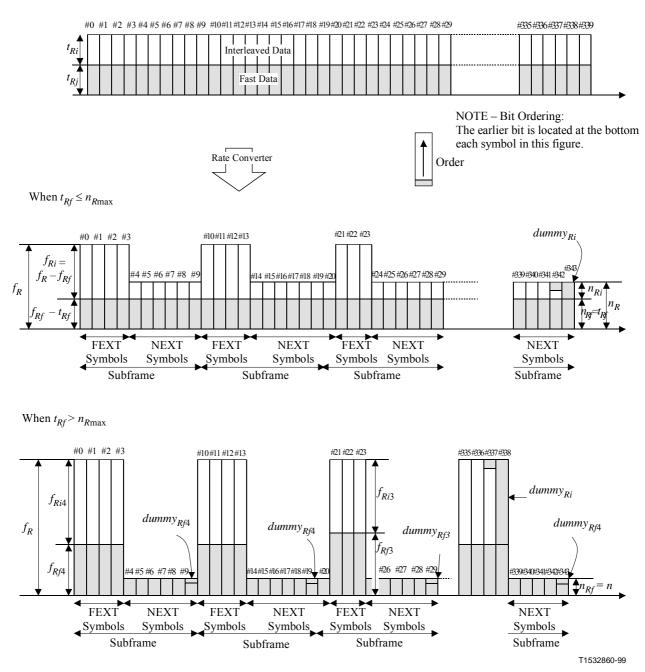


Figure Q.12/G.992.1 – Bit distribution for Rate Converter under Dual latency and Dual Bitmap mode

Q.4.5 FEXT Bitmapping (replaces 7.16)

The FEXT Bitmapping mode uses the Dual Bitmapping technique (Q.4.4) to transmit data only during FEXT. The ATU-C shall transmit only the pilot tone during the $NEXT_R$ symbol. The ATU-R disables Bitmap-N_C and shall not transmit any signal during the $NEXT_C$ symbol (see Figures Q.10 and Q.16).

Annex Q-EU does not support the FEXT Bitmapping mode.

Q.4.6 Tone Ordering (replacement for 7.7)

A DMT time-domain signal has a high peak-to-average ratio (its amplitude distribution is almost Gaussian), and large values may be clipped by the digital-to-analogue converter. The error signal caused by clipping can be considered as an additive negative impulse for the time sample that was clipped. The clipping error power is almost equally distributed across all tones in the symbol in which clipping occurs. Clipping is therefore most likely to cause errors on those tones

that, in anticipation of a higher received SNR, have been assigned the largest number of bits (and therefore have the densest constellations). These occasional errors can be reliably corrected by the FEC coding if the tones with the largest number of bits have been assigned to the interleave buffer.

The numbers of bits and the relative gains in two bitmaps to be used for every tone are calculated in ATU-R receiver, and sent back to ATU-C according to a defined protocol (see 10.9.14). The pairs of numbers are typically stored, in ascending order of frequency or tone numbers *i*, in bit and gain tables for Bitmap- F_R and Bitmap- N_R .

For Bitmap- F_R , the "tone-ordered" encoding shall first assign f_{Rf} bits from the rate converter (see Q.4.4.2) to the tones with the smallest number of bits assigned to them, and the remaining f_{Ri} bits to the remaining tones. For Bitmap- N_R , it shall first assign n_{Rf} bits from the rate converter to the tones with the smallest number of bits assigned to them, and the remaining n_{Ri} bits to the remaining tones.

All tones shall be encoded with the number of bits assigned to them; one tone in each bitmap may therefore have a mixture of bits from the fast and interleaved buffers.

The ordered bit tables b'_{iF} and b'_{iN} shall be based on the original bit tables b_{iF} and b_{iN} as follows:

For k = 0 to N_{downmax} {

From the bit table, find the set of all *i* with the number of bits per tone $b_i = k$

Assign b_i to the ordered bit allocation table in ascending order of i

```
}
```

Two ordered bit tables for Bitmap- F_R and Bitmap- N_R shall be prepared. A complementary de-ordering procedure should be performed in ATU-R receiver. It is not necessary, however, to send the results of the ordering process to the receiver because the bit tables F_R and N_R were originally generated in ATU-R, and therefore those tables have all the information necessary to perform the de-ordering.

Q.4.7 Modulation (pertains to 7.11)

Q.4.7.1 Inverse Synchronization Symbol (replaces 7.11.4)

Except for the pilot tone, Inverse Synchronization symbol shall be generated from a tone-by-tone 180 degree phase reversal of Synchronization symbol (i.e. + maps to -, and - maps to +, for each of the 4-QAM signal constellation).

Q.4.7.2 Data subcarriers (modifies 7.11.1.1)

The channel analysis signal defined in 10.6.6 allows for a maximum of NSCds-1 carriers (at frequencies $n\Delta f$, n = 1 to NSCds-1) to be used.

Q.4.7.3 Nyquist frequency (modifies 7.11.1.3)

The carrier at the Nyquist frequency (#NSCds) shall not be used for user data and shall be real valued; other possible uses are for further study.

Q.4.7.4 Modulation by the inverse discrete Fourier transform (replaces 7.11.2)

The modulating transform defines the relationship between the 2*NSCds real values x_n and the Z_i :

$$x_{n} = \sum_{i=0}^{2^{*}NSCds-1} \exp\left(\frac{j\pi ni}{NSCds}\right) Z_{i} \quad \text{for } n = 0 \text{ to } 2^{*}NSC-1$$
(7-21)

The value of NSCds shall be 1024 for this Annex. However, the highest used subcarrier index shall be limited to 869.

The constellation encoder and gain scaling generate only NSCds-1 complex values of Z_i . In order to generate real values of x_n , the input values (NSCds-1 complex values plus zero at DC and one real value for Nyquist if used) shall be augmented so that the vector Z has Hermitian symmetry. That is,

 $Z_i = \operatorname{conj} \left(Z'_{2*NSCds-i} \right) \quad \text{for } i = \operatorname{NSCds+1} \text{ to } 2*\operatorname{NSCds-1}$ (7-22)

Q.4.7.5 Synchronization symbol (modifies 7.11.3)

The synchronization symbol permits recovery of the frame boundary after micro-interruptions that might otherwise force retraining.

The data symbol rate, $f_{symb} = 4$ kHz, the carrier separation, $\Delta f = 4.3125$ kHz, and the IDFT size, N = 2*NSCds, are such that a cyclic prefix of 15.625%*NSCds samples could be used. That is, when NSCds = 256, there are 40 samples in the cyclic prefix.

$$(512+40) \times 4.0 = 512 \times 4.3125 = 2208 \tag{7-23}$$

The cyclic prefix shall, however, be shortened to 12.5%*NSCds samples, and a synchronization symbol (with a nominal length of NSCds*2.125 samples) is inserted after every 68 data symbols. That is,

$$(2 + 0.125)$$
*NSCds × 69 = $(2 + 0.15625)$ *NSCds × 68(7-24)

The data pattern used in the synchronization symbol shall be the pseudo-random sequence PRD, $(d_n, \text{ for } n = 1 \text{ to } 2*\text{NSCds})$ defined by:

$$d_n = 1$$
 for $n = 1$ to 9 (7-25)
 $d_n = d_{n-4} \oplus d_{n-9}$ for $n = 10$ to 2*NSCds (7-26)

The first pair of bits (d_1 and d_2) shall be used for the DC and Nyquist subcarriers (the power assigned to them is zero, so the bits are effectively ignored); the first and second bits of subsequent pairs are then used to define the X_i and Y_i for i = 1 to NSCds-1 as shown in Table 7-13.

The period of the PRD is only 511 bits, so d_{n+511} is equal to d_n . The d_1 - d_9 shall be re-initialized for each synchronization symbol, so each symbol uses the same data.

The two bits that modulate the pilot carrier, shall be overwritten by $\{0,0\}$: generating the $\{+,+\}$ constellation.

The minimum set of subcarriers to be used is the set used for data transmission (i.e. those for which $b_i > 0$); subcarriers for which $b_i = 0$ may be used at a reduced PSD as defined in transmit PSD paragraphs of Annexes A, B and C. The data modulated onto each subcarrier shall be as defined above; it shall not depend on which subcarriers are used.

Q.4.7.6 Cyclic prefix (replaces 7.12)

The last 12.5%*NSCds samples of the output of the IDFT (x_n for n = 2*NSCds-0.125*NSCds to 2*NSCds-1) shall be prepended to the block of 2*NSCds samples and read out to the digital-to-analogue converter (DAC) in sequence. For example, when NSCds=256, the subscripts, n, of the DAC samples in sequence are 480 ... 511, 0 ... 511.

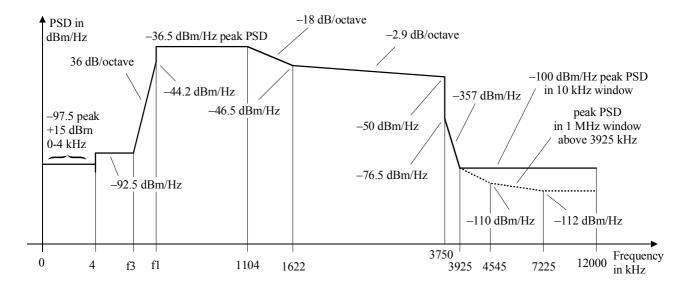
The cyclic prefix shall be used for all symbols beginning with the C-RATES1 segment of the initialization sequence, as defined in 10.6.2.

Q.4.8 ATU-C Downstream transmit spectral masks (replaces 7.14)

The downstream spectral masks of Annex Q-EU are as specified in this section. When C-MSG1 bit 16 is 0, the PSD mask as specified in § Q.4.8.1 shall be used. When C-MSG1 bit 16 is 1, the PSD mask as specified in § Q.4.8.2 shall be used.

Q.4.8.1 Downstream non-overlapped PSD mask definition

The non-overlapped PSD masks are defined with absolute peak values in Figure Q.13. The low frequency stop band is defined for frequencies below f1 kHz (tone n1); the high frequency stop band is defined at frequencies greater than 3750 kHz (tone 869). The in-band region of these PSD masks is the frequency band from f1 kHz to 3750 kHz.



Frequency band f (kHz)	Equation for line (dBm/Hz)
0 < f < 4	-97.5
4 < f < f3	-92.5
f3 < f < f1	$-92.5 + 36 \cdot \log 2(f/f3)$
f1 < f < 1104	-36.5
1104 < f < 1622	-36.5 - 18.0*log2(f/1104)
1622 < f < 3750	-46.5 - 2.9*log2(f/1622)
3750 < f < 3925	-76.5 - 357*log2(f/3750)
3925 < f < 12000	-100

Frequency (kHz)	PSD level (dBm/Hz)	Measurement BW
0	-97.5	100 Hz
4	-97.5	100 Hz
4	-92.5	100 Hz
f3	-92.5	10 kHz
fl	-44.2	10 kHz
fl	-36.5	10 kHz
1104	-36.5	10 kHz
1622	-46.5	10 kHz
3750	-50	10 kHz
3750	-76.5	10 kHz
3925 - 12000	-100	10 kHz

Additionally the PSD masks shall satisfy the following requirements:

Frequency (kHz)	PSD level (dBm/Hz)	Measurement BW
3925	-100	1 MHz
4545	-110	1 MHz
7225	-112	1 MHz
12000	-112	1 MHz

The corner frequencies f1 and f3 depend on the associated upstream PSD mask used, see §Q.5.6) and are defined as follows:

Mask designator (DS-mm)	Associated upstream mask	f1 (kHz)	f3 (kHz)
DS-32	EU-32	138	54.45
DS-36	EU-36	155.25	61.26
DS-40	EU-40	172.5	68.06
DS-44	EU-44	189.75	74.87
DS-48	EU-48	207	81.67
DS-52	EU-52	224.25	88.48
DS-56	EU-56	241.5	95.29
DS-60	EU-60	258.75	102.09
DS-64	EU-64	276	108.9

NOTE 1 – All PSD measurements are in 100 Ω ; the POTS band total power measurement is in 600 Ω .

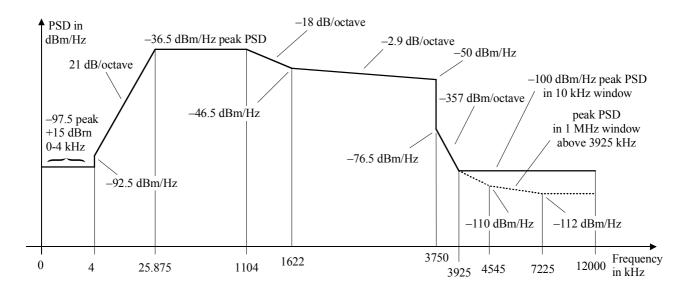
- NOTE 2 The breakpoint frequencies and PSD values are exact; the indicated slopes are approximate. The breakpoints in the tables shall be connected by linear straight lines on a dB/log(f) plot.
- NOTE 3 MBW specifies the Measurement Bandwidth. The MBW specified for a certain breakpoint with frequency fi is applicable for all frequencies satisfying fi< $f \le fj$, where fj is the frequency of the next specified breakpoint.
- NOTE 4 The power in a 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency i.e. power in the [f, f + 1 MHz] window shall conform to the specification at frequency f.
- 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.

Figure Q.13: Non-overlapped Downstream Channel PSD Masks

Spectral Shaping of the In-Band Region defined in Q.4.8.3 and Transmit Signals with Limited Transmit Power defined in Q.4.8.4 shall be applied.

Q.4.8.2 Downstream Overlapped PSD mask definition

The overlapped PSD mask is defined with absolute peak values in Figure Q.14. The low frequency stop band is defined for frequencies below 25.875 kHz (tone 6); the high frequency stop band is defined at frequencies greater than 3750 kHz (tone 869). The in-band region of this PSD mask is the frequency band from 25.875 kHz to 3750 kHz.



Frequency band f (kHz)	Equation for line (dBm/Hz)
0 < f < 4	-97.5
4 < f < 25.875	$-92.5 + 21*\log 2(f/4)$
25.875 < f < 1104	-36.5
1104 < f < 1622	-36.5 - 18.0*log2(f/1104)
1622 < f < 3750	-46.5 - 2.9*log2(f/1622)
3750 < f < 3925	-76.5 - 357*log2(f/3750)
3925 < f < 12000	-100

Frequency (kHz)	PSD level (dBm/Hz)	Measurement Bandwidth
0	-97.5	100 Hz
4	-97.5	100 Hz
4	-92.5	100 Hz
10	interpolated	10 kHz
25.875	-36.5	10 kHz
1104	-36.5	10 kHz
1622	-46.5	10 kHz
3750	-50.0	10 kHz
3750	-76.5	10 kHz
3925 - 12000	-100	10 kHz

Additionally, the PSD mask shall be satisfying following requirements:

Frequency (kHz)	PSD level (dBm/Hz)	Measurement Bandwidth
3925	-100	1 MHz
4545	-110	1 MHz
7225	-112	1 MHz
12000	-112	1 MHz

NOTE 1 –	All PSD measurements are in 100 Ω ; the POTS band total	power measurement is in 600 Ω .
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- NOTE 2 The breakpoint frequencies and PSD values are exact; the indicated slopes are approximate. The breakpoints in the tables shall be connected by linear straight lines on a dB/log(f) plot.
- NOTE 3 MBW specifies the Measurement Bandwidth. The MBW specified for a certain breakpoint with frequency fi is applicable for all frequencies satisfying $fi < f \le fj$, where fj is the frequency of the next specified breakpoint.
- NOTE 4 The power in a 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency i.e. power in the [f, f + 1 MHz] window shall conform to the specification at frequency f.
- 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.

Figure Q.14: Overlapped Downstream Channel PSD Mask.

Q.4.8.3 Spectral Shaping of the In-Band Region of the PSD Spectrum

In order to shape the ATU-C PSD, frequency dependent gains, called spectral shaping values (ssv_i), shall be applied on each tone during initialization and showtime. The ssv_i values shall be represented with 1 bit before and 10 bits after the decimal point.

Table Q.2 defines the corner points for the nominal PSD shape of the inband region as gain in dB, i.e log_ssv_i . Log_ssv_i on other tones shall be linearly interpolated between corner points on a logarithmic scale for the gain (dB) and a linear scale for the frequency (Hz). Note that the corner points defined in Table Q.2 are relative values. Table Q.3 defines the similar corner points for the overlapped spectrum.

The spectral shaping values shall be converted from logarithmic scale (log_ssv_i , dB values) to linear ssv_i values according to:

$$ssv_i = \frac{Round\left(1024 \times 10^{\frac{\log_s ssv_i}{20}}\right)}{1024}$$

These points are not passed at initialization for the nominal PSD shape but are provided here for reference. However, for additional spectral shaping (see Q.4.8.5), parameters are passed during G.994.1.

The combined accuracy of the process of linear interpolation of the log_ssvi values and the process of conversion to linear ssv_i values shall be strictly less than one half lsb of the 10 bit after the decimal point format of the linear ssvi values. No error shall be introduced when log_ssv_i equals 0dB or is interpolated between log_ssv_i values, which equal 0dB.

- NOTE 1: The above definition ensures that the maximum deviation between ssv_i values used by transmitter and receiver is one lsb.
- NOTE 2: The above needs an accuracy that is strictly < 1/2 lsb. An accuracy of = 1/2 lsb, will lead to inaccurate results.

Tone Index	$Log_ssv_i(dB)$	Comments	
nl	0	f1 kHz defines the beginning of the inband region. No shaping is applied in the	
		low stop band.	
256	0	1104 kHz	
376	-10	1622 kHz (-10 = -50 - Nominal PSD lowband)	
869	-13.5	3750 kHz (-13.5 = -53.5 - Nominal_PSD_lowband)	

Table Q.2: Corner points for the non-overlapped nominal in-band PSD shape.

Tone Index	$Log_ssv_i(dB)$	Comments	
6	0	25.875 kHz defines the beginning of the inband region. No shaping is applied	
		in the low stop band.	
256	0	1104 kHz	
376	-10	1622 kHz (-10 = -50 - Nominal PSD lowband)	
869	-13.5	3750 kHz (-13.5 = -53.5 - Nominal_PSD_lowband)	

Table Q.3: Corner points for the overlapped nominal in-band PSD shape

The absolute values of the transmit PSD are obtained by scaling the relative shaping values with a NOMINAL_PSD_lowband, defined for the lower in-band frequencies. Note that the nominal in-band transmit PSD is frequency dependent. The NOMINAL_PSD_lowband is -40 dBm/Hz (below 1104 kHz) for both the overlapped and non-overlapped spectra.

NOTE 3: In-band PSD spectral shaping is applied prior to the IFFT.

NOTE 4: The value of MAXNOMATPds may be limited by regional regulations.

Q.4.8.4 Transmit Signals with Limited Transmit Power

For cases where the transmit signal must be limited to a maximum aggregate transmit power (e.g. $ATP_{dsmax} = +20$ dBm), then

- b) During initialization the PSD transmit level is specified as an offset from the nominal value, i.e. (Nominal PSD_lowband + ssvi x power cutback) dB, and all values of gi = 1 for the offset value x and power cutback. The value of x shall be the greater of 0 dB and (21.1 ATPdsmax) dB for non-overlapped and (21.5 ATPdsmax) dB for overlapped. For ATPdsmax = 20 dBm, the corresponding value of x shall be 1.1 dB for non-overlapped and 1.5 dB for overlapped cases.
- b) If bi>0, then valid range for gi is [-14.5 to +2.5+x] (dB);
 If bi>0, then gi shall be in the [g_{sync} 2.5 to g_{sync} + 2.5] (dB) range;
 If bi=0, then gi shall be equal to 0 (linear) or in the [-14.5 to g_{sync}] (dB) range;
 For G.992.1 Annex Q-EU, g_{sync} <= x dB

The g_i values shall be constrainted by following relation:

Constraint on g _i values	$\sum_{i=32}^{2*NSCds-1} ssv_i^2 * g_i^2 \le \sum_{i=32}^{2*NSCds-1} ssv_i^2$
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Q.4.8.5 Additional inband spectral shaping

An ATU-R may request additional downstream inband spectral shaping by passing parameters to the ATU-C in a G.994.1 MP, or MS message. The ATU-C may select additional downstream inband spectral shaping by passing parameters to the ATU-R in a G.994.1 MS message. Within the framework of G.994.1, the ATU-C has the ability to make the final decision on the downstream inband PSD shape to be used.

The additional inband spectral shaping parameters are listed in Q.7.2.2 and defined in Q.7.3. If the Additional inband spectral shaping Spar(2) bit is set to ONE in Table Q.7.2, its associated Npar(3) octets in Tables Q.7.2.1 to Q.7.2.1.5 define the inband spectral shape. If the additional inband spectral shaping Spar(2) bit is set to ZERO, its associated Npar(3) octets are not transmitted and the nominal inband PSD shape defined in Q.4.8.3 shall be used. These Npar(3) octets define the downstream PSD levels in the low band (between f1 and 1104 kHz), at 1622 kHz and at 3750 kHz. The PSD levels between 1104 kHz and 1622 kHz, and between 1622 kHz and 3750 kHz are linearly interpolated in log scale. The defined values are the PSD level in dB below the NOMINAL_PSD_lowband of -40dBm/Hz. For example, if all three values are set to 20 dB, the result will be a flat PSD of -60dBm/Hz. If the three values are set to 2 dB, 12 dB and 15.5 dB, the result is the PSD defined in Q.4.8.1 reduced by 2dB. In order not to violate the PSD mask defined in Q.4.8.1, the second value shall be no less than 10 dB and the third value shall be no less than 13.5 dB.

Q.4.8.6 Egress control

G.992.1 Annex Q-EU equipment shall be able to reduce the PSD below -80 dBm/Hz for the Amateur radio bands between 1.81 MHz and 2.00 MHz, and between 3.5 MHz and 3.8 MHz. The ATU-C may apply additional spectral shaping as described in Q.4.8.5 to help achieve this requirement.

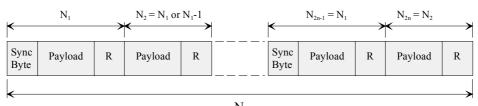
Q.4.9 Support of higher downstream bit rates with S = 1/2n (replaces 7.6.4)

With a rate of 4000 data frames per second and a maximum of 255 bytes (maximum RS codeword size) per data frame, the ADSL downstream line rate is limited to approximately 8 Mbit/s per latency path. The line rate limit can be increased beyond this for the interleaved path by mapping 2n RS codewords into one FEC data frame (i.e. by using S = 1/2n in the interleaved path). S = 1/2n shall be used in the downstream direction only over bearer channel AS0.

For a selected value of $n \ge 1$, the K_I data bytes per interleaved mux data frame shall be packed into 2n RS codewords, split into n equal parts, each consisting of 2 consecutive RS codewords. This forces rate adaptation to occur in 32n kbit/s increments. Each of the n parts of the data frame shall begin with a sync byte and shall obey the rules defined in Table Q.4 for insertion of dummy bytes. The smallest value of n that can support the K_I data bytes shall be used.

Support of S = 1/2 (i.e., n=1), S = 1/4 (i.e., n=2), S = 1/6 (i.e., n=3), and S = 1/8 (i.e., n=4), is mandatory.

The resulting data frame structure shall be as shown in Figure Q.15.



 N_{I} Figure Q.15 – Data frame for S = 1/2n mode

When K_I is divisible by 2n, the 2n codewords have the same length $N_{2i-1} = N_{2i} = (K_I/2n + R_I)$ for i = 1 to n, otherwise the odd numbered codewords are equal and are one byte longer than the even numbered codewords, i.e. $N_{2i-1} = (K_I + n)/2n + R_I$ bytes, and $N_{2i} = (K_I - n)/2n + R_I$ bytes for i = 1 to n. For the FEC output data frame, $N_I = \sum_{i=1}^{n} N_i$, with $N_I < 512n - 1$ bytes.

The convolutional interleaver requires all codewords to have the same odd length. To achieve the odd codeword length, insertion of dummy (not transmitted) bytes may be required. For S = 1/2n, the dummy byte addition to the odd numbered and/or even numbered codewords at the input of the interleaver shall be as in Table Q.4.

N _{2i-1}	N _{2i}	Dummy Byte Insertion Action
Odd	Odd	No action
Even	Even	Add one dummy byte at the beginning of all codewords
Odd	Even	Add one dummy byte at the beginning of each even numbered codeword
Even	Odd	Add one dummy byte at the beginning of each odd numbered codeword and two dummy bytes at the beginning of each even numbered codeword [the de-interleaver shall insert one dummy byte into the de-interleaver matrix on the first byte and the $(D + 1)$ th byte of the corresponding codeword to make the addressing work properly]

Table Q.4/G.992.1 –Dummy byte insertion at interleaver input for S = 1/2n

Q.5 ATU-R Functional Characteristics (pertains to clause 8)

Q.5.1 Framing (pertains to 8.4)

Q.5.1.1 Superframe structure (replaces 8.4.1.1)

The superframe structure of ATU-R transmitter is identical to that of ATU-C transmitter, as specified in Q.4.3.1.

Q.5.1.2 Hyperframe structure (replaces 8.4.1.3)

The hyperframe structure of ATU-R transmitter is functionally similar to that of ATU-C transmitter, except that the inverse synch symbol is used in the 1st superframe (SPF#0) (see Figure Q.16). The hyperframe is composed of 345 DMT symbols, numbered from 0 to 344. Each symbol is under $FEXT_C$ or $NEXT_C$ duration (see Q.5.3), and the following numerical formula gives the information which duration N_{dmt}-th DMT symbol belongs to at ATU-R transmitter (see Figure Q.17).

128 DMT symbols are allocated in the FEXT_{C} duration, and 217 DMT symbols are allocated in the NEXT_{C} duration. The symbols are composed of:

FEXT _C symbol:	
Number of symbol using Bitmap- F_{C}	= 126
Number of synch symbol	= 1
Number of inverse synch symbol	= 1
NEXT _C symbol:	
Number of symbol using Bitmap-N _C	= 214
Number of synch symbol	= 3

During FEXT Bitmapping mode, the ATU-R shall not transmit any signal.

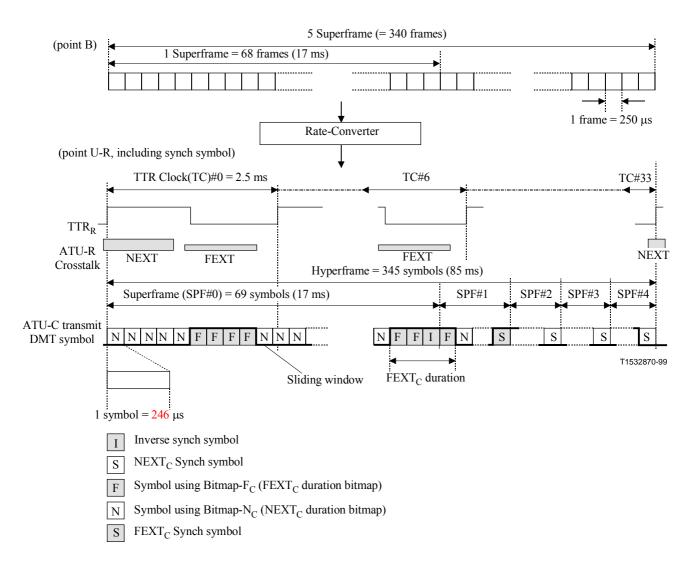


Figure Q.16/G.992.1 – Hyperframe structure for upstream

ттр	
TTR _R	
0	0 1 2 3 4 5 6 7 8 9
1	10 11 12 13 14 15 16 17 18 19
2	20 21 22 23 24 25 26 27 28 29
3	30 31 32 33 34 35 36 37 38 39 40
4	41 42 43 44 45 46 47 48 49 50
5	51 52 53 54 55 56 57 58 59 60
6	61 62 63 64 65 66 67 ISS 69 70
7	71 72 73 74 75 76 77 78 79 80
8	81 82 83 84 85 86 87 88 89 90
9	91 92 93 94 95 96 97 98 99 100 101
10	101 102 103 104 105 106 107 108 109 110 111
11	112 113 114 115 116 117 118 119 120 121
12	122 123 124 125 126 127 128 129 130 131
13	132 133 134 135 136 SS 138 139 140 141
14	142 143 144 145 146 147 148 149 150 151
15	152 153 154 155 156 157 158 159 160 161
16	162 163 164 165 166 167 168 169 170 171 172
17	173 174 175 176 77 178 179 180 181 82
18	183 184 185 186 187 188 189 190 191 92
19	193 194 195 196 197 198 199 200 201 202
20	203 204 205 <i>SS</i> 207 208 209 210 211 212
21	213 214 215 216 217 218 219 220 221 222
22	223 224 225 226 227 228 229 230 231 232
23	233 234 235 236 237 238 239 240 241 242 243
24	244 245 246 247 248 249 250 251 252 253
25	254 255 256 257 258 259 260 260 262 263
26	264 265 266 267 268 269 270 271 272 273
27	274 SS 276 277 278 279 280 281 282 283
28	284 285 286 287 288 289 290 291 292 293
29	294 295 296 297 298 299 300 301 302 303
30	<u>304</u> 305 306 307 308 <u>309</u> 310 311 312 313 <u>3</u> 14
31	315 316 317 318 319 320 321 322 323 324
32	325 326 327 328 329 330 331 332 333 334
33	335 336 337 338 339 340 341 342 343 S5
	ISS Inverse synch symbol SS FEXT _R Synch symbol SS NEXT _R synch symbol
	FEXT _R data symbol NEXT _R data symbol T1535340-00

Figure Q.17/G.992.1 – Symbol pattern in a hyperframe with cyclic prefix – Upstream

Q.5.1.3 Subframe structure (replaces 8.4.1.4)

A subframe is 10 consecutive DMT symbols (except for synch symbols) as shown in Table Q.5. The 34 subframes form a hyperframe.

Subframe No.	DMT symbol No.	Note
0	0-9	
1	10-19	
2	20-29	
3	30-39	
4	40-49	
5	50-59	
6	60-70	#68 is Inverse Synch Symbol
7	71-80	
8	81-90	
9	91-100	
10	101-110	
11	111-120	
12	121-130	
13	131-141	#137 is Synch Symbol
14	142-151	
15	152-161	
16	162-171	
17	172-181	
18	182-191	
19	192-201	
20	202-212	#206 is Synch Symbol
21	213-222	
22	223-232	
23	233-242	
24	243-252	
25	253-262	
26	263-272	
27	273-283	#275 is Synch Symbol
28	284-293	
29	294-303	
30	304-313	
31	314-323	
32	324-333	
33	334-344	#344 is Synch Symbol

Table Q.5/G.992.1 – Subframe (upstream)

Q.5.2 Dual Bitmapping and rate conversion (replaces 8.15)

The function of the rate converter (see Q.5.2.2), tone ordering (see Q.5.4), constellation encoding, and gain scaling shall use one of two bitmaps stored in the ATU. This method is called the dual bitmap.

Q.5.2.1 Dual Bitmap (new)

The Dual Bitmap switching shall be the same as for the downstream data, specified in Q.4.4.1. The number of bits and the relative gains to be used for every tone are calculated in the bit loading algorithm during the initialization sequence, and transmitted in C-B&G.

Q.5.2.2 Rate Converter (new)

The rate converter buffering changes the data frame boundaries between the reference points B and C according to Bitmap- F_C , Bitmap- N_C and the Sliding Window. Two independent rate converters are prepared for fast data and interleaved data. The amounts of fast and interleaved data in Bitmap- F_C and Bitmap- N_C shall be calculated in the following formulae:

If $t_{Cf} \le n_{Cmax}$:

$$n_{Cf} = t_{Cf}$$
$$n_{Ci} = n_C - n_{Cf}$$
$$f_{Cf} = t_{Cf}$$
$$f_{Ci} = f_C - f_{Cf}$$

If $t_{Cf} > n_{Cmax}$:

$$n_{Cf} = n_{C \max}$$

$$n_{Ci} = 0$$

$$f_{Cf4} = \left[\frac{t_{Cf} \times 10 - n_{Cf} \times 6}{4}\right]$$

$$f_{Cf3} = \left[\frac{t_{Cf} \times 10 - n_{Cf} \times 7}{3}\right]$$

$$f_{Ci} = \begin{cases} f_{Ci4} = f_C - f_{C4} \\ f_{Ci3} = f_C - f_{Cf3} \end{cases}$$

Where:

^t Cf	is the number of allocated bits in one frame for fast bytes at the reference point B.
^t Ci	is the number of allocated bits for interleaved bytes at the reference point B.
f_{Cf} and n_{Cf}	are the numbers of fast bits in Bitmap- F_C and Bitmap- N_C , respectively.
fCf3	is the number of fast bits in Bitmap-F _C if the subframe (see Q.5.1.3) contains 3 Bitmap-F _C except
f _{Cf4}	for synch symbols. is the number of fast bits in Bitmap- F_C if the subframe contains 4 Bitmap- F_C except for synch
f_{Ci} and n_{Ci}	symbols. are the numbers of interleaved bits in Bitmap-F _C and Bitmap-N _C , respectively.
ⁿ C	is the number of total bits in Bitmap-N _C , which is specified in the B&G tables.
· · · · · · · · · · · ·	

During FEXT Bitmap mode, n_{Cf} and n_{Ci} are zero.

To convert the bit rate to be a multiple of 32 kbit/s, the dummy bits for fast data are inserted to the tail of each subframe, and the dummy bits for interleaved data are inserted to the end of the Hyperframe. The number of the dummy bits shall be as follows:

If $t_{Cf} \le n_{Cmax}$:

$$dummy_{Cf} = 0$$
$$dummy_{Ci} = (f_{Ci} \times 126 + n_{Ci} \times 214) - t_{Ci} \times 340$$

If $t_{Cf} > n_{Cmax}$:

$$dummy_{Cf 4} = (f_{Cf} \times 4 + n_{Cf} \times 6) - t_{Cf} \times 10$$

$$dummy_{Cf 3} = (f_{Cf} \times 3 + n_{Cf} \times 7) - t_{Cf} \times 10$$

$$dummy_{Ci} = (f_{Ci4} \times 96 + f_{Ci3} \times 30) - t_{Ci} \times 340$$

If the fast data buffer uses single latency only, additional dummy bits are inserted at the tail of each FEXT symbol in the 4 Bitmap- F_C constructed subframe. The number of additional dummy bits inserted at the tail of each FEXT symbol shall be as follows:

$$dummy_{SCf} = f_{Cf3} - f_{Cf4}$$

The receiver shall determine Bitmap-F_C and Bitmap-N_C so that $dummy_{Ci}$ is less than 126, $dummy_{Cf4}$ is less than 4 and $dummy_{Cf3}$ is less than 3 in the initialization sequence. At the receiver, the inserted dummy bits shall be removed.

Q.5.3 FEXT Bitmapping (replaces 8.16)

The FEXT Bitmapping mode uses the Dual Bitmapping technique (Q.4.4) to transmit data only during FEXT. The ATU-C shall transmit only the pilot tone during the NEXT_R symbol. The ATU-R disables Bitmap-N_C and shall not transmit any signal during the NEXT_C symbol (see Figures Q.10 and Q.16).

Annex Q-EU does not support the FEXT Bitmapping mode.

Q.5.4 Tone Ordering (pertains to 8.7)

The tone ordering algorithm shall be the same as for the downstream data, specified in Q.4.4.

For Bitmap-F_C, the "tone-ordered" encoding shall first assign f_{Cf} bits from the rate converter (see Q.5.2.2) to the tones with the smallest number of bits assigned to them, and the remaining f_{Ci} bits to the remaining tones. For Bitmap-N_C, it shall first assign n_{Cf} bits from the rate converter to the tones with the smallest number of bits assigned to them, and the remaining n_{Ci} bits to the remaining tones. Two ordered bit tables for Bitmap-F_C and Bitmap-N_C shall be prepared.

Q.5.5 Modulation (pertains to 8.11)

Q.5.5.1 Inverse synchronization symbol (replaces 8.11.4)

Inverse Synchronization symbol shall be generated from a tone-by-tone 180 degree phase reversal of Synchronization symbol (i.e. + maps to -, and - maps to +, for each of the 4-QAM signal constellation).

Q.5.5.2 Gain scaling in synchronization symbol (new)

At initialization time, the sync symbol reference transmit PSD level shall be set at the nominal PSD level +10log(g_{sync}^2) dBm/Hz, with g_{sync}^2 defined as the average g_i^2 value over the used (i.e. $b_i > 0$) subcarriers in the NEXT or FEXT bitmap, whichever results in the highest average gain. The sync symbol reference transmit PSD shall not be updated with used subcarrier gain changes during SHOWTIME.

I.5.5.3 Nyquist frequency (supplements 8.11.1.2)

The upstream Nyquist frequency for Annex Q-EU shall be at subcarrier NSCus (f = 4.3125*NSCus kHz).

I.5.5.4 Modulation by the inverse discrete Fourier transform (supplements 8.11.2)

For Annex Q-EU, see A.2.1.

I.5.5.5 Synchronization symbol (supplements 8.11.3)

For Annex Q-EU, see A.2.2.

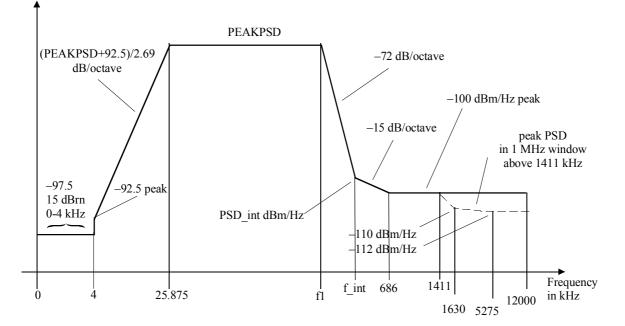
Q.5.6 ATU-R Upstream Transmit Spectral Mask (replaces 8.14)

The upstream PSD masks of Annex Q-EU are defined with absolute peak values in Figure Q.18. The low frequency stop band is defined for frequencies below 25.875 kHz; the high frequency stop band is defined at frequencies greater than f1 kHz (tone n1). The in-band region of these PSD masks is the frequency band from 25.875 kHz to f1 kHz.

ATU-x may optionally support upstream masks EU-36 to EU-64 specified in Figure Q.18

NOTE: The value of MAXNOMATPus may be limited by regional regulations.





Frequency band f (kHz)	Equation for line (dBm/Hz)
0 < f < 4	-97.5
4 < f < 25.875	-92.5+(PEAKPSD+92.5)* log ₂ (f/4)/log ₂ (25.875/4)
25.875 < f < f1	PEAKPSD
f1< f< f_int	$PEAKPSD-72*log_2(f/f1)$
f_int < f < 686	PSD_int-15*log2(f/f_int)
f > 686	-100

Frequency (kHz)	PSD level (dBm/Hz)	Measurement BW
0	-97.5	100 Hz
4	-97.5	100 Hz
4	-92.5	100 Hz
25.875	PEAKPSD	10 kHz
f1	PEAKPSD	10 kHz
f_int	PSD_int	10 kHz
686 - 12000	-100	10 kHz

Additionally the PSD masks shall satisfy the following requirements:

Frequency (kHz)	PSD level (dBm/Hz)	Measurement BW
1411	-100	1 MHz
1630	-110	1 MHz
5275	-112	1 MHz
12000	-112	1 MHz

NSCus is a function of the upstream mask parameters, which are defined as follows:

D / ·	DDVD1 1	C 1 1	1 /1 1 1	c 1 0	
Parameters in	FEXI bitmap	for mode 1.	both bitmaps	s for mode 2	$(see \ (Q. 7.3))$:

Designator (EU-nn)	NSCus	Template Nominal PSD P ₀ (dBm/Hz)	Template Maximum Aggregate Transmit Power (dBm)	PEAKPSD (dBm/Hz)	Frequency f1 (kHz)	Intercept Frequency f_int (kHz)	Intercept PSD Level PSD_int (dBm/Hz)
EU-32	32	-38.0	12.5	-34.5	138.00	242.92	-93.2
EU-36	64	-38.5	12.5	-35.0	155.25	274.03	-94.0
EU-40	64	-39.0	12.5	-35.5	172.50	305.06	-94.7
EU-44	64	-39.4	12.5	-35.9	189.75	336.33	-95.4
EU-48	64	-39.8	12.5	-36.3	207.00	367.54	-95.9
EU-52	64	-40.1	12.5	-36.6	224.25	399.07	-96.5
EU-56	64	-40.4	12.5	-36.9	241.50	430.58	-97.0
EU-60	64	-40.7	12.5	-37.2	258.75	462.04	-97.4
EU-64	64	-41.0	12.5	-37.5	276.00	493.45	-97.9

Parameters in NEXT bitmap for mode 1 (see §Q.7.3):

Designator (EU-nn)	NSCus	Template Nominal PSD P ₀ (dBm/Hz)	Template Maximum Aggregate Transmit Power (dBm)	PEAKPSD (dBm/Hz)	Frequency f1 (kHz)	Intercept Frequency f_int (kHz)	Intercept PSD Level PSD_int (dBm/Hz)
EU-32	32	-38.0	12.5	-34.5	138.00	242.92	-93.2
EU-36	64	-38.7	12.5	-35.2	155.25	273.47	-94.0
EU-40	64	-39.9	12.5	-36.4	172.50	302.26	-94.7
EU-44	64	-40.7	12.5	-37.2	189.75	331.87	-95.3
EU-48	64	-41.4	12.5	-37.9	207.00	361.55	-95.8
EU-52	64	-41.8	12.5	-38.3	224.25	392.16	-96.4
EU-56	64	-42.1	12.5	-38.6	241.50	423.12	-96.9
EU-60	64	-42.3	12.5	-38.8	258.75	454.51	-97.3
EU-64	64	-42.3	12.5	-38.8	276.00	486.91	-97.8

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. The breakpoints in the tables shall be connected by linear straight lines on a dB/log(f) plot.

NOTE 3 – MBW specifies the Measurement Bandwidth. The MBW specified for a certain breakpoint with frequency fi is applicable for all frequencies satisfying fi< $f \le fj$, where fj is the frequency of the next specified breakpoint.

NOTE 4 – The power in a 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency i.e. power in the [f, f + 1 MHz] window shall conform to the specification at frequency f.

NOTE 5 – The step in the PSD mask at 4 kHz is to protect V.90 performance. Originally, the PSD mask continued the 21.5 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-R interface (see Figures Q.3 & Q.4).

Figure Q.18: Upstream Channel PSD Masks

Q.5.7 Forward error correction (supplements 8.6)

The minimum FEC coding capabilities (Table 8-3) for an ATU-R shall include the following interleave depths for the interleaved buffer:

D = 1, 2, 4, 8, and 16

Q.5.8 Cyclic prefix (supplements 8.12)

For Annex Q-EU, see A.2.3.

Q.6 EOC Operation and Maintenance (pertains to clause 9)

Q.6.1 ADSL line related primitives (supplements 9.3.1)

Q.6.1.1 ADSL line related near-end defects (supplements 9.3.1.3)

Two near-end defects are further defined:

- *Loss-of-signal (LOS)*: The ADSL power shall be measured only in the FEXT_C duration at ATU-C, or only in the FEXT_R duration at ATU-R.
- Severely errored frame (SEF): A SEF defect occurs when the content of two consecutively received ADSL synchronization symbols in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-R, does not correlate with the expected content over a subset of the tones. An SEF defect terminates when the content of two consecutively received ADSL synchronization symbols in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-C, or in the FEXT_R duration at ATU-R, does not consecutively received ADSL synchronization symbols in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-R, correlate with the expected contents over the same subset. The correlation method, the selected subset of tones, and the threshold for declaring these defect conditions are implementation discretionary.

Q.6.1.2 ADSL line related far-end defects (supplements 9.3.1.4)

Loss-of-signal is further defined:

• *Loss-of-signal (LOS)*: The ADSL power shall be measured only in the FEXT_C duration at ATU-C, or only in the FEXT_R duration at ATU-R.

Q.6.2 Test Parameters (supplements 9.5)

Q.6.2.1 Near-end test parameters (supplements 9.5.1)

The near-end primitives are further defined:

- *Attenuation (ATN)*: The received signal power shall be measured only in the FEXT_C duration at ATU-C, or only in the FEXT_R duration at ATU-R.
- Signal-to-Noise ratio (SNR) margin: During FEXT Bitmap mode, this primitive represents the snr margin in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-R.

Q.6.2.2 Far-end test parameters (supplements 9.5.2)

The far-end primitives are further defined:

- *Attenuation (ATN)*: The received signal power shall be measured only in the FEXT_C duration at ATU-C, or only in the FEXT_R duration at ATU-R.
- *Signal-to-Noise ratio SNR margin*: During FEXT Bitmap mode, this primitive represents the snr margin in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-R.

Q.6.3 Data registers in the ATU-R (supplements 9.2.4)

For the S=1/2n framing mode (see §Q.4.9), the downstream RS_I shall be the number of parity bytes per sync byte, i.e., $RS_I = R_I/(n^*S)$.

Q.7 Initialization (pertains to clause 10)

Q.7.1 Initialization with Hyperframe (replaces 10.1.5)

The exchange of messages between ATU-C and ATU-R should be performed in FEXT_{C} and FEXT_{R} . The DMT symbol has two symbol rates: one is 4.3125 kbaud for the symbol without a cyclic prefix, and the other is 4 x 69/68 kbaud for the symbol with a cyclic prefix. 32 times of the TTR has the same period as 345 times of the 4.3125 kbaud, and 34 times of the TTR is the same as 345 times of 4 x 69/68 kHz.

During FEXT Bitmap mode, the ATU-R shall not transmit any signal during the NEXT_C symbols duration and the ATU-C shall transmit only the pilot tone as the NEXT_R signal except:

- C-PILOT1 (C-PILOT1A) which is accompanied by a signal to allow the ATU-C to indicate the phase of TTR_C to the ATU-R (see Q.7.4.1);
- C-QUIETn where no signal is transmitted.

The ATU-C begins transmitting C-PILOT1 at the beginning of the hyperframe without cyclic prefix. The ATU-C informs the phase of the TTR_C to ATU-R during C-PILOT1. The ATU-R begins transmitting R-REVERB1 at the beginning of the hyperframe without cyclic prefix. The ATU-R performs the training of any receiver equalizer using this phase information of the TTR_R generated from received TTR_C.

From C-PILOT1 to C-SEGUE1, the following numerical formula gives the information which duration N_{dmt}-th DMT symbol belongs to at ATU-R (see Figure Q.19).

then FEXT_R symbols

then NEXT_R symbols

For $N_{dmt} = 0, 1, \dots 344$ $S = 256 \times N_{dmt} \mod 2760$ if { (S + 255 < a) or (S > a + b) } else where a = 1243, b = 1461

In order to enter C-RATES1 at the beginning of the hyperframe with cyclic prefix, the number of symbols from C-PILOT1 to C-SEGUE1 shall be a multiple of 345 DMT symbols.

From R-REVERB1 to R-SEGUE1, the following numerical formula gives the information which duration N_{dmt}-th symbol belongs to at ATU-C (see Figure Q.20).

For $N_{dmt} = 0, 1, ..., 344$, $S = 256 \times N_{dmt} \mod 2760$ if { (S > a) and (S + 255 < a + b) } then FEXT_C symbols else then NEXT_C symbols where a = 1315, b = 1293

From C-RATES1 to C-SEGUE3, the number of symbols is a multiple of 345 DMT symbols. The following numerical formula gives the information which duration N_{dmt} -th DMT symbol belongs to. ATU-C transmits the message data in FEXT_R symbols (see Figure Q.11).

For N _{dmt} = 0, 1,, 344	
$S = 272 \times N_{dmt} \mod 2760$	
if { (S + 271 \ge a) and (S \le a + b) }	then NEXT _R symbols
else	then FEXT _R symbols
where $a = 1243$, $b = 1461$	

The ATU-R enters R-REVERB3 at the beginning of the hyperframe with cyclic prefix, which is extracted from received signal. From R-REVERB3 to R-SEGUE5, the number of symbols is a multiple of 345 DMT symbols. The following numerical formula gives the information which duration N_{dmt} -th DMT symbol belongs to. ATU-R transmits the message data in FEXT_C symbols (see Figure Q.17).

For $N_{dmt} = 0, 1,, 344$
$S = 272 \text{ x N}_{dmt} \mod 2760$
if $\{ (S > a) and (S + 271 < a + b) \}$
else
where a = 1315, b = 1293

then $\ensuremath{\mathsf{FEXT}}_C$ symbols then $\ensuremath{\mathsf{NEXT}}_C$ symbols

TTR _C											
0	0 1	2	3	4	5		6	7	8	9	10
1			14	4		6	17	18	0		21
2		23 24	25	13		27	28	29		$\frac{20}{30}$	
3	32 33	34 35	36		37	38	3		10	41	42
4	43 44			47	48	49		50	51	52	53
5	54 55	56	57	58	59		60	61	62	63	64
6	65 6	6 67	68	69		70	71	72	7	3 74	
7	75 76	77 78	79		30	81	82	83	3	84 8	35
8	86 87	88 89) 9	0	91	92	9	03	94	95	96
9	97 98	99 1	.00	101	102	10)3	104	105	106	107
10	108 109		111	112	11	3	114	115	116		118
11		20 121	122	12		124	125	126		27 12	
12	129 130	131 132	133		134	135	13		37		139
13	140 141			44	145	140		47	148	149	150
14	151 152		154	155	156		57	158	159	160	161
15	162 16		165	166		67	168	169	17		
16		174 175	176	- L	77	178	179				82
17	183 184	185 18			188	189	19		.91	192	193 204
18 19	194 195 205 206	196 1 207	97 208	198 209	199 21	$\frac{20}{0}$	211	201	202	203	204
20	203 200		208	209		221	222	212		24 22	
20	226 227	228 229	219		231	232	222		34		236
21	237 238	239 24		41	242	243			245	235	247
22	248 249		251	252	253		54	255	256	257	258
24	259 260		262	263	20		265	266	26		269
25	270 2	71 272	273	2	74	275	276	27			79
26	280 281	282 283	3 28	4	285	286	28	37 2	88	289	290
27	291 292	293 2	94 2	295	296	29	7	298	299	300	301
28	302 303	304	305	306	30	7 3	308	309	310	311	312
29	313 31	4 315	316	31	7 3	18	319	320	32	21 322	2
30	323 324	325 326	327	3	28	329	330) 33	1	332 3	33
31	334 335	336 33	7 33	38	339	340	3	41	342	343	344
		symbol ₃ symbol								T1	535350-0

Figure Q.19/G.992.1 – Symbol pattern in a hyperframe without cyclic prefix – Downstream

_	-	-	
Ľ	Ľ	υ.	
1	1.	IV.	D
-	•	••	к

ſ																				
R										Ľ		_								
0	0		1	2		3		4		5	5	6		1		8	8		9	10
1	11		12		13		14		15		16		17		18		19		20	21
2		22	23		24		25		26	<u>i </u>	27		28		29		3		3	<u> </u>
3	32	33		34	13	35	3		13	7		38		39	1	40	┶	41		42
4	43	44		45		46		47		48		49		50		51		52		53
5	54		55	5	6	5′		5			59		50		51		62		63	64
6	6		66		67	Ļ	68	╧	69		70		71		72		73		74	
7	75	76	7		78		79		80	<u>i</u>	8		8		<u> </u>	3	1	34	1	5
8	86	87		88	_	89) 0	_	91		92		93		94		95		96
9	97	9		99		100		101		10		10		10		10		10		107
10	108		109		10		11		12	<u>.</u>	13		114		115		116		117	118
11		19	12		121		122		123	<u>. </u>	12		125		12	-	12			8
12	129	130		31 142	1.	32	13		13	-		35	_	36	_	.37		149		39
13	140	141	52	142	2	143 154		144 15		145 15		146	57	147	58	148	, 59	-	9 60	150 161
14 15	131		32 163		5 164		+ 65	_	5 166	1.	167	1.	168		58 169		39 170	<u> </u>	171	172
16		173	1	74	104		176	_	17	ļ	107	78	108	/0	-	80	_	81		82
17	183	184	1	185	_	86	-	, 87		88		189		9 190		30 191		192		⁵² 193
18	194	19		196	<u> </u>	197	_	198		199		20		$\frac{1}{20}$		20	2	20)3	204
19	205		206		07	20)9		10	_	<u> </u>	-	212	_	- 213	_	214	215
20		16	217		218		219		220		221		222	_	22		22		22	_ <u>_</u>
21	226	227		28	-	29	23		23		2	32	2	33	2	234	_	235		236
22	239	238		239		240	2	241		242	Т	243	╧	244	╧	245	╧┱	246		247
23	248	2	49	25	0	25	1	25	2	25	53	25	54	25	55	2:	56	2	57	258
24	25	9	260	2	261	2	62	2	263		264	Т	265	<u> </u>	266		267		268	269
25	1 2	270	27	1	272	2	273	┺	274		27	5	27	6	27	7	27	78	27	79
26	280	281		282	2	83	28	84	2	85		286		287	T	288	Τ	289		290
27	291	29	2	293		294		295		296	5	297	7	298	3	29	9	30	0	301
28	302		303	30	04	30)5	30)6	3	07	3	808		09	3	310		311	312
29	31	3	314		315		316		317		318		319		320		321		322	2
30	323	324	32	25	32	6	327	7	32	8	32	29	33	30	3	31	3	32		33
31	334	335		336		337	3	38		339		340		341		342		343	;	344
		-	C	symbo symbo						•									T1	535360-0

Figure Q.20/G.992.1 – Symbol pattern in a hyperframe without cyclic prefix – Upstream

Q.7.2 Handshake – Non-standard information block (new)

This section defines the format of the G.994.1 non-standard information block to support Annex Q-EU, and tabulates the parameters used by Annex Q-EU. The use of these parameters is described in §Q.7.3 and §Q.7.4.

Q.7.2.1 Non-standard information block format (new)

Figure Q.21 defines the format of the non-standard information block.

8	7	6	5	4	3	2	1
		Non-stan		nation length ctet)	= M + 6		
				ntry code see Note 1)			
		Provid		ndor identifi see Note 2)	cation)		
		Ve		fic informati – Note 3)	on		

NOTE 1 – The value of this field shall be B5 00, the country code for USA

NOTE 2 – The value of this field shall be 43 45 4E 54, ASCII "CENT" for Centillium Communications

NOTE 3 – These octets are defined in Q.7.2.2. Formatting of these octets shall comply with the parsing rules defined in G.994.1 9.2.1 to 9.2.3

Figure Q.21 – Non-standard information block format

Q.7.2.2 Non-standard information block parameters (new)

The G.994.1 non-standard parameters for Annex Q-EU are listed in Tables Q.6 to Q.7.2.1.2.5 below.

In order to minimize message length, the parameters for additional inband spectral shaping (Spar(2) octet and its related Npar(3) octets) shall only be included in MP or MS messages, and shall not be included in CLR or CL messages. All Annex Q-EU modems shall support additional inband spectral shaping.

Note - This deviates from the rules specified in G.994.1 for standard information fields, where it is stated in §9.6:

"Once a Transaction C (see 10.1) has been completed, any subsequent MS message within the same G.994.1 session shall only contain those octets of the identification (I) and standard information (S) fields, and those blocks of non-standard information (NS) that were contained in both the CLR and CL messages of the previous Transaction C".

Bits								
8	7	6	5	4	3	2	1	NPar(1)s
x	х	х	х	х	х	х	1	Reserved for future use
х	х	х	х	Х	х	1	х	Reserved for future use
х	х	х	х	х	1	х	х	Reserved for future use
х	х	х	х	1	х	х	х	Reserved for future use
х	х	х	1	Х	х	Х	х	Reserved for future use
х	х	1	х	х	х	Х	х	Reserved for future use
х	1	х	х	х	х	х	х	Reserved for future use
х	0	0	0	0	0	0	0	No parameters in this octet

 Table Q.6 – Non-standard information field – NPar(1) coding

Bits								
8	7	6	5	4	3	2	1	SPar(1)s
х	Х	х	х	х	х	х	1	G.992.1 Annex Q (and Annex Q-EU)
х	х	х	х	х	х	1	х	G.992.1 Annex I-EU
х	х	х	х	х	1	х	х	G.992.1 Annex C-EU
х	х	х	х	1	х	х	х	Reserved for future use
х	х	х	1	х	х	х	х	Reserved for future use
х	х	1	х	х	х	х	х	Reserved for future use
х	1	х	х	х	х	х	х	Reserved for future use
x	0	0	0	0	0	0	0	No parameters in this octet

 $Table \ Q.7-Non-standard \ information \ field - SPar(1) \ coding$

Table Q.7.1 – Non-standard information field – G.992.1 Annex Q NPar(2) coding – Octet 1

Bits												
8	7	6	5	4	3	2	1	G.992.1 Annex Q NPar(2)s – Octet 1				
Х	Х	х	х	х	х	х	1	$n_{\text{C-PILOT1}} = 64$				
х	х	х	х	х	х	1	х	$n_{\text{C-PILOT1}} = 128$				
х	х	х	х	х	1	х	х	$n_{\text{C-PILOT1}} = 256$				
х	х	х	х	1	х	х	х	Amateur radio notch – 1.8 MHz band				
х	х	х	1	х	х	х	х	Amateur radio notch – 3.5 MHz band				
х	х	1	х	х	х	х	х	$n_{\text{C-PILOT1}} = 96$				
х	х	0	0	0	0	0	0	No parameters in this octet				
Since A4	nce A48 is the only TTR indication signal specified for Annex Q-EU, there is no need to include it in G.994.1.											

Bits									
8	7	6	5	4	3	2	1	G.992.1 Annex Q NPar(2)s – Octet 2	
х	х	х	х	х	х	х	1	R-ACK1	
х	х	х	х	х	х	1	х	R-ACK2	
х	х	х	х	х	1	х	х	Reserved for future use	
х	х	х	х	1	х	х	Х	Reserved for future use	
х	х	х	1	х	х	х	х	Reserved for future use	
х	х	1	х	х	х	х	х	G.997.1 – Clear EOC OAM	
х	х	0	0	0	0	0	0	No parameters in this octet	
	Since Annex Q-EU only supports ATM transport, STM and ATM parameters are not specified. Since FBM mode is not supported, the DBM bit is also not specified.								

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex Q SPar(2)s
X	Х	х	х	х	Х	Х	1	Additional inband spectral shaping
х	х	х	х	х	х	1	х	Extended upstream
х	х	х	х	х	1	Х	Х	Reserved for future use
х	Х	х	х	1	х	Х	Х	Reserved for future use
х	х	х	1	х	х	х	х	Reserved for future use
х	Х	1	х	х	Х	Х	Х	Reserved for future use
х	Х	0	0	0	0	0	0	No parameters in this octet

Table Q.7.2 – Non-standard information field – G.992.1 Annex Q SPar(2) coding

Table Q.7.2.1 – Non-standard information field – G.992.1 Annex Q Additional inband spectral shaping Npar(3) coding Octet 1

Bit 8	S	7	6	5	4	3	2	1	G.992.1 Annex Q Additional inband spectral shaping Npar(3)s Octet 1
x		X					х	X	NOMINAL_PSD_lowband (bits 8 & 7)
x		х	х	х	Х	х			Reserved for future use

Table Q.7.2.1.1 – Non-standard information field – G.992.1 Annex Q Additional inband spectral shaping Npar(3) coding Octet 2

Bits		_						G.992.1 Annex Q Additional inband spectral shaping
8	7	6	5	4	3	2	1	Npar(3)s Octet 2
x	х	х	х	х	х	х	х	NOMINAL PSD lowband (bits 6 to 1)

Table Q.7.2.1.2 – Non-standard information field – G.992.1 Annex Q Additional inband spectral shaping Npar(3) coding Octet 3

Bits 8	7	6	5	4	3	2	1	G.992.1 Annex Q Additional inband spectral shaping Npar(3)s Octet 3
x	х					Х	Х	PSD level at 1622 kHz (bits 8 & 7)
x	Х	х	Х	Х	Х			Reserved for future use

Table Q.7.2.1.3 – Non-standard information field – G.992.1 Annex Q Additional inband spectral shaping Npar(3) coding Octet 4

Bits								G.992.1 Annex Q Additional inband spectral shaping
8	7	6	5	4	3	2	1	Npar(3)s Octet 4
x	х	х	х	х	х	х	Х	PSD level at 1622 kHz (bits 6 to 1)

Table Q.7.2.1.4 – Non-standard information field – G.992.1 Annex Q Additional inband spectral shaping Npar(3) coding Octet 5

Bits 8	7	6	5	4	3	2	1	G.992.1 Annex Q Additional inband spectral shaping Npar(3)s Octet 5
X X	X X	x	x	x	x	Х	х	PSD level at 3750 kHz (bits 8 & 7) Reserved for future use

Table Q.7.2.1.5 – Non-standard information field – G.992.1 Annex Q Additional inband spectral shaping Npar(3) coding Octet 6

Bits								G.992.1 Annex Q Additional inband spectral shaping
8	7	6	5	4	3	2	1	Npar(3)s Octet 6
х	Х	х	х	Х	х	х	Х	PSD level at 3750 kHz (bits 6 to 1)

Table Q.7.2.2 – Non-standard information field – G.992.1 Annex Q Extended upstream NPar(3) coding Octet 1

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex Q Extended upstream NPar(3)s Octet 1
x	х	x	Х	х	Х	х	1	Mode 1 upstream mask
х	х	х	х	х	х	1	х	Mode 2 upstream mask
х	х	х	х	х	1	х	х	Optional upstream masks for non-overlapped spectrum
х	х	х	х	1	х	х	х	EU-64
х	х	х	1	х	х	х	х	EU-32
х	х	1	х	х	х	х	х	EU-36
х	х	0	0	0	0	0	0	No parameters in this octet

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex Q Extended upstream NPar(3)s Octet 2
x	х	х	х	Х	Х	х	1	EU-40
x	х	х	х	х	Х	1	х	EU-44
х	х	х	х	х	1	х	х	EU-48
x	х	х	х	1	х	х	х	EU-52
х	х	х	1	х	х	х	х	EU-56
x	х	1	х	х	Х	х	х	EU-60
х	х	0	0	0	0	0	0	No parameters in this octet

Table Q.7.2.2.1 – Non-standard information field – G.992.1 Annex Q Extended upstreamNPar(3) coding Octet 2

Q.7.3 Handshake – Parameter definitions (supplements 10.2)

Q.7.3.1 Handshake – ATU-C (supplements 10.2)

Q.7.3.1.1 CL messages (supplements 10.2.1)

See Table Q.8.

NSF parameter	Definition
G.992.1 Annex Q	If set to ONE, this Spar(1) bit indicates that the ATU-C is configured to support G.992.1 Annex Q, and possibly Annex Q-EU.
ⁿ C-PILOT1 ⁼⁶⁴	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 64.
ⁿ C-PILOT1 ⁼⁹⁶	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 96.
ⁿ C-PILOT1 ⁼¹²⁸	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 128.
ⁿ C-PILOT1 ⁼²⁵⁶	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 256.
Amateur radio notch – 1.8 MHz band	If set to ONE, this Npar(2) bit indicates that the ATU-C is configured to reduce its transmit power between 1.81 and 2.0 MHz to ≤ -80 dBm.
Amateur radio notch – 3.5 MHz band	If set to ONE, this Npar(2) bit indicates that the ATU-C is configured to reduce its transmit power between 3.5 and 3.8 MHz to ≤ -80 dBm.
Extended upstream	If set to ONE, this Spar(2) bit indicates that the ATU-C is configured to support extended upstream.

Table Q.8/G.992.1 – ATU-C CL message NPar(2) bit definitions for Annex Q

EU-xx	If the Extended upstream Spar(2) bit is set to ONE, these Npar(3) bits indicate the extended upstream masks that the ATU-C supports. For non-overlapped spectrum, extended upstream masks are associated with downstream masks according to Figure Q.13. For overlapped spectrum, any EU-xx may be used with the overlapped downstream spectrum specified in §Q.4.8.2.
Mode 1 upstream	If set to ONE, this NPar(3) bit indicates that the ATU-C is configured to support upstream
mask	mask mode 1 (different masks during FEXT and NEXT periods).
Mode 2 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-C is configured to support upstream mask mode 2 (same mask during FEXT and NEXT periods).
Optional upstream masks for non- overlapped spectrum	If set to ONE, this NPar(3) bit indicates that the ATU-C is configured to support the optional upstream masks when using non-overlapped spectrum downstream.

Q.7.3.1.2 MS messages (supplements 10.2.2)

See Table Q.9.

NSF bit	Definition	
G.992.1 Annex Q	If set to ONE, this Spar(1) bit indicates that the ATU-C is selecting G.992.1 Annex Q, and possibly Annex Q-EU.	
ⁿ C-PILOT1 ⁼⁶⁴	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 64 (Note 1).	
ⁿ C-PILOT1 ⁼⁹⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 96 (Note 1).	
ⁿ C-PILOT1 ⁼¹²⁸	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 128 (Note 1).	
ⁿ C-PILOT1 ⁼²⁵⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 256 (Note 1).	
Amateur radio notch – 1.8 MHz band	If set to ONE, this Npar(2) bit indicates that the ATU-C shall reduce its transmit power between 1.81 and 2.0 MHz to ≤ -80 dBm.	
Amateur radio notch – 3.5 MHz band	If set to ONE, this Npar(2) bit indicates that the ATU-C shall reduce its transmit power between 3.5 and 3.8 MHz to ≤ -80 dBm.	
Additional inband spectral shaping	If set to ONE, this Spar(2) bit indicates that the ATU-C shall apply additional downstream inband spectral shaping as defined by the values of REDUCED_PSD_lowband, PSD level at 1622 kHz, and PSD level at 3750 kHz	
REDUCED_PSD_ lowband	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-C shall apply in the passband below 1104 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz.	
PSD level at 1622 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-C shall apply at 1622 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs between the REDUCED_PSD_lowband level at 1104 kHz and the PSD level at 1622 kHz.	
PSD level at 3750 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-C shall apply at 3750 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs between the PSD level at 1622 kHz and the PSD level at 3750 kHz.	

Table Q.9/G.992.1 – ATU-C MS message NPar(2) bit definitions for Annex Q

Extended upstream	If set to ONE, this Spar(2) bit indicates that the ATU-C is selecting extended upstream operation.	
EU-xx	If set to ONE, this Npar(3) bit indicates that the ATU-C is selecting upstream PSD mask US- xx. For non-overlapped spectrum, extended upstream masks are associated with downstream masks according to Figure Q.13. For overlapped spectrum, any EU-xx may be used with the overlapped downstream spectrum specified in §Q.4.8.2.	
Mode 1 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-C is selecting upstream mask mode 1 (different masks during FEXT and NEXT periods). (Note 2)	
Mode 2 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-C is selecting upstream mask mode 2 (same mask during FEXT and NEXT periods). (Note 2)	
Optional upstream masks for non- overlapped spectrum	If set to ONE, this NPar(3) bit indicates that the ATU-C is selecting one of the optional upstream masks when using non-overlapped spectrum downstream.	
Note 1: One and only one pilot tone bit shall be set in an MS message. Note 2: One and only one upstream mask mode bit shall be set in an MS message.		

Q.7.3.2 Handshake – ATU-R (supplements 10.3)

Q.7.3.2.1 CLR messages (supplements 10.3.1)

See Table Q.10.

Table Q.10/G.992.1 – ATU-R CLR message NPar(2) bit definitions for Annex Q

NSF bit	Definition
C 002 1 Amman O	If get to ONE this Super(1) hit indicates that the ATU D is configured to support C 002.1
G.992.1 Annex Q	If set to ONE, this Spar(1) bit indicates that the ATU-R is configured to support G.992.1 Annex Q, and possibly Annex Q-EU.
ⁿ C-PILOT1 ⁼⁶⁴	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot
	tone on subcarrier 64.
ⁿ C-PILOT1 ⁼⁹⁶	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot
	tone on subcarrier 96.
ⁿ C-PILOT1 ⁼¹²⁸	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot
ng pu om -256	tone on subcarrier 128. This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot
ⁿ C-PILOT1 ⁼²⁵⁶	tone on subcarrier 256.
Amateur radio notch	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports the 1.8 MHz
– 1.8 MHz band	Amateur radio band notch.
Amateur radio notch	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports the 3.5 MHz
– 3.5 MHz band	Amateur radio band notch.
Extended upstream	If set to ONE, this Spar(2) bit indicates that the ATU-R is configured to support extended
	upstream.
EU-xx	If the Extended upstream Spar(2) bit is set to ONE, these Npar(3) bits indicate the extended
	upstream masks that the ATU-R supports. For non-overlapped spectrum, extended upstream
	masks are associated with downstream masks according to Figure Q.13. For overlapped
	spectrum, any EU-xx may be used with the overlapped downstream spectrum specified in §Q.4.8.2.
Mode 1 upstream	If set to ONE, this NPar(3) bit indicates that the ATU-R is configured to support upstream
mask	mask mode 1 (different masks during FEXT and NEXT periods).

Mode 2 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-R is configured to support upstream mask mode 2 (same mask during FEXT and NEXT periods).
Optional upstream masks for non- overlapped spectrum	If set to ONE, this NPar(3) bit indicates that the ATU-R is configured to support the optional upstream masks when using non-overlapped spectrum downstream.

Q.7.3.2.2 MS messages (supplements 10.3.2)

Table Q.11.

Table Q.11/G.992.1 – ATU-R MS message NPar(2) bit definitions for Annex Q

NSF bit	Definition
G.992.1 Annex Q	If set to ONE, this Spar(1) bit indicates that the ATU-R is selecting G.992.1 Annex Q, and possibly Annex Q-EU.
ⁿ C-PILOT1 ⁼⁶⁴	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is selecting the pilot tone on subcarrier 64 (Note 1).
ⁿ C-PILOT1 ⁼⁹⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is selecting the pilot tone on subcarrier 96 (Note 1).
ⁿ C-PILOT1 ⁼¹²⁸	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is selecting the pilot tone on subcarrier 128 (Note 1).
ⁿ C-PILOT1 ⁼²⁵⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is selecting the pilot tone on subcarrier 256 (Note 1).
Amateur radio notch – 1.8 MHz band	This selection shall only be performed by the ATU-C. Therefore, this Npar(2) bit shall either be set to the same value as in a previous CL message or set to ONE.
Amateur radio notch – 3.5 MHz band	This selection shall only be performed by the ATU-C. Therefore, this Npar(2) bit shall either be set to the same value as in a previous CL message or set to ONE.
Additional inband spectral shaping	If set to ONE, this Spar(2) bit indicates that the ATU-R is selecting additional downstream inband spectral shaping as defined by the values of REDUCED_PSD_lowband, PSD level at 1622 kHz, and PSD level at 3750 kHz
REDUCED_PSD_ lowband	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R wishes to have applied in the passband below 1104 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz.
PSD level at 1622 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R wishes to have applied at 1622 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs between the REDUCED_PSD_lowband level at 1104 kHz and the PSD level at 1622 kHz.
PSD level at 3750 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R wishes to have applied at 3750 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs between the PSD level at 1622 kHz and the PSD level at 3750 kHz.
Extended	If set to ONE, this Spar(2) bit indicates that the ATU-R is selecting extended upstream
upstream	operation.
EU-xx	If set to ONE, this Npar(3) bit indicates that the ATU-R is selecting upstream PSD mask US- xx. For non-overlapped spectrum, extended upstream masks are associated with downstream masks according to Figure Q.13. For overlapped spectrum, any EU-xx may be used with the
	overlapped downstream spectrum specified in §Q.4.8.2.
Mode 1 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-R is selecting upstream mask mode 1 (different masks during FEXT and NEXT periods). (Note 2)

Mode 2 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-R is selecting upstream mask mode 2 (same mask during FEXT and NEXT periods). (Note 2)	
Optional upstream masks for non- overlapped spectrum	If set to ONE, this NPar(3) bit indicates that the ATU-R is selecting one of the optional upstream masks when using non-overlapped spectrum downstream.	
Note 1: One and only one pilot tone bit shall be set in an MS message. Note 2: One and only one upstream mask mode bit shall be set in an MS message.		

Q.7.3.2.3 MP messages (new)

Table Q.12.

Table Q.12/G.992.1 – ATU-R MP message NPar(2) bit definitions for Annex Q

NSF bit	Definition
	Definition
G.992.1 Annex Q	If set to ONE, this Spar(1) bit indicates that the ATU-R is proposing G.992.1 Annex Q, and possibly Annex Q-EU.
ⁿ C-PILOT1 ⁼⁶⁴	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the pilot tone on subcarrier 64 (Note 1).
ⁿ C-PILOT1 ⁼⁹⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is proposing the pilot tone on subcarrier 96 (Note 1).
ⁿ C-PILOT1 ⁼¹²⁸	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the pilot tone on subcarrier 128 (Note 1).
ⁿ C-PILOT1 ⁼²⁵⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the pilot tone on subcarrier 256 (Note 1).
Amateur radio notch – 1.8 MHz band	This selection shall only be performed by the ATU-C. Therefore, this Npar(2) bit shall either be set to the same value as in a previous CL message or set to ONE.
Amateur radio notch – 3.5 MHz band	This selection shall only be performed by the ATU-C. Therefore, this Npar(2) bit shall either be set to the same value as in a previous CL message or set to ONE.
Additional inband spectral shaping	If set to ONE, this Spar(2) bit indicates that the ATU-R is proposing additional downstream inband spectral shaping as defined by the values of REDUCED_PSD_lowband, PSD level at 1622 kHz, and PSD level at 3750 kHz
REDUCED_PSD_l owband	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R wishes to have applied in the passband below 1104 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz.
PSD level at 1622 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R wishes to have applied at 1622 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs between the REDUCED_PSD_lowband level at 1104 kHz and the PSD level at 1622 kHz.
PSD level at 3750 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R wishes to have applied at 3750 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs between the PSD level at 1622 kHz and the PSD level at 3750 kHz.
Extended upstream	If set to ONE, this Spar(2) bit indicates that the ATU-R is proposing extended upstream operation.
EU-xx	If set to ONE, this Npar(3) bit indicates that the ATU-R is proposing upstream PSD mask US- xx. For non-overlapped spectrum, extended upstream masks are associated with downstream masks according to Figure Q.13. For overlapped spectrum, any EU-xx may be used with the overlapped downstream spectrum specified in §Q.4.8.2.
Mode 1 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-R is proposing upstream mask mode 1 (different masks during FEXT and NEXT periods).

Mode 2 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-R is proposing upstream mask mode 2 (same mask during FEXT and NEXT periods).	
Optional upstream masks for non- overlapped spectrum	If set to ONE, this NPar(3) bit indicates that the ATU-R is proposing one of the optional upstream masks when using non-overlapped spectrum downstream.	
Note 1: More than one pilot tone bit may be set in an MP message.		

Q.7.4 Transceiver Training – ATU-C (supplements 10.4)

During transceiver training from C-REVERB1 to C-SEGUE1 except C-PILOTn and C-QUIETn, the ATU-C shall transmit both $FEXT_R$ and $NEXT_R$ symbols when Bitmap-N_R is enabled (Dual Bitmap mode), and shall not transmit the $NEXT_R$ symbols except pilot tone when Bitmap-N_R is disabled (FEXT Bitmap mode). The duration of each state is defined as Figure Q.26.

Q.7.4.1 C-PILOT1 (supplements 10.4.2)

The ATU-C shall start the N_{SWF} (sliding window frame) counter from 0 immediately after entering C-PILOT1, and increment the N_{SWF} counter modulo 345 after transmission of each DMT symbol. According to the sliding window function and this counter, the ATU-C decides to transmit all of the subsequent symbols in either FEXT_R or NEXT_R symbols (for example, see Figures Q.11, Q.19 and Q.24).

C-PILOT1 has two signals.

The first signal is the pilot tone, a single frequency sinusoid at $f_{C-PILOT1}$ defined as:

$$X_{k} = \begin{cases} 0, & k \neq n_{C-PILOT1}, \ 0 \le k \le NSCds \\ A_{C-PILOT1}, & k = n_{C-PILOT1} \end{cases}$$

The frequency of the pilot tone shall be selected from one of the following choices during G.994.1 as:

- 4. $f_{\text{C-PILOT1}} = 276 \text{ kHz} (n_{\text{C-PILOT1}} = 64).$
- 5. $f_{\text{C-PILOT1}} = 414 \text{ kHz} (n_{\text{C-PILOT1}} = 96).$

6.
$$f_{\text{C-PILOT1}} = 552 \text{ kHz} (n_{\text{C-PILOT1}} = 128).$$

7. $f_{\text{C-PILOT1}} = 1104 \text{ kHz} (n_{\text{C-PILOT1}} = 256).$

Transmitters that support Annex Q-EU shall support all of these pilot tones.

The second signal is the TTR indication signal used to transmit $NEXT_R/FEXT_R$ information. The ATU-R can detect the phase information of the TTR_C from this signal. The TTR indication signal shall be selected during G.994.1 as:

A48 signal -the constellation encoding of the 48th carrier with 2-bit constellation as follows:

(+, +) to indicate a FEXT_R symbol;

(+, -) to indicate a NEXT_R symbol.

Q.7.4.2 C-PILOT1A (supplements 10.4.3)

C-PILOT1A has two signals and it is the same transmitted signal as C-PILOT1 (C.7.4.1).

Q.7.4.3 C-REVERB3 (supplements 10.4.11)

In order to synchronize the first symbol of C-RATES1 with the beginning of the hyperframe and to inform the entering timing of C-RATES1 to the ATU-R, the first symbol of C-SEGUE1 shall be transmitted inside of the FEXT_R duration as shown in Figure Q.22. Therefore, the duration of C-REVERB3 is 3628 DMT symbols.

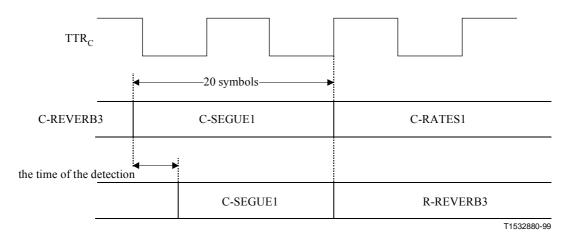


Figure Q.22/G.992.1 – Timing diagram from C-SEGUE1 to C-RATES1

Q.7.4.4 C-REVERB1 (replaces 10.4.5)

C-REVERB1 is a signal that allows the ATU-C and ATU-R receiver to adjust its automatic gain control (AGC) to an appropriate level. The data pattern used in C-REVERB1 shall be the pseudo-random downstream sequence (PRD), d_n for n = 1 to 2*NSCds, defined in Q.4.7.5 and repeated here for convenience:

$d_n = 1$	for $n = 1$ to 9	(10-1)
$d_n = d_{n-4} \oplus d_{n-9}$	for $n = 10$ to 2*NSCds	

The bits shall be used as follows: the first pair of bits (d_1 and d_2) is used for the DC and Nyquist subcarriers (the power assigned to them is, of course, zero, so the bits are effectively ignored); then the first and second bits of subsequent pairs are used to define the X_i and Y_i for i = 1 to NSCds-1 as defined in Table 7-13.

The period of PRD is only 511 bits, so d_{n+511} is equal to d_n . The bits d_1 to d_9 shall be re-initialized for each symbol, so each symbol of C-REVERB1 is identical.

The two bits that modulate the pilot carrier shall be overwritten by $\{0,0\}$: generating the $\{+,+\}$ constellation.

The duration of C-REVERB1 is 512 (repeating) symbols without cyclic prefix.

Q.7.4.4.1 Power Cut-back (supplements 10.4.5.1)

For Annex Q-EU, see A.3.1.

Q.7.5 Transceiver Training – ATU-R (supplements 10.5)

During transceiver training from R-REVERB1 to R-SEGUE1 except R-QUIETn, the ATU-R shall transmit both $FEXT_C$ and $NEXT_C$ symbols when Bitmap-N_C is enabled (Dual Bitmap mode) and shall not transmit $NEXT_C$ symbols when Bitmap-N_C is disabled (FEXT Bitmap mode). The duration of each state is defined as Figure Q.26.

Q.7.5.1 **R-QUIET2** (supplements 10.5.1)

The ATU-R enters R-REVERB1 after it completes timing recovery and Hyperframe synchronization from C-PILOT1/C-PILOT1A.

Q.7.5.2 R-REVERB1 (supplements 10.5.2)

The data pattern used in R-REVERB1 is the pseudo-random upstream sequence PRU defined in 8.11.3, repeated as necessary for the the selected NSCus:

$$\begin{cases} d_n = 1 & \text{for } n = 1 \text{ to } 6 \\ d_n = d_{n-5} & \bigoplus d_{n-6} & \text{for } n = 7 \text{ to } 2*NSCus \end{cases}$$
(C.10-1)

The period of PRU is only 63 bits, so d_{n+63} is equal to d_n .

The ATU-R shall start its N_{SWF} counter immediately after entering R-REVERB1, and then increment the N_{SWF} counter with modulo 345 from 0 when it transmits each DMT symbol. The ATU-C and ATU-R shall have the same value since hyperframe alignment between the ATU-C and ATU-R shall be maintained. According to the sliding window and this counter, the ATU-R decides to transmit all of the subsequent symbols in either the FEXT_C or the NEXT_C symbol.

Q.7.5.3 R-QUIET3 (replaces 10.5.3)

The final symbol of R-QUIET3 accommodates the frame alignment of the transmitter to that of the receiver. It may be shortened by any number of samples. The maximum duration of R-QUIET3 is 6145 DMT symbols.

Q.7.5.4 R-REVERB2 (supplements 10.5.5)

After ATU-R detects C-SEGUE1, the ATU-R enters R-SEGUE1. The maximum duration of R-REVERB2 is 3643 DMT symbols.

Q.7.6 Channel analysis (ATU-C) (supplements 10.6)

ATU-C shall transmit only FEXT_R symbols, and shall not transmit the NEXT_R symbols except the pilot tone from C-RATES1 to C-CRC2. During C-MEDLEY, the ATU-C shall transmit both FEXT_R and NEXT_R symbols when Bitmap-N_R is enabled (Dual Bitmap mode). The ATU-C shall not transmit NEXT_R symbols except the pilot tone, when Bitmap-N_R is disabled (FEXT Bitmap mode). The duration of each state is defined in Figure Q.26.

Q.7.6.1 C-SEGUE1 (supplements 10.6.1)

The duration of C-SEGUE1 is 20 symbols in order that the first symbol of C-SEGUE1 shall be inside of the FEXT_R duration.

Q.7.6.2 C-MEDLEY (replaces 10.6.6)

C-MEDLEY is a wideband pseudo-random signal used for estimation at the ATU-R of the downstream SNR. The data to be transmitted are derived from the pseudo-random sequence, PRD_m defined as:

$$d_n = 1$$
 for $n = 1$ to 14 and $d_n = d_{n-5} \oplus d_{n-11} \oplus d_{n-12} \oplus d_{n-14}$ for $n > 14$,

and modulated as defined in 10.4.5. In contrast to C-REVERB1, the cyclic prefix is used and the data sequence continues from one symbol to the next (i.e. d_1 to d_{14} are not re-initialized for each symbol). Because the sequence is of length 2¹⁴-1, and far fewer bits are used for each symbol, the subcarrier vector for C-MEDLEY changes from one symbol period to the next. For non-overlapped spectrum, 2*(869-mm+1) bits are used each symbol, where mm is the minimum subcarrier specified for PSD mask DS-mm in Table Q.13. For overlapped spectrum, 2*864 bits are used each symbol. The pilot subcarrier is overwritten by the (+,+) signal constellation. The duration of C-MEDLEY is as shown in Figure Q.26. Following C-MEDLEY the ATU-C shall enter the state C-REVERB4.

With the periodical noise of TCM-ISDN, SNR also changes in the same cycle, as shown in Figure Q.23. The ATU-C transmits the signal in both of $NEXT_R$ and $FEXT_R$ symbols, and the ATU-R estimates two SNRs from the received $NEXT_R$ and $FEXT_R$ symbols, respectively, as defined in Figure Q.24.

The following formula gives the information that received N_{dmt}-th DMT symbol belongs to:

When Bitmap-N_R is disabled (FEXT Bitmap mode), ATU-C shall transmit only the pilot tone as NEXT_R symbol. The number of bits of NEXT_R shall be no more than the number of bits of FEXT_R.

At the transmitter, the PRD_m sequence generator shall continue to be updated during $NEXT_R$ symbols when Bitmap-N_R is disabled (FEXT Bitmap mode).

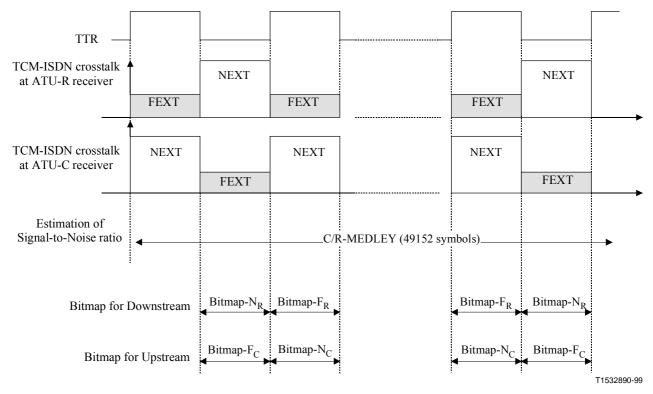


Figure Q.23/G.992.1 – Estimation of periodic Signal-to-Noise Ratio

TTR _C	
0	
1	10 11 12 13 14 15 15 16 17 19
2	20 21 22 23 24 25 746 777 78
3	30 31 32 33 34 35 36 36 37 39 40
4	41 42 43 44 45 46 47 48 49 50
5	51 52 53 54 55 56 57 58 59 60
6	61 62 63 64 65 66 67 68 69 70
7	71 72 73 74 75 76 76 80
8	81 82 83 84 85 86 87 88 89 90
9	91 92 93 94 95 96 97 98 99 101
10	101 102 103 104 105 106 107 108 109 111
11	112 113 114 115 116 117 118 119 129 12
12	
13	132 133 134 135 136 137 138 139 141
14	142 143 144 145 146 147 X48 X49 151
15	152 153 154 155 156 157 158 159 160
16	162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 182 182
17 18	173 174 175 176 177 178 179 188 182 183 184 185 186 187 188 189 199 192
18	103 104 105 106 107 108 109 200 201 202
20	203 204 205 206 207 208 209 211 212
21	213 214 215 216 217 218 228 222 222
22	223 224 225 226 227 228 228 228 238 238 238 238 238 238 238
23	233 234 235 236 237 238 239 249 243
24	244 245 246 247 248 249 259 253
25	254 255 256 257 258 259 269 269 263 263
26	264 265 266 267 258 269 279 272 273
27	274 275 276 277 278 279 280 283
28	284 285 286 287 288 289 290 293 293
29	294 295 296 297 298 299 300 300 302 303
30	304 305 306 307 308 309 3330 3332<
31	315 316 317 318 319 320 322 322 322 324
32	325 326 327 328 3 29 334 332 333 3 34
33	335 336 337 338 339 340 344 344 344
	Symbol for estimation of FEXT _R S/N Symbol not used for S/N estimation
	Symbol for estimation of NEXT _R S/N T1535370-00
	Symbol for estimation of INEXTR S/IN

Figure Q.24/G.992.1 – Symbol pattern in a hyperframe for S/N estimation – Downstream

Q.7.6.3 C-RATES1 (supplements 10.6.2)

In order to support data rates greater than 32 Mbit/s, the B_I field has 11 bits. The RRSI fields shall use the same extended syntax as defined in Q.7.9.4 for C-RATES-RA.

For the S=1/2n framing mode (see §Q.4.9), the downstream RS_I shall be the number of parity bytes per sync byte, i.e., $RS_I = R_I/(n^*S)$.

. .

Suffix(ces) of <i>m_i</i> (Note 1)	Parameter (Note 3)
47-44	Minimum required downstream SNR margin at initialization (Note 2)
43-18	Reserved for future use
17	Trellis coding option
16	Overlapped spectrum option (Note 4)
15	Unused (shall be set to "1")
14-12	Reserved for future use
11	NTR
10-9	Framing mode
8-6	Transmit PSD during initialization
5	Reserved
4-0	Maximum numbers of bits per subcarrier supported
NOTE 1 – Within the separate fields	s the least significant bits have the lowest subscripts.
NOTE 2 – A positive number of dB;	; binary coded 0-15 dB.
NOTE 3 – All reserved bits shall be	set to "0".
NOTE 1 The initialization sequence	a allows for interworking of overlapped and non-overlapped spectrum

Q.7.6.4 C-MSG1 (supplements 10.6.4)

NOTE 4 – The initialization sequence allows for interworking of overlapped and non-overlapped spectrum implementations. Therefore, this indication is for information only.

Q.7.6.4.1 Maximum numbers of bits per subcarrier supported – Bits 4-0 (replaces 10.6.4.8)

The N_{downmax} (transmit) capability shall be binary encoded onto $\{m_4, ..., m_0\}$ (e.g. $10001_2 = 17$). The maximum number of bits for the upstream data, N_{upmax} , that the ATU-C receiver can support need not be signalled to the ATU-R; it will be implicit in the bits and gains message, C-B&G, which is transmitted after channel analysis.

Q.7.7 Channel analysis (ATU-R) (supplements 10.7)

From R-RATES1 to R-CRC2, the ATU-R shall transmit only the FEXT_{C} symbols and shall not transmit the NEXT_{C} symbols. In R-SEGUE2 and R-MEDLEY, the ATU-R shall transmit both FEXT_{C} and NEXT_{C} symbols when Bitmap-N_C is enabled (Dual Bitmap mode) and shall not transmit NEXT_{C} symbols when Bitmap-N_C is disabled (FEXT Bitmap mode). The duration of each state is defined in Figure Q.26.

Q.7.8 R-SEGUE1 (supplements 10.7.1)

The maximum duration of R-SEGUE1 is 14 symbols (see Figure Q.22).

Q.7.8.1 R-REVERB3 (supplements 10.7.2)

The ATU-R shall start R-REVERB3 aligned with the beginning of a Hyperframe.

Q.7.8.2 **R-SEGUE2** (supplements 10.7.3)

The duration of R-SEGUE2 is 13 symbols.

Q.7.8.3 R-MEDLEY (replaces 10.7.8)

R-MEDLEY is a wideband pseudo-random signal used for estimation of the upstream SNR at the ATU-C. The data to be transmitted are derived from the pseudo-random sequence PRU_m defined as:

d $_{n}$ = 1 for n = 1 to 23 and d $_{n}$ = d $_{n-18} \oplus$ d $_{n-23}$ for n> 23.

In contrast to R-REVERB1, the cyclic prefix is used and the data sequence continues from one symbol to the next (i.e.

 d_1 to d_{23} are not re-initialized for each symbol). Because the sequence is of length 2^{23} -1, and $2^*(nn-5)$ bits are used for each symbol (where nn is the maximum subcarrier specified for PSD mask EU-nn in Table Q.18), the subcarrier vector for R-MEDLEY changes from one symbol period to the next. Following R-MEDLEY the ATU-R enters signalling state R-REVERB4. The duration of R-MEDLEY is as shown in Figure Q.26.

With the periodical noise of TCM-ISDN, SNR also changes in the same cycle, as shown in Figure Q.23. ATU-R shall transmit the signal in both of $NEXT_C$ and $FEXT_C$ symbols, and ATU-C shall estimate two SNRs from the received $NEXT_C$ and $FEXT_C$ symbols, respectively, as defined in Figure Q.25.

The following numerical formula gives the information that received N_{dmt}-th DMT symbol belongs to:

For $N_{dmt} = 0, 1, ..., 344$ $S = 272 \times N_{dmt} \mod 2760$ if { (S > b) and (S + 271 < c) } then symbol for estimation of FEXT_C SNR if { (S + 271 < a) } then symbol for estimation of NEXT_C SNR where a = 1148, b = 1315, c = 2608

When Bitmap-N_C is disabled (FEXT Bitmap mode), the ATU-R shall not transmit NEXT_C symbol. The number of bits of NEXT_C shall be no more than the number of bits of FEXT_C.

At the transmitter, the PRU_m sequence generator shall continue to be updated during $NEXT_C$ symbols when Bitmap- N_C is disabled (FEXT Bitmap mode).

TTR _R _	
0	
1	
2	20 22 25 26 27 28 29
3	30 32 33 34 35 36 37 38 39 40 44 45 46 47 48 49 50
5	43 43 44 45 46 47 48 49 50 55 54 55 56 57 58 59 60
6	34 35 36 37 38 39 60 63 62 63 64 65 66 67 68 69 70
7	71 75 76 77 78 79 80
8	81 83 84 85 86 87 88 89 90
9	91 92 93 94 95 96 97 98 99 100 101
10	101 105 106 107 108 109 110 111
11	
12	127 128 129 130 131
13	<i>132 134 135</i> 136 137 138 139 140 14
14	142 143 145 146 147 148 149 150 151
15	152 333 344 355 156 157 158 159 160 161
16	162 63 64 65 165 167 168 169 170 171 172
17	176 77 178 179 180 181 182
18	183 184 185 186 187 188 189 190 191 92
19	193 194 195 196 19 198 199 200 201 202
20	203 204 205 206 207 208 209 210 211 212
21	213 214 215 217 218 219 220 221 222
22	223 227 228 229 230 231 232
23	233 234 235 238 239 240 241 242 243
24 25	244 245 246 247 248 249 250 251 252 253
25 26	254 255 257 238 259 260 260 262 263 264 265 265 268 269 270 271 272 273
26 27	203 203 203 203 211 212 213 234 235 235 278 279 280 281 282 283
27	284 285 286 287 288 289 290 291 292 293
20	294 295 296 297 298 299 300 301 302 303
30	304 305 306 308 309 310 311 312 313 314
31	<u>313</u> 316 317 318 319 320 321 322 323 324
32	325 326 327 328 329 330 331 332 333 34
33	335 336 337 338 339 340 341 342 343 344
	T1535290-00
	Symbol for estimation of FEXT _C S/N Symbol not used for S/N estimation
	Symbol for estimation of NEXT _C S/N

Figure Q.25/G.992.1 – Symbol pattern in a hyperframe for S/N estimation – Upstream

Q.7.8.4 R-MSG1 (supplements 10.7.6)

Suffix(ces) of m_i (Note 1)	Parameter (Note 2)
47-18	Reserved for future use
17	Trellis coding option
16	Overlapped spectrum option (Note 3)
15	Unused (shall be set to "1")
14	Support of $S = 1/2$ mode (see Q.4.9) (Note 4)
13	Support of dual latency downstream
12	Support of dual latency upstream
11	Network Timing Reference
10, 9	Framing mode
8-5	Reserved for future use
4-0	Maximum numbers of bits per subcarrier supported
NOTE 1 – Within the separate fields t	he least significant bits have the lowest subscripts.
NOTE 2 – All reserved bits shall be set	et to "0".
NOTE 3 - The initialization sequence	allows for interworking of overlapped and non-overlapped spectrum
implementations. Therefore, this indic	ation is for information only.
1	auton is for minormation only.

Table Q.14/G.992.1 – Assignment of 48 bits of R-MSG1

NOTE 4 – Since the S=1/2 mode is mandatory for Annex Q, a modem supporting Annex Q shall set this bit to binary ONE.

Q.7.8.4.1 Maximum numbers of bits per subcarrier supported – Bits 4-0 (replaces 10.7.6.6)

The N_{upmax} (transmit) capability is encoded onto $\{m_4, ..., m_0\}$ with a conventional binary representation (e.g. $10001_2 = 17$).

Q.7.9 Exchange – ATU-C (supplements 10.8)

During C-RATESn, C-MSGn, C-B&G, and C-CRCn, the ATU-C shall transmit the FEXT_R symbol. In the other signals, the ATU-C shall transmit both $FEXT_R$ and $NEXT_R$ symbols when Bitmap-N_R is enabled (Dual Bitmap mode), and shall not transmit the $NEXT_R$ symbols except pilot tone when Bitmap-N_R is disabled (FEXT Bitmap mode). The duration of each state is defined in Figure Q.27.

Q.7.9.1 C-MSG2 (supplements 10.8.9)

Replace Table 10-13 with Table Q.15.

Suffix(ces) of <i>m_i</i> (Note 1)	Parameter (Note 2)	
31-26	Estimated average loop attenuation	
25-21	Reserved for future use	
20-16	Performance margin with selected rate option	
15-11	Reserved for future use	
10-0	Total number of bits supported	
NOTE 1 – Within the separate fields the least significant bits have the lowest subscripts.		
NOTE 2 – All reserved bits shall be set to "0".		

Table Q.15/G.992.1 -	Assignment of 32 bits of C-MSG2
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For NSCus=32,

 $n_{1C-MSG2} = 43$ $n_{2C-MSG2} = 91$

Otherwise,

 $n_{1C-MSG2} = 139$ $n_{2C-MSG2} = 187$

Q.7.9.1.1 Total number of bits per symbol supported (replaces 10.8.9.3)

The ATU-C receiver shall also calculate the maximum number of bits per symbol that the upstream channel can support with the performance margin defined in C-MSG-RA at an error rate of 10^{-7} .

The maximum number of bits per symbol is defined at the reference point B, that is calculated from the FEXT_C and NEXT_C downstream channel performance [e.g. if the maximum numbers of bits that can be supported in FEXT_C and NEXT_C symbols are 111 and 88 {Total number of bits per symbol supported} = $(111 \times 126 + 88 \times 214)/340 = 96$]. This number is encoded into bits 10-0 using a conventional binary representation [e.g. if the maximum number of bits that can be supported is 96 (data rate = 384 kbit/s), { m_{10} , ..., m_0 } = 000011111112].

NOTE – The number of symbols per hyperframe is 340. The number of FEXT symbols is 126. The number of NEXT symbols is 214.

Q.7.9.1.2 Estimated average upstream loop attenuation (supplements 10.8.9.1)

For Annex Q-EU, see A.3.2.

Q.7.9.2 C-B&G (replaces 10.8.13)

C-B&G shall be used to transmit to the ATU-R the bits and gains information, Bitmap-F_C { b_1 , g_1 , b_2 , g_2 , ... $b_{NSCus-1}$, $g_{NSCus-1}$ }, and Bitmap-N_C { $b_{NSCus+1}$, $g_{NSCus+1}$, $b_{NSCus+2}$, $g_{NSCus+2}$, ..., $b_{2*NSCus-1}$, $g_{2*NSCus-1}$ }, that are to be used on the upstream carriers. b_i of Bitmap-F_C indicates the number of bits to be coded by ATU-R transmitter onto the *i* th upstream carrier in FEXT_C symbols; g_i of Bitmap-F_C indicates the scale factor, relative to the gain that was used for that carrier during the transmission of R-MEDLEY, that shall be applied to the *i* th upstream carrier in FEXT_C symbols. Similarly, b_i of Bitmap-N_C indicates the number of bits onto the (*i* – NSCus) th upstream carrier in

NEXT_C symbols; g_i of Bitmap-N_C indicates the scale factor that shall be applied to the (*i* – NSCus) th upstream carrier in NEXT_C symbols.

Because no bits or energy will be transmitted at DC or one-half the sampling rate, b_0 , g_0 , b_{NSCus} , g_{NSCus} , $b_{2*NSCus}$, and $g_{2*NSCus}$ are all presumed to be zero and shall not be transmitted.

Each b_i shall be represented as an unsigned 5-bit integer, with valid b_i s lying in the range of zero to N_{upmax} , the maximum number of bits that the ATU-R is prepared to modulate onto any subcarrier, which is communicated in R-MSG1.

Each g_i shall be represented as an unsigned 11-bit fixed-point quantity, with the binary point assumed just to the right of

the third most significant bit. For example, a g_i with binary representation (most significant bit listed first)

 001.01000000_2 would instruct the ATU-R to scale the constellation for carrier *i*, by a gain factor of 1.25, so that the power in that carrier shall be 1.94 dB higher than it was during R-MEDLEY.

For subcarriers on which no data are to be transmitted, and the receiver will never allocate bits (e.g. out-of-band subcarriers) both b_i and g_i shall be set to zero (00000₂ and 00000000 000₂, respectively). For subcarriers on which no data are to be currently transmitted, but the receiver may allocate bits later (e.g. as a result of an SNR improvement), the b_i shall be set to zero and the g_i to a value in the 0.19 to 1.33 range (000.00110000₂ to 001.0101010₁).

Let NSCu=128, except when EU-32 is used where NSCu=32. The C-B&G information shall be mapped in a 32*(NSCu-1)-bit [4*(NSCu-1) byte] message *m* defined by:

 $m = \{m_{32*(NSCu-1)-1}, m_{32(NSCu-1)-2}, ..., m_1, m_0\} = \{g_{2*NSCu-1}, b_{2*NSCu-1}, ..., g_{NSCu+1}, b_{NSCu+1}, g_{NSCu-1}, ..., g_1, b_1\},$ (C.10-2)

with the MSB of b_i and g_i in the higher *m* index and m_0 being transmitted first. The message *m* shall be transmitted in 4*(NSCu-1) FEXT_R symbols. When NSCu=32, including C_CRC5, the total length is 336 symbols while for NSCu=128, the total length is 336+3*345=1371 symbols, using the transmission method as described in 10.8.9.

When Bitmap-N_C is disabled (FEXT Bitmap mode), b_i and g_i of Bitmap-N_C shall be set to zero. For index between NSCus+1 and 127, the m values are set to 0.

Q.7.9.3 C-SEGUE3 (replaces 10.8.16)

The duration of C-SEGUE3 is 18 symbols. Following C-SEGUE3, the ATU-C completes the initialization and enters C-SHOWTIME. In C-SHOWTIME, ATU-C shall transmit the signal using Bitmap- F_R and Bitmap- N_R with the sliding window.

When Bitmap-N_R is disabled (FEXT Bitmap mode), ATU-C shall transmit only the pilot tone as NEXT_R symbols.

	←bits>									
fields	7	6	5	4	3	2	1	0		
RS _F	$B_{10}(AS0)$	0		value of RS _F						
			MS	MSB LSB						
RSI	$B_8(AS0)$	$B_9(AS0)$		value of RS _I						
			MS	MSB LSB						
S	I9	I ₈		value of S						
			MS	MSB LSB						
Ι	I ₇	I ₆	I_5 I_4 I_3 I_2 I_1 I_0							
FS(LS2)	value of FS(LS2) set to $\{0000000_2\}$									

Table Q.16/G.992.1 – RRSI fields of C-RATES-RA

The RS_I field has been extended to include bit B₉ of B_I (AS0) in bit 6, and The RS_F field has been extended to include the most significant bit B₁₀ of B_I (AS0) in bit 7, B_I (AS0) being the number of payload bytes in the AS0 bearer channel in the downstream interleave buffer. This is to support the higher data rates for the S=1/4, S=1/6 and S=1/8 modes.

The S field shall be coded $\{100100_2\}$ to indicate S=1/4, $\{100110_2\}$ to indicate S=1/6, and $\{101000_2\}$ to indicate S=1/8.

For the S=1/2n framing mode (see §Q.4.9), the downstream RS_I shall be the number of parity bytes per sync byte, i.e., $RS_I = R_I/(n^*S)$.

Q.7.10 Exchange – ATU-R (supplements 10.9)

ATU-R shall transmit only the FEXT_{C} symbols in R-MSGn, R-RATESn, R-B&G, R-CRCn. In other signals, the ATU-R shall transmit both FEXT_{C} and NEXT_{C} symbols when Bitmap-N_C is enabled (Dual Bitmap mode) and shall not transmit NEXT_{C} symbols when Bitmap-N_C is disabled (FEXT Bitmap mode). The duration of each state is defined in Figure Q.27.

Q.7.10.1 R-MSG-RA (supplements 10.9.2)

Replace Table 10-15 with Table Q.17.

Suffix(ces) of m_i	Parameter
(Note)	All reserved bits shall be set to 0
79-72	Reserved for ITU-T
71 - 70	Extension to number of RS payload bytes, K
69, 68	Extension to number of tones carrying data (ncloaded)
67-56	B _{fast-max}
55-49	Number of RS overhead bytes, (R)
48-40	Number of RS payload bytes, K
39-32	Number of tones carrying data (ncloaded)
31-25	Estimated average loop attenuation
24-21	Coding gain
20-16	Performance margin with selected rate option
15 - 14	Extension to total number of bits per DMT symbol, B _{max}
13-12	Maximum Interleave Depth downstream
11-0	Total number of bits per DMT symbol, B _{max}
NOTE – Within the sepa	arate fields the least significant bits have the lowest subscripts.

Table Q.17/G.992.1 – Assignment of 80 bits of R-MSG-RA (Annex Q-EU)

Q.7.10.1.1 Total number of bits supported (B_{max}) (replaces 10.9.2.8)

This parameter shall be defined as in R-MSG2, see Q.7.9.1.

Q.7.10.1.2 B_{fast-max} (new)

 $B_{fast-max}$ is the maximum number of bits of the fast buffer for fast data transmitted on the condition that the bits of the fast data can be equally assigned to all FEXT-symbols and NEXT-symbols.

Fast Buffered Data Bfast-max is tf.

Q.7.10.2 R-MSG2 (supplements 10.9.8)

Table Q.10/0.772.1 – Assignment of 52 bits of R-10/502						
Suffix(ces) of <i>m_i</i> (Note 1)	Parameter (Note 2)					
31-25	Estimated average loop attenuation					
24-21 Reserved for future use						
20-16 Performance margin with selected rate option						
15 - 14 Extension to total number of bits per DMT symbol, B _{max}						
13-12 Reserved for future use						
11-0 Total number of bits per DMT symbol, B _{max}						
NOTE 1 – Within the separate fields the least significant bits have the lowest subscripts.						
NOTE 2 – All reserved bits shall	NOTE 2 – All reserved bits shall be set to "0".					

Table Q.18/G.992.1 – Assignment of 32 bits of R-MSG2

 $N_{1R-MSG2} = 10$ $N_{2R-MSG2} = 20$

Q.7.10.2.1 Total number of bits per symbol supported (supplements 10.9.8.3)

The maximum number of bits per symbol that the downstream channel can support is encoded into bits 15, 14 and 11 - 0.

The maximum number of bits per symbol is defined at the reference point B, that is calculated from the FEXT_R and NEXT_R downstream channel performance. For example, if the maximum numbers of bits that can be supported in FEXT_R and NEXT_R symbols are 111 and 88, the total number of bits per symbol supported is (111 x 126 + 88 x 214)/340 = 96.

NOTE – The number of symbols per hyperframe is 340, the number of FEXT symbols is 126, and the number of NEXT symbols is 214.

Q.7.10.2.2 Estimated average downstream loop attenuation (supplements 10.9.8.1)

For Annex Q-EU, see A.3.3.

Q.7.10.3 R-REVERB5 (supplement of 10.9.12)

The duration of R-REVERB5 is 345n-40, 3<=n<=19, when NSCu=128, or 3<=n<=16 when NSCu=32.

Q.7.10.4 R-B&G (replaces 10.9.14)

The purpose of R-B&G is to transmit to ATU-C the bits and gains information, Bitmap-F_R { b_1 , g_1 , b_2 , g_2 , ..., $b_{NSCds-1}$, $g_{NSCds-1}$ }, and Bitmap-N_R { $b_{NSCds+1}$, $g_{NSCds+1}$, $b_{NSCds+2}$, $g_{NSCds+2}$, ..., $b_{2*NSCds-1}$, $g_{2*NSCds-1}$ }, to be used on the downstream subcarriers. b_i of Bitmap-F_R indicates the number of bits to be coded by ATU-C transmitter onto the *i* th downstream subcarrier in FEXT_R symbols; g_i of Bitmap-F_R indicates the scale factor that shall be applied to the *i* th downstream subcarrier in FEXT_R symbols, relative to the gain that was used for that carrier during the transmission of C-MEDLEY. Similarly, b_i of Bitmap-N_R indicates the number of bits onto the (*i* – NSCds) th downstream carrier in NEXT_R symbols; g_i of Bitmap-N_R indicates the scale factor that shall be applied to the (*i* – NSCds) th downstream carrier in NEXT_R symbols. Because no bits or energy will be transmitted at DC or one-half the sampling rate, b_0 , g_0 , b_{NSCds} , g_{NSCds} , $b_{2*NSCds}$, and $g_{2*NSCds}$ are all presumed to be zero, and are not transmitted. When subcarrier 64 is reserved as the pilot tone, b_{64} and $b_{NSCds+64}$, shall be set to 0, g_{64} and $g_{NSCds+64}$ shall be set to g_{sync} . When subcarrier 128 is reserved as the pilot tone, b_{128} and $b_{NSCds+128}$, shall be set to 0, g_{128} and $g_{NSCds+128}$ shall be set to g_{sync} . When subcarrier 256 is reserved as the pilot tone, b_{256} and $b_{NSCds+256}$, shall be set to 0, g_{256} and $g_{NSCds+256}$ shall be set to 0, g_{256} and $g_{NSCds+256}$ shall be set to g_{sync} . The value g_{sync} represents the gain scaling applied to the sync symbol.

Each b_i is represented as an unsigned 5-bit integer, with valid b_i lying in the range of zero to N_{downmax} , the maximum number of bits that the ATU-C is prepared to modulate onto any subcarrier, which is communicated in C-MSG1.

Each g_i is represented as an unsigned 11-bit fixed-point quantity, with the binary point assumed just to the right of the third most significant bit. For example, a g_i with binary representation (most significant bit listed first) 001.01000000₂ would instruct the ATU-C to scale the constellation for carrier *i* by a gain factor of 1.25, so that the power in that carrier shall be 1.94 dB higher than it was during C-MEDLEY.

For subcarriers on which no data are to be transmitted, and the receiver will never allocate bits (e.g. out-of-band subcarriers) both b_i and g_i shall be set to zero (00000₂ and 00000000 000₂, respectively). For subcarriers on which no data are to be currently transmitted, but the receiver may allocate bits later (e.g. as a result of an SNR improvement), the b_i shall be set to zero and the g_i to a value in the 0.19 to 1.33 range (000.00110000₂ to 001.01010101₂).

The R-B&G information shall be mapped in a (2*NSCds-2)*16-bit ((2*NSCds-2)*2 byte) message *m* defined by:

 $m = \{m_{(2*NSCds-2)*16-1}, m_{(2*NSCds-2)*16-2}, ..., m_1, m_0\} = \{g_{2*NSCds-1}, b_{2*NSCds-1}, ..., g_{NSCds+1}, b_{NSCds+1}, b_{NSCds-1}, ..., g_{1}, b_{1}\},$ (Q.10-3)

with the MSB of b_i and g_i in the higher *m* index and m_0 being transmitted first. The message *m* shall be transmitted in (2*NSCds-2)*2 symbols, using the transmission method as described in 10.9.8.

When Bitmap-N_R is disabled (FEXT Bitmap mode), b_i and g_i of Bitmap-N_R shall be set to zero.

Q.7.10.5 R-SEGUE5 (replaces 10.9.17)

The duration of R-SEGUE5 is 13 symbols. Following R-SEGUE-5, ATU-R completes the initialization and enters R-SHOWTIME. In R-SHOWTIME, ATU-R shall transmit the signal using Bitmap- F_C and Bitmap- N_C with the sliding window.

When Bitmap-N_C is disabled (FEXT Bitmap mode), ATU-R shall not transmit NEXT_C symbols.

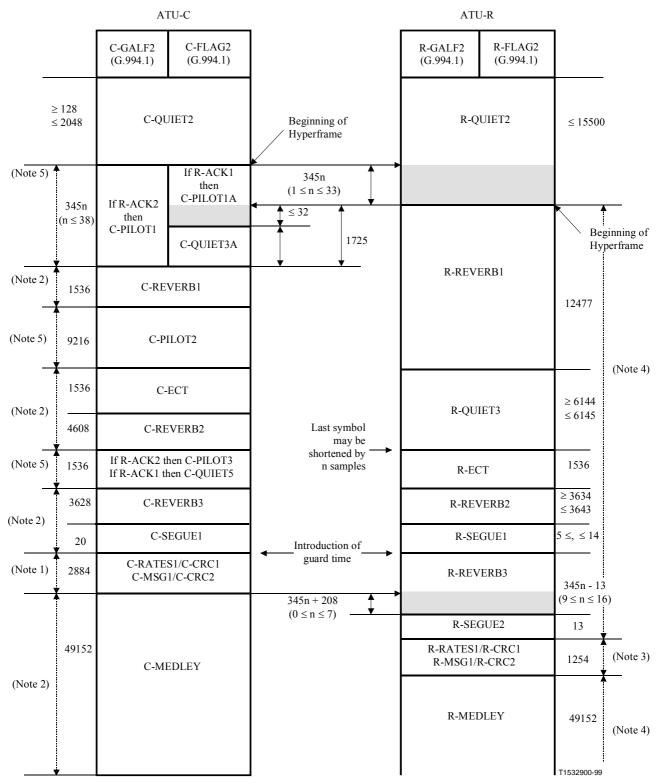
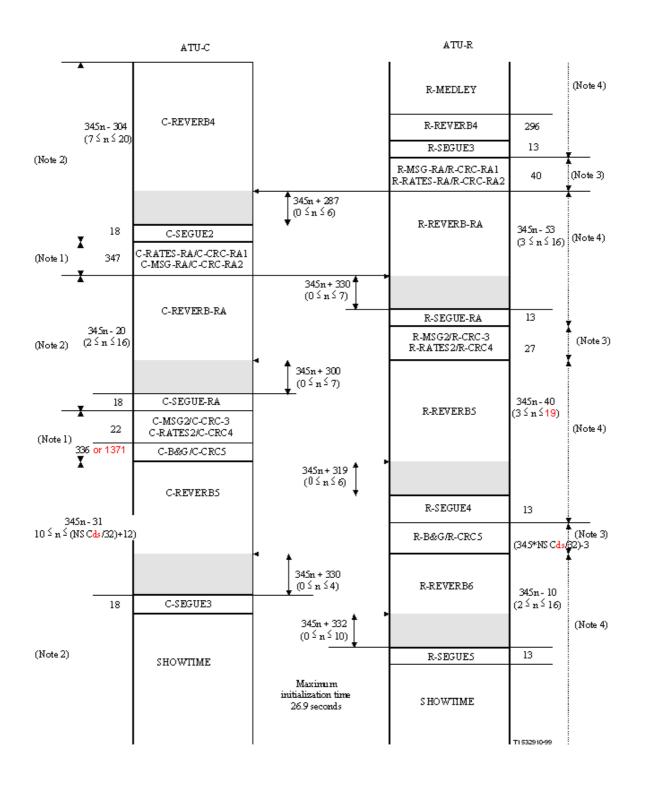


Figure Q.26/G.992.1 – Timing diagram of the initialization sequence – Part 1



- NOTE 1 The ATU-C shall transmit the FEXTR symbols, and shall not transmit as NEXTR symbols except the pilot tone.
- NOTE 2 The ATU-C shall transmit both FEXTR and NEXTR symbols, when Bitmap-NR is enabled (Dual Bitmap mode). ATU-C shall not transmit the NEXTR symbols except pilot tone, when Bitmap-NR is disabled (FEXT Bitmap mode).
- NOTE 3 The ATU-R shall transmit the FEXTC symbols, and shall not transmit the NEXTC symbols.
- NOTE 4 The ATU-R shall transmit both FEXTC symbols, when Bitmap-NC is enabled (Dual Bitmap mode). ATU-R shall not transmit NEXTC symbols, when Bitmap-NC is disabled (FEXT Bitmap mode).
- NOTE 5 The ATU-C shall transmit both FEXTR and NEXTR symbols.

Figure Q.27/G.992.1 – Timing diagram of the initialization sequence – Part 2

[Editor's note: updated Figure Q.27 to parameterize the length of C-B&G and the maximum length of R-REVERB5.]

Q.8 AOC On-line adaptation and reconfiguration (pertains to clause 11)

Q.8.1.1 Bit swap request (replaces 11.2.3)

The receiver shall initiate a bit swap by sending a bit swap request to the transmitter via the AOC channel. This request tells the transmitter which subcarriers are to be modified. The format of the request is shown in Table Q.19.

ĺ	Message header	Message field 1-4				
	$\{11111111_2\}$	Bitmap index	Subchannel	Command	Subchannel	
	(8 bits)	(1 bit)	index – bits 10	(5 bits)	index – bits 8	
			& 9		to 1	
			(2 bits)		(8 bits)	

Table Q.19/G.992.1 -	Format of the bit swa	ap request message
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The request shall comprise nine bytes as follows:

- an AOC message header consisting of 8 binary ones;
- message fields 1-4, each of which consists of a one-bit bitmap index, subchannel index bits 10 & 9, and a five-bit command followed by bits 8 to 1 of the subchannel index. One-bit bitmap index, subchannel index bits 10 & 9, and valid five-bit commands for the bit swap message shall be as shown in Table Q.20. In Table Q.20, the MSB for the bit swap request command represents the Bitmap index. For downstream data, Bitmap index equals 0 indicates Bitmap-F_R, and Bitmap index equals 1 indicates Bitmap-N_R. Similarly for upstream data, Bitmap index equals 0 indicates Bitmap-F_C, and 1 indicates Bitmap-N_C. The next 2 bits are subchannel index bits 10 & 9. The ten-bit subchannel index is counted from low to high frequencies with the lowest frequency subcarrier having the number zero. The subcarrier index zero shall not be used;
- the bit swap between $FEXT_{C/R}$ symbols and $NEXT_{C/R}$ symbols is not allowed.

Value (8 bit)	Interpretation					
yzz000002	Do nothing					
yzz000012	Increase the number of allocated bits by one					
yzz00010 ₂ Decrease the number of allocated bits by one						
yzz00011 ₂ Increase the transmitted power by 1 dB						
yzz00100 ₂ Increase the transmitted power by 2 dB						
yzz00101 ₂ Increase the transmitted power by 3 dB						
yzz001102	Reduce the transmitted power by 1 dB					
yzz001112	Reduce the transmitted power by 2 dB					
yzz01xxx ₂	Reserved for vendor discretionary commands					
NOTE – y is "0" for FEX	NOTE – y is "0" for $FEXT_{C/R}$ symbols, and "1" for $NEXT_{C/R}$ symbols of the Sliding Window.					
NOTE – subchannel inde	NOTE – subchannel index = zz_2 *256 + subchannel index value from lower 8 bit field					

Table Q.20/G.992.1 - Bit swap request command

The bit swap request message (i.e. header and message fields) shall be transmitted five consecutive times.

To avoid g_i divergence between ATU-C and ATU-R after several bit swaps, for a g_i update of Δ dB the new g_i value should be given by:

$$g_i' = (1/256) \times round(256 \times g_i \times 10 \exp(\Delta/20))$$
 (Q.11-1)

Q.8.1.2 Extended bit swap request (supplements 11.2.4)

The format of the extended bit swap request is shown in Table Q.21.

Message header		Message	sage field 1-6		
{11111100 ₂ }	Bitmap index	Subchannel index – bits 10	Command (5 bits)	Subchannel index – bits 8	
(8 bits)	(1 bit)	& 9	(5 0105)	to 1	
		(2 bits)		(8 bits)	

Table Q.21/G.992.1 – Format of the bit swap request message

In the same manner as the bit swap request, each of the message fields of the extended bit swap request consists of one-bit bitmap index, a five-bit command followed by a related ten-bit subchannel index.

Q.8.1.3 Bit swap acknowledge (supplements 11.2.5)

The bit swap superframe counter number shall only indicate the last superframe (SPF#4) of a hyperframe.

The new bit and/or transmit power table(s) shall then take effect starting from the first frame (frame 0) of SPF#0 of a hyperframe.

If the bit swap superframe counter number contained in the received bit swap acknowledge message does not indicate SPF#4, then the new table(s) shall take effect starting from frame 0 of SPF#0 of the next hyperframe.

Q.9 POTS splitter

For operation according to G.992.1 Annex Q-EU, the Annex E.4/G.992.3 requirements applying over a frequency band up to 1104 kHz, shall be met over a frequency band up to 3750 kHz.

付属資料3

G.992.1 ANNEX Q-EU (REVISION 4S.0) PROPRIETARY EXTENSION TO G.992.1 ANNEX I

This document defines G.992.1 Annex Q-EU (Quad spectrum downstream with extended upstream spectrum), a proprietary extension to G.992.1 Annex I to extend the data rate beyond 32 Mbit/s downstream and 4 Mbit/s upstream on short loops by way of:

- Increased downstream bandwidth → increased number of subcarriers, NSCds=1024 (used subcarriers up to 869)
- Increase upstream bandwidth \rightarrow increased number of subcarriers, NSCus=96
- Increased bit loading, beyond 15 bits/bin
- Extended framing \rightarrow S=1/2n, with support for n = 1 to 4

Due to the increase in upstream data rates, the upstream maximum interleave depth has been increased to 16. Support of this is mandatory.

The attached text is the approved text for Annex I, marked up with revision control to show the changes necessary to support the additional functionality.

Revision R4 has the following changes with respect to Revision R3.2:

- modified and upstream PSDs. Added EU-S68 to S96
- •
- added G.994.1 code points to support above changes

ANNEX Q-EU

Specific requirements for an ADSL system to support downstream data rates greater than 32 Mbit/s and upstream data rates greater than 4 Mbit/s on short loops operating in the same cable as ISDN as defined in ITU-T Recommendation G.961 Appendix III

Q.1 Scope

This annex describes those specifications that are unique to an ADSL system coexisting in the same binder as TCM-ISDN as defined Recommendation G.961 Appendix III. The subclauses in this annex provide supplementary and replacement material to the clauses in the main body. The nature of the material is parenthetically indicated in the subclause heading. The modifications described in this annex allow a performance improvement from the ADSL system specified in Annex C for short loops in an environment coexisting with TCM-ISDN in the same cable. Specifically, this Annex specifies extensions to downstream and upstream bandwidth, framing modes, and maximum bit loading to support downstream data rates greater than 32 Mbit/s and upstream data rates greater than 4 Mbit/s. This annex also defines those parameters of this ADSL system that have been left undefined in the main body of this Recommendation. An ADSL system implementing Annex Q-EU shall support Annex Q. It is recommended that an ADSL system implementing Annex Q-EU shall support Annex Q.

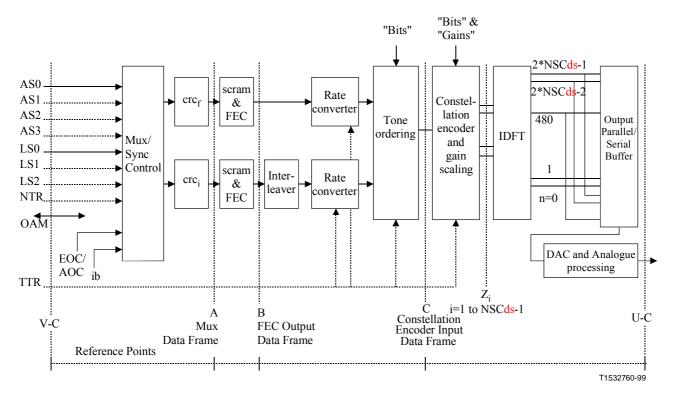
Q.2 Definitions

Bitmap-F _C ATU-R transmitter bitmap under TCM-ISDN FEXT noise generated at ATU-C	
Bitmap-F _R ATU-C transmitter bitmap under TCM-ISDN FEXT noise generated at ATU-R	
Bitmap-N _C ATU-R transmitter bitmap under TCM-ISDN NEXT noise generated at ATU-C	
Bitmap-N _R ATU-C transmitter bitmap under TCM-ISDN NEXT noise generated at ATU-R	
Dual BitmapThe Dual Bitmap method has dual bit rates under the FEXT and NEXT noise from TCM-ISDNFEXT BitmapSimilar to the Dual Bitmap method however transmission only occurs during FEXT noise from TCM-ISDN	
FEXT _C duration TCM-ISDN FEXT duration at ATU-C estimated by the ATU-R	
FEXT _C symbol DMT symbol transmitted by ATU-R during TCM-ISDN FEXT	
FEXT _R duration TCM-ISDN FEXT duration at ATU-R estimated by the ATU-C	
FEXT _R symbol DMT symbol transmitted by ATU-C during TCM-ISDN FEXT	
Hyperframe5 Superframes structure which synchronized TTRNEXT _C durationTCM-ISDN NEXT duration at ATU-C estimated by the ATU-R	
NEXT _C symbol DMT symbol transmitted by ATU-R during TCM-ISDN NEXT	
NEXT _R duration TCM-ISDN NEXT duration at ATU-R estimated by the ATU-C	
NEXT _R symbol DMT symbol transmitted by ATU-C during TCM-ISDN NEXT	
NSCds The highest subcarrier index that can be used for downstream transmission (i.e., the subcarrier index corresponding to the Nyquist frequency) For example, NSCds = 256 for a downstream channel using the frequency band up to 1.104MHz; NSCds = 512 for a downstream channel using the frequency band up to 2.208MHz.	n
NSCus The highest subcarrier index that can be used for upstream transmission (i.e., the subcarrie index corresponding to the Nyquist frequency) For example, NSCus = 64 for an upstream channel using the frequency band up to 276 kHz.	
N _{SWF} Sliding Window frame counter	
Subframe10 consecutive DMT symbols (except for sync symbols) according to TTR timingTTRTCM-ISDN Timing Reference	
TTR _C Timing reference used in ATU-C	
TTR _R Timing reference used in ATU-R	
UI Unit Interval	

Q.3 Reference Models

Q.3.1 ATU-C transmitter reference model (replaces figures in 5.1)

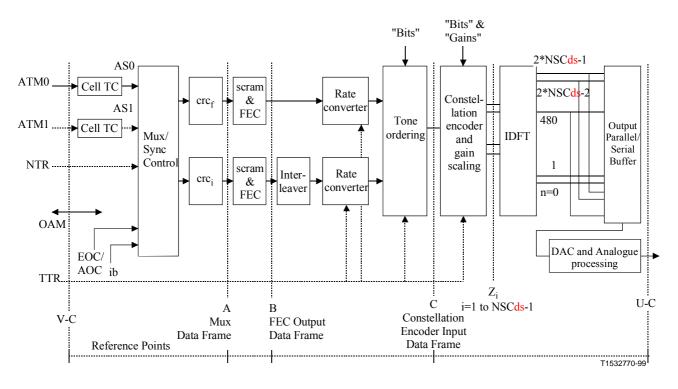
See Figure Q.1 and Figure Q.2.



NOTE - The TTR may be generated in ATU-C without being provided from the TCM-ISDN clock.

Figure Q.1/G.992.1 – ATU-C transmitter reference model for STM transport

Annex Q-EU does not currently support STM transport. It only supports ATM transport.

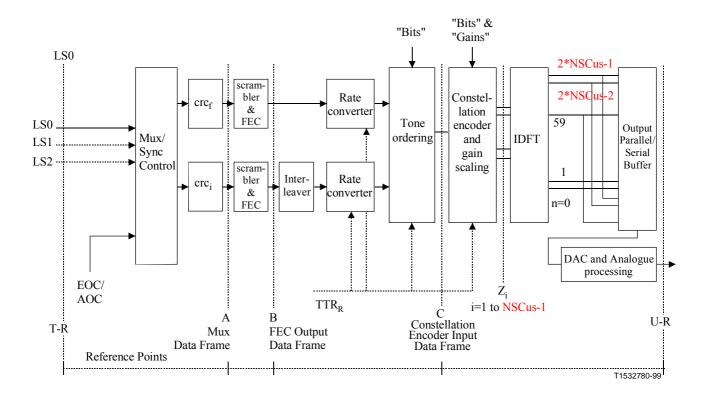


NOTE - The TTR may be generated in ATU-C without being provided from the TCM-ISDN clock.

Figure Q.2/G.992.1 – ATU-C transmitter reference model for ATM transport

Q.3.2 ATU-R transmitter reference model (replaces figures in 5.2)

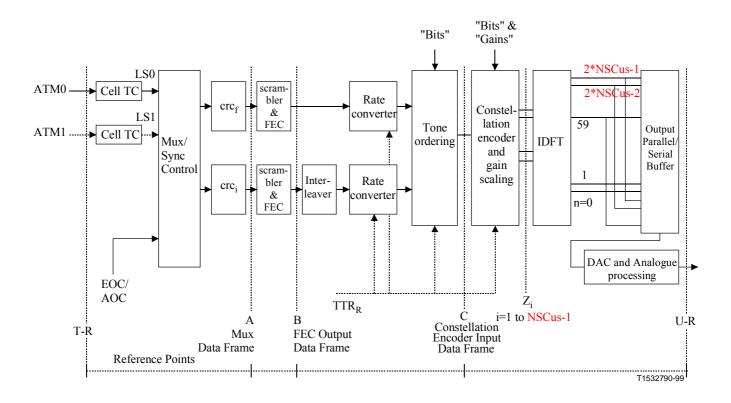
See Figure Q.3 and Figure Q.4.



NOTE – The TTR_R shall be generated in ATU-R from the received TTR_C signal, and it is locked to 690 periods of upstream sampling clock (1.104 MHz).

Figure Q.3/G.992.1 – ATU-R transmitter reference model for STM transport

Annex Q-EU does not currently support STM transport. It only supports ATM transport.



NOTE – The TTR_R shall be generated in ATU-R from the received TTR_C signal, and it is locked to 690 periods of upstream sampling clock (1.104 MHz).



Q.3.3 ATU-C/R transmitter timing model (replacement for 5.3)

Q.3.3.1 TCM-ISDN crosstalk timing model (new)

Figure Q.5 shows the timing chart of the crosstalk from TCM-ISDN.

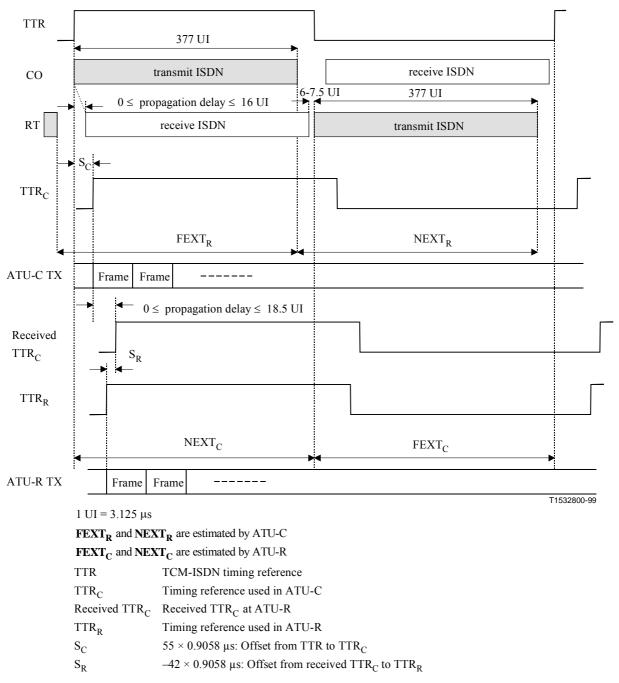


Figure Q.5/G.992.1 – Timing chart of the TCM-ISDN crosstalk

The data stream of TCM-ISDN is transmitted in TTR period. CO transmits the stream in the first half of the TTR period and RT transmits in the second half of the TTR period. ATU-C receives NEXT noise from the ISDN in the first half of the TTR period and FEXT noise from the ISDN in the second half of the TCM-ISDN period. On the other hand, ATU-R receives FEXT noise from the ISDN in the first half of the TTR period and NEXT noise from the ISDN in the second half of the TTR period.

As defined in Q.7.6.2 and Q.7.8.3, the ATU-C shall estimate the FEXT_R and NEXT_R duration at ATU-R, and the ATU-R shall estimate FEXT_C and NEXT_C duration at ATU-C taking propagation delay on the subscribe line into consideration.

The ATU-C shall transmit any symbols by synchronizing with the TTR_C . The ATU-R shall transmit any symbols synchronizing with the TTR_R generated from received TTR_C .

Q.3.3.2 Sliding window (new)

Figure Q.6 shows the timing chart of the transmission for the Annex Q-EU downstream at ATU-C.

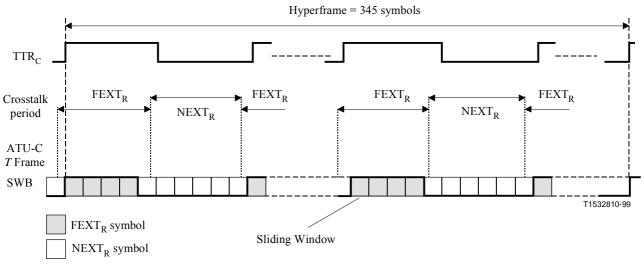


Figure Q.6/G.992.1 – Sliding window for downstream symbols

The Sliding Window defines the transmission symbols under the crosstalk noise environment synchronized to the period of TTR. The $\text{FEXT}_{C/R}$ symbol represents the symbol completely inside the $\text{FEXT}_{C/R}$ duration. The $\text{NEXT}_{C/R}$ symbol containing the $\text{NEXT}_{C/R}$ duration. Thus, there are more $\text{NEXT}_{C/R}$ symbols than $\text{FEXT}_{C/R}$ symbols.

The ATU-C decides which transmission symbol is FEXT_R or NEXT_R symbol according to the sliding window and transmits it with the corresponding bit table. Similarly, the ATU-R decides the transmission symbol is a FEXT_C or NEXT_C and transmits it with the corresponding bit table. Although the phase of the sliding window is asynchronous with $\text{TTR}_{C/R}$, the pattern is fixed to the 345 frames of the hyperframe.

Q.3.3.3 ATU-C Symbol Synchronization to TTR (new)

345 symbols are 34 cycles with cyclic prefix of TTR_C (or 32 cycles of TTR_C without cyclic prefix). This implies a PLL lock at the ATU-R.

Q.3.3.4 Dual Bitmap switching (new)

The ATU-C transmits FEXT_R symbols using Bitmap-F_R (in FEXT_R duration), and transmits NEXT_R symbols using Bitmap-N_R (in NEXT_R duration) according to the result of initialization. The ATU-R transmits FEXT_C symbols using Bitmap-F_C (in FEXT_C duration), and transmits NEXT_C symbols using Bitmap-N_C (in NEXT_C duration) in the same manner.

The ATU-C shall have the capability to disable Bitmap-N_C and Bitmap-N_R (see Q.4.5 and Q.5.3).

Q.3.3.5 Loop timing at ATU-R (new)

The phase relation between received symbol and transmitted symbol of ATU-R at the reference point U-R shall meet the phase tolerances as shown in Figure Q.7.

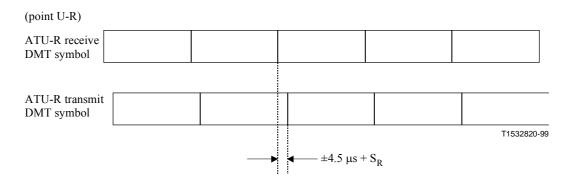
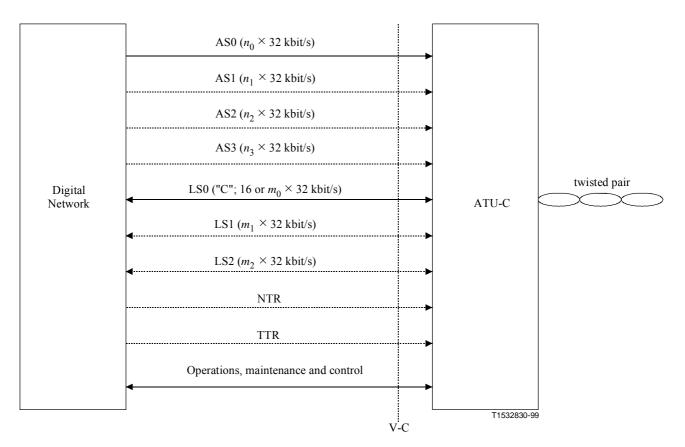


Figure Q.7/G.992.1 – Loop timing for ATU-R

- Q.4 ATU-C functional characteristics (pertains to clause 7)
- Q.4.1 STM transmission protocols specific functionality (pertains to 7.1)
- Q.4.1.1 ATU-C input and output V interface for STM transport (replaces figure in 7.1.1)

See Figure Q.8.



NOTE 1 – Optional bearer channels (both duplex and simplex) and features are shown with dotted lines. NOTE 2 – TTR may be generated in the ATU-C without being provided from the V-C reference point.

Figure Q.8/G.992.1 – ATU-C functional interfaces for STM transport at the V-C reference point

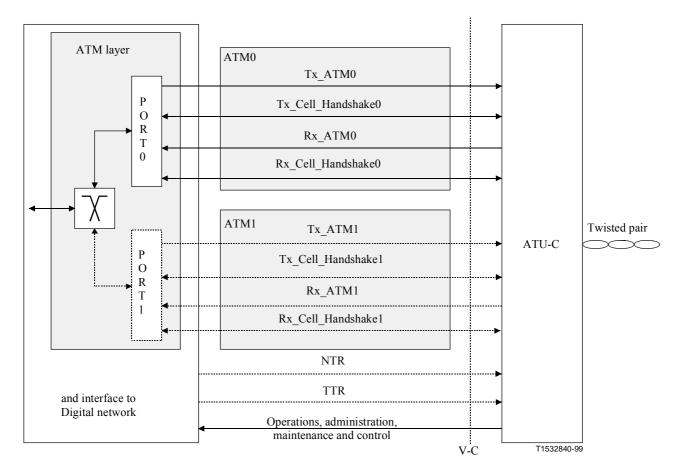
Q.4.1.2 Payload transfer delay (supplements 7.1.4)

Since Annex Q-EU uses a rate converter, the maximum payload transfer delay is longer than specified values in 7.1.4. The additional one-way transfer delay due to the rate converters shall be less than 1.7 ms for fast data and 13 ms for interleaved data.

Q.4.2 ATM transmission protocols specific functionalities (pertains to 7.2)

Q.4.2.1 ATU-C Input and Output V interface for ATM transport (replaces figure in 7.2.1)

See Figure Q.9.



NOTE - TTR can be generated in the ATU-C without being provided from the V-C reference point.

Figure Q.9/G.992.1 – ATU-C functional interfaces to the ATM layer at the V-C reference point

Q.4.2.2 Payload transfer delay (supplements 7.2.2)

Since Annex Q-EU uses a rate converter, the maximum payload transfer delay is longer than specified values in 7.2.2. The additional one-way transfer delay due to the rate converters shall be less than 1.7 ms for fast data and 13 ms for interleaved data.

Q.4.3 Framing (pertains to 7.4)

Q.4.3.1 Superframe structure (supplements 7.4.1.1)

Since the rate converter reorders the user data and overhead bit-level data to create hyperframes, the input data frames to the constellation encoder are different than those defined in 7.4.1.1.

Q.4.3.2 Hyperframe structure (replaces 7.4.1.3)

Annex Q-EU uses the hyperframe structure shown in Figure Q.10. Figure Q.10 shows the phase relationship between the TTR_C and the hyperframe at the point U-C. Each hyperframe is composed of 5 superframes, which are numbered from 0 to 4. In order to indicate the boundary of the hyperframe, the inverse synch symbol is used for the 4th superframe (SPF#3), which is generated from a tone-by-tone 180-degree phase reversal of the synchronization symbol (see Q.4.7.1) except for the pilot tone.

The bit-level data stream from the rate-converter is extracted according to the size of Bitmap- F_R and Bitmap- N_R using the Sliding Window (see Q.3.3.2).

In order to make the bit rate to be a multiple of 32 kbit/s, the dummy bits are inserted at the end of hyperframe by the

rate converter (see Q.4.4.2). The hyperframe is composed of 345 DMT symbols, numbered from 0 to 344. Each symbol is assigned as $FEXT_R$ or $NEXT_R$ or $NEXT_R$ or $NEXT_R$ duration (see Q.2), and the following numerical formula gives the information which duration N_{dmt}-th DMT symbol belongs to at ATU-C transmitter (see Figure Q.11).

 $\label{eq:states} \begin{array}{ll} \mbox{For $N_{dmt}=0,1,...,344$} \\ \mbox{$S=272$ x N_{dmt} mod 2760} \\ \mbox{$if $\{$ (S+271 < a)$ or $(S>a+b)$ $\}$} \\ \mbox{$else$} \\ \mbox{$then $FEXT_R$ symbol$} \\ \mbox{$then $NEXT_R$ symbol$} \\ \mbox{$where $a=1243$, $b=1461$} \\ \end{array}$

Thus, 128 DMT symbols are allocated in the FEXT_R duration, and 217 DMT symbols are allocated in the NEXT_R duration. The symbols are composed of:

FEXT _R symbol:						
Number of symbol using Bitmap-F _R	= 126					
Number of synch symbol	= 1					
Number of inverse synch symbol NEXT $_{R}$ symbol:	= 1					
Number of symbol using Bitmap-N _R	= 214					
Number of synch symbol	= 3					

During FEXT Bitmap mode, the ATU-C shall transmit only the pilot tone in NEXT_R symbols.

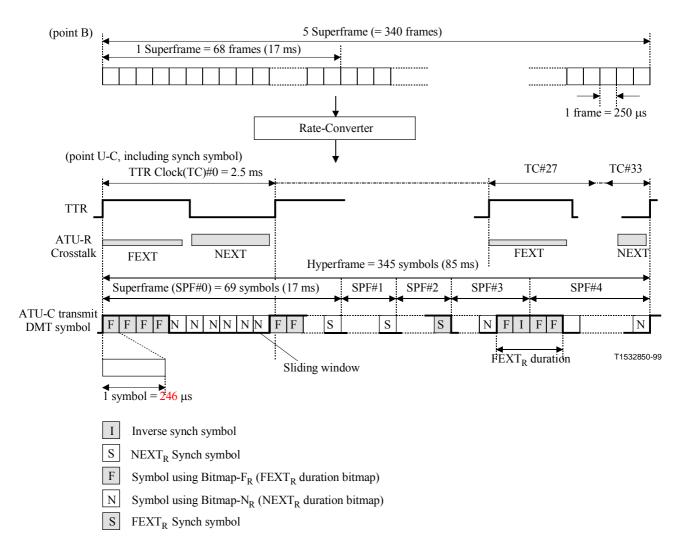


Figure Q.10/G.992.1 – Hyperframe structure for downstream

2									
0	0 1 2	3	4	5		6	7	8	9
1	10 11 12	13	14	15	16	5 17	7 18	3 1	9
2	20 21 22	23	24	25	26	27	28	29	
3	30 31 32	33 3	34	35	36	37	38	39	40
4	41 42	43 44	4	45	46	47	48	49	50
5	51 52 5	3 54		55	56	57	58	59	60
6	61 62 63	64	6	5 6	6	67	SS	69	70
7	71 72 73	74	75	76	7	7 7	8 7	9 8	30
8	81 82 83	84	85	86	87	88	89) 9()
9	91 92 93	94	95	96	97	98	99	100	101
10	101 102 103	104 10	05	106	107	108	109	110	111
11		14 11:		116	117	118	119	120	121
12	122 123 12				127	128	129	130	131
13	132 133 134	135	13						141
14	142 143 144	145	146						51
15	152 153 154	155	156		158				
16	162 163 164		166	167	168	169	170	171	172
17			76	177	178	179	180	181	182
18	183 184 1 193 194 19	85 180 5 196		187 97 1	188 98	189 199	190 200	191 201	192
19 20	203 204 205	5 196 SS	20		· · ·		· · ·		202
20	203 204 203 213 214 215	216	217	· · · ·		<u> </u>			212 22
21	213 214 213 223 224 225	226	227		229	·			
22	233 234 235		227	238	239	240	241	242	243
23		246 24		248	249	250	251	252	253
25		56 257		258	259	260	260	262	263
26	264 265 26					270	271	272	273
27	274 ISS 276	277	27		9 2	80 2	81 2	82 2	283
28	284 285 286	287	288	289	29	0 29	1 29	2 29)3
29	294 295 296	297	298	299	300	301	302	303	;
30	304 305 306	307 3	08	309	310	311	312	313	314
31	315 316 3	317 31	8	319	320	321	322	323	324
32	325 326 32	27 328	3	329	330	331	332	333	334
33	335 336 337	7 338	3	39 3	40	341	342	343	SS
	ISS Inverse synch sym	ibol S	SS F	EXT _r Sy	/nch syn	nbol SS	NEXT	Г _R synch	symbol
	FEXT _R data symbol	ol 🗌	N	IEXT _R da	ata symb	ol		T1	535330-00

Figure Q.11/G.992.1 – Symbol pattern in a hyperframe with cyclic prefix – Downstream

Q.4.3.3 Subframe Structure (replaces 7.4.1.4)

A subframe is 10 consecutive DMT symbols (except for synch symbols) as shown in Table Q.1. The 34 subframes form a hyperframe.

Subframe No.	DMT symbol No.	Note
0	0-9	
1	10-19	
2	20-29	
3	30-39	
4	40-49	
5	50-59	
6	60-70	#68 is Synch Symbol
7	71-80	
8	81-90	
9	91-100	
10	101-110	
11	111-120	
12	121-130	
13	131-141	#137 is Synch Symbol
14	142-151	
15	152-161	
16	162-171	
17	172-181	
18	182-191	
19	192-201	
20	202-212	#206 is Synch Symbol
21	213-222	
22	223-232	
23	233-242	
24	243-252	
25	253-262	
26	263-272	
27	273-283	#275 is Inverse Synch Symbol
28	284-293	
29	294-303	
30	304-313	
31	314-323	
32	324-333	
33	334-344	#344 is Synch Symbol

Table Q.1/G.992.1 – Subframe (downstream)

Q.4.3.4 Reduced overhead framing with merged fast and sync bytes (modifies 7.4.3.2)

In S=1/2n framing mode (see Q.4.9), there are n Sync bytes per symbol time. The contents of the Sync bytes is the same as in regular framing except that it repeats at n times the rate causing the superframe to be 68/n symbols in length. The contents of the sync bytes are shown in Table 7-6/G.992.1. In S=1/2n framing mode, "Frame Number" in column 1 in Table 7-6/G.992.1 is replaced by "Sync Byte Index Number".

As a result of the increase in superframe rate, the superframe contents is carried more frequently. For the case when N=2, the EOC and AOC bandwidth doubles, thereby transferring actual messages at twice the rate. The CRC byte is carried twice as frequently and therefore the maximum error rate rises from just over 58 per second to 117 per second. Where the duration of an error condition is measured, this needs to be taken into consideration. The indicator bits are also sent twice as often, which needs to be taken into consideration.

Q.4.4 Dual Bitmapping and Rate Conversion (replaces 7.15)

The functions of the rate converter (see Q.4.4.2), tone ordering (see Q.4.6), constellation encoding, and gain scaling shall use one of two bitmaps stored in the ATU. This method is called the dual bitmap.

Q.4.4.1 Dual Bitmap (new)

The Dual Bitmap method has individual bit rates under the FEXT and NEXT noise, and this needs an additional bit and gain table, $\{b_i, g_i\}$, and ordered bit table, b'_i , for the tone ordering. The dual bitmaps are switched synchronized with the sliding window pattern of NEXT/FEXT symbols. The number of bits and the relative gains to be used for every tone are calculated in the bit loading algorithm during the initialization sequence, and transmitted in R-B&G.

Q.4.4.2 Rate Converter (new)

The rate converter buffering changes the data frame boundaries between the reference points B and C according to Bitmap- F_R , Bitmap- N_R and the Sliding Window. Two independent rate converters are prepared for fast data and interleaved data. The amount of fast and interleaved data in Bitmap- F_R and Bitmap- N_R shall be calculated with the following formulae and illustrated in Figure Q.12:

If $t_{Rf} \le n_{Rmax}$:

$$n_{Rf} = t_{Rf}$$

$$n_{Ri} = n_R - n_{Rf}$$

$$f_{Rf} = t_{Rf}$$

$$f_{Ri} = f_R - f_{Rf}$$

If $t_{Rf} > n_{Rmax}$:

$$n_{Rf} = n_{R \max}$$

$$n_{Ri} = 0$$

$$f_{Rf} = \begin{cases} f_{Rf4} = \left\lceil \frac{t_{Rf} \times 10 - n_{Rf} \times 6}{4} \right\rceil$$

$$f_{Rf3} = \left\lceil \frac{t_{Rf} \times 10 - n_{Rf} \times 7}{3} \right\rceil$$

$$f_{Ri} = \begin{cases} f_{Ri4} = f_R = f_{Rf4} \\ f_{Ri3} = f_R - f_{Rf3} \end{cases}$$

Where:

^t Rf	is the number of allocated bits in one frame for fast bytes at the reference point B.
t _{Ri}	is the number of allocated bits for interleaved bytes at the reference point B.
f_{Rf} and n_{Rf}	are the numbers of fast bits in Bitmap- F_R and Bitmap- N_R , respectively.
f _{Rf3}	is the number of fast bits in Bitmap- F_R if the subframe (see Q.4.3.3) contains 3 Bitmap- F_R except
f _{Rf4}	for synch symbols. is the number of fast bits in Bitmap- F_R if the subframe contains 4 Bitmap- F_R except for synch
f _{Ri} and n _{Ri} ⁿ R	symbols. are the numbers of interleaved bits in Bitmap- F_R and Bitmap- N_R , respectively. is the number of total bits in Bitmap- N_R , which is specified in the B&G tables.

During FEXT Bitmap mode, n_{Rf} and n_{Ri} are zero.

To convert the bit rate to be a multiple of 32 kbit/s, the dummy bits for fast data are inserted to the tail of each subframe, and the dummy bits for interleaved data are inserted to the end of the Hyperframe. The number of the dummy bits shall be as follows:

If $t_{Rf} \le n_{Rmax}$:

$$dummy_{Rf} = 0$$
$$dummy_{Ri} = (f_{Ri} \times 126 + n_{Ri} \times 214) - t_{Ri} \times 340$$

If $t_{Rf} > n_{Rmax}$:

$$dummy_{Rf4} = (f_{Rf} \times 4 + n_{Rf} \times 6) - t_{Rf} \times 10$$

$$dummy_{Rf3} = (f_{Rf} \times 3 + n_{Rf} \times 7) - t_{Rf} \times 10$$

$$dummy_{Ri} = (f_{Ri4} \times 96 + f_{Ri3} \times 30) - t_{Ri} \times 340$$

If the fast data buffer uses single latency only, additional dummy bits are inserted at the tail of each FEXT symbol in the 4 Bitmap- F_R constructed subframe. The number of additional dummy bits inserted at the tail of each FEXT symbol shall be as follows:

$$dummy_{SRf} = f_{Rf3} - f_{Rf4}$$

The receiver shall determine Bitmap- F_R and Bitmap- N_R so that $dummy_{Ri}$ is less than 126, $dummy_{Rf4}$ is less than 4 and $dummy_{Rf3}$ is less than 3 in the initialization sequence. At the receiver, the inserted dummy bits shall be removed.

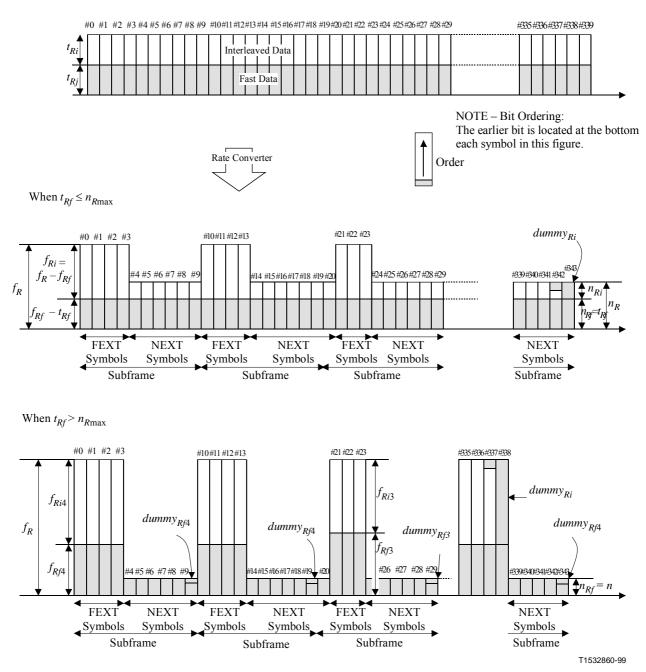


Figure Q.12/G.992.1 – Bit distribution for Rate Converter under Dual latency and Dual Bitmap mode

Q.4.5 FEXT Bitmapping (replaces 7.16)

The FEXT Bitmapping mode uses the Dual Bitmapping technique (Q.4.4) to transmit data only during FEXT. The ATU-C shall transmit only the pilot tone during the NEXT_R symbol. The ATU-R disables Bitmap-N_C and shall not transmit any signal during the NEXT_C symbol (see Figures Q.10 and Q.16).

Annex Q-EU does not support the FEXT Bitmapping mode.

Q.4.6 Tone Ordering (replacement for 7.7)

A DMT time-domain signal has a high peak-to-average ratio (its amplitude distribution is almost Gaussian), and large values may be clipped by the digital-to-analogue converter. The error signal caused by clipping can be considered as an additive negative impulse for the time sample that was clipped. The clipping error power is almost equally distributed across all tones in the symbol in which clipping occurs. Clipping is therefore most likely to cause errors on those tones

that, in anticipation of a higher received SNR, have been assigned the largest number of bits (and therefore have the densest constellations). These occasional errors can be reliably corrected by the FEC coding if the tones with the largest number of bits have been assigned to the interleave buffer.

The numbers of bits and the relative gains in two bitmaps to be used for every tone are calculated in ATU-R receiver, and sent back to ATU-C according to a defined protocol (see 10.9.14). The pairs of numbers are typically stored, in ascending order of frequency or tone numbers *i*, in bit and gain tables for Bitmap- F_R and Bitmap- N_R .

For Bitmap- F_R , the "tone-ordered" encoding shall first assign f_{Rf} bits from the rate converter (see Q.4.4.2) to the tones with the smallest number of bits assigned to them, and the remaining f_{Ri} bits to the remaining tones. For Bitmap- N_R , it shall first assign n_{Rf} bits from the rate converter to the tones with the smallest number of bits assigned to them, and the remaining n_{Ri} bits to the remaining tones.

All tones shall be encoded with the number of bits assigned to them; one tone in each bitmap may therefore have a mixture of bits from the fast and interleaved buffers.

The ordered bit tables b'_{iF} and b'_{iN} shall be based on the original bit tables b_{iF} and b_{iN} as follows:

For k = 0 to N_{downmax} {

From the bit table, find the set of all *i* with the number of bits per tone $b_i = k$

Assign b_i to the ordered bit allocation table in ascending order of i

```
}
```

Two ordered bit tables for Bitmap- F_R and Bitmap- N_R shall be prepared. A complementary de-ordering procedure should be performed in ATU-R receiver. It is not necessary, however, to send the results of the ordering process to the receiver because the bit tables F_R and N_R were originally generated in ATU-R, and therefore those tables have all the information necessary to perform the de-ordering.

Q.4.7 Modulation (pertains to 7.11)

Q.4.7.1 Inverse Synchronization Symbol (replaces 7.11.4)

Except for the pilot tone, Inverse Synchronization symbol shall be generated from a tone-by-tone 180 degree phase reversal of Synchronization symbol (i.e. + maps to -, and - maps to +, for each of the 4-QAM signal constellation).

Q.4.7.2 Data subcarriers (modifies 7.11.1.1)

The channel analysis signal defined in 10.6.6 allows for a maximum of NSCds-1 carriers (at frequencies $n\Delta f$, n = 1 to NSCds-1) to be used.

Q.4.7.3 Nyquist frequency (modifies 7.11.1.3)

The carrier at the Nyquist frequency (#NSCds) shall not be used for user data and shall be real valued; other possible uses are for further study.

Q.4.7.4 Modulation by the inverse discrete Fourier transform (replaces 7.11.2)

The modulating transform defines the relationship between the 2*NSCds real values x_n and the Z_i :

$$x_{n} = \sum_{i=0}^{2^{*}NSCds-1} \exp\left(\frac{j\pi ni}{NSCds}\right) Z_{i} \quad \text{for } n = 0 \text{ to } 2^{*}NSC-1$$
(7-21)

The value of NSCds shall be 1024 for this Annex. However, the highest used subcarrier index shall be limited to 869.

The constellation encoder and gain scaling generate only NSCds-1 complex values of Z_i . In order to generate real values of x_n , the input values (NSCds-1 complex values plus zero at DC and one real value for Nyquist if used) shall be augmented so that the vector Z has Hermitian symmetry. That is,

 $Z_i = \operatorname{conj} \left(Z'_{2*NSCds-i} \right) \quad \text{for } i = \operatorname{NSCds+1} \text{ to } 2*\operatorname{NSCds-1}$ (7-22)

Q.4.7.5 Synchronization symbol (modifies 7.11.3)

The synchronization symbol permits recovery of the frame boundary after micro-interruptions that might otherwise force retraining.

The data symbol rate, $f_{symb} = 4$ kHz, the carrier separation, $\Delta f = 4.3125$ kHz, and the IDFT size, N = 2*NSCds, are such that a cyclic prefix of 15.625%*NSCds samples could be used. That is, when NSCds = 256, there are 40 samples in the cyclic prefix.

$$(512+40) \times 4.0 = 512 \times 4.3125 = 2208 \tag{7-23}$$

The cyclic prefix shall, however, be shortened to 12.5%*NSCds samples, and a synchronization symbol (with a nominal length of NSCds*2.125 samples) is inserted after every 68 data symbols. That is,

$$(2 + 0.125)$$
*NSCds × 69 = $(2 + 0.15625)$ *NSCds × 68(7-24)

The data pattern used in the synchronization symbol shall be the pseudo-random sequence PRD, $(d_n, \text{ for } n = 1 \text{ to } 2*\text{NSCds})$ defined by:

$$d_n = 1$$
 for $n = 1$ to 9 (7-25)
 $d_n = d_{n-4} \oplus d_{n-9}$ for $n = 10$ to 2*NSCds (7-26)

The first pair of bits (d_1 and d_2) shall be used for the DC and Nyquist subcarriers (the power assigned to them is zero, so the bits are effectively ignored); the first and second bits of subsequent pairs are then used to define the X_i and Y_i for i = 1 to NSCds-1 as shown in Table 7-13.

The period of the PRD is only 511 bits, so d_{n+511} is equal to d_n . The d_1 - d_9 shall be re-initialized for each synchronization symbol, so each symbol uses the same data.

The two bits that modulate the pilot carrier, shall be overwritten by $\{0,0\}$: generating the $\{+,+\}$ constellation.

The minimum set of subcarriers to be used is the set used for data transmission (i.e. those for which $b_i > 0$); subcarriers for which $b_i = 0$ may be used at a reduced PSD as defined in transmit PSD paragraphs of Annexes A, B and C. The data modulated onto each subcarrier shall be as defined above; it shall not depend on which subcarriers are used.

Q.4.7.6 Cyclic prefix (replaces 7.12)

The last 12.5%*NSCds samples of the output of the IDFT (x_n for n = 2*NSCds-0.125*NSCds to 2*NSCds-1) shall be prepended to the block of 2*NSCds samples and read out to the digital-to-analogue converter (DAC) in sequence. For example, when NSCds=256, the subscripts, n, of the DAC samples in sequence are 480 ... 511, 0 ... 511.

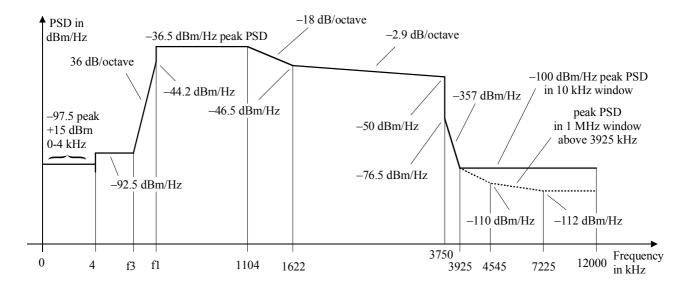
The cyclic prefix shall be used for all symbols beginning with the C-RATES1 segment of the initialization sequence, as defined in 10.6.2.

Q.4.8 ATU-C Downstream transmit spectral masks (replaces 7.14)

The downstream spectral masks of Annex Q-EU are as specified in this section. When C-MSG1 bit 16 is 0, the PSD mask as specified in § Q.4.8.1 shall be used. When C-MSG1 bit 16 is 1, the PSD mask as specified in § Q.4.8.2 shall be used.

Q.4.8.1 Downstream non-overlapped PSD mask definition

The non-overlapped PSD masks are defined with absolute peak values in Figure Q.13. The low frequency stop band is defined for frequencies below f1 kHz (tone n1); the high frequency stop band is defined at frequencies greater than 3750 kHz (tone 869). The in-band region of these PSD masks is the frequency band from f1 kHz to 3750 kHz.



Frequency band f (kHz)	Equation for line (dBm/Hz)
0 < f < 4	-97.5
4 < f < f3	-92.5
f3 < f < f1	$-92.5 + 36 \log(f/f3)$
f1 < f < 1104	-36.5
1104 < f < 1622	-36.5 - 18.0*log2(f/1104)
$1622 \le f \le 3750$	-46.5 - 2.9*log2(f/1622)
3750 < f < 3925	-76.5 - 357*log2(f/3750)
3925 < f < 12000	-100

Frequency (kHz)	PSD level (dBm/Hz)	Measurement BW
0	-97.5	100 Hz
4	-97.5	100 Hz
4	-92.5	100 Hz
f3	-92.5	10 kHz
fl	-44.2	10 kHz
fl	-36.5	10 kHz
1104	-36.5	10 kHz
1622	-46.5	10 kHz
3750	-50	10 kHz
3750	-76.5	10 kHz
3925 - 12000	-100	10 kHz

Additionally the PSD masks shall satisfy the following requirements:

Frequency (kHz)	PSD level (dBm/Hz)	Measurement BW
3925	-100	1 MHz
4545	-110	1 MHz
7225	-112	1 MHz
12000	-112	1 MHz

The corner frequencies f1 and f3 depend on the associated upstream PSD mask used, see §Q.5.6) and are defined as follows:

Mask designator	Associated	f1 (kHz)	f3 (kHz)
(DS-mm)	upstream mask		
DS-32	EU-32	138	54.45
DS-36	EU-36	155.25	61.26
DS-40	EU-40	172.5	68.06
DS-44	EU-44	189.75	74.87
DS-48	EU-48	207	81.67
DS-52	EU-52	224.25	88.48
DS-56	EU-56	241.5	95.29
DS-60	EU-60	258.75	102.09
DS-64	EU-64	276	108.9
DS-68	EU-S68	293.25	115.71
DS-72	EU-S72	310.5	122.51
DS-76	EU-S76	327.75	129.32
DS-80	EU-S80	345	136.12
DS-84	EU-S84	362.25	142.93
DS-88	EU-S88	379.5	149.74
DS-92	EU-S92	396.75	156.54
DS-96	EU-S96	414	163.35

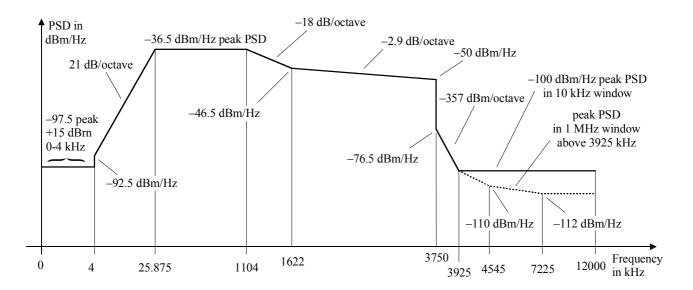
- NOTE 1 All PSD measurements are in 100 Ω ; the POTS band total power measurement is in 600 Ω .
- NOTE 2 The breakpoint frequencies and PSD values are exact; the indicated slopes are approximate. The breakpoints in the tables shall be connected by linear straight lines on a dB/log(f) plot.
- NOTE 3 MBW specifies the Measurement Bandwidth. The MBW specified for a certain breakpoint with frequency fi is applicable for all frequencies satisfying $fi < f \le fj$, where fj is the frequency of the next specified breakpoint.
- NOTE 4 The power in a 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency i.e. power in the [f, f + 1 MHz] window shall conform to the specification at frequency f.
- 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.

Figure Q.13: Non-overlapped Downstream Channel PSD Masks

Spectral Shaping of the In-Band Region defined in Q.4.8.3 and Transmit Signals with Limited Transmit Power defined in Q.4.8.4 shall be applied.

Q.4.8.2 Downstream Overlapped PSD mask definition

The overlapped PSD mask is defined with absolute peak values in Figure Q.14. The low frequency stop band is defined for frequencies below 25.875 kHz (tone 6); the high frequency stop band is defined at frequencies greater than 3750 kHz (tone 869). The in-band region of this PSD mask is the frequency band from 25.875 kHz to 3750 kHz.



Frequency band f (kHz)	Equation for line (dBm/Hz)
0 < f < 4	-97.5
4 < f < 25.875	$-92.5 + 21*\log 2(f/4)$
25.875 < f < 1104	-36.5
1104 < f < 1622	-36.5 - 18.0*log2(f/1104)
1622 < f < 3750	-46.5 - 2.9*log2(f/1622)
3750 < f < 3925	-76.5 - 357*log2(f/3750)
3925 < f < 12000	-100

Frequency (kHz)	PSD level (dBm/Hz)	Measurement Bandwidth
0	-97.5	100 Hz
4	-97.5	100 Hz
4	-92.5	100 Hz
10	interpolated	10 kHz
25.875	-36.5	10 kHz
1104	-36.5	10 kHz
1622	-46.5	10 kHz
3750	-50.0	10 kHz
3750	-76.5	10 kHz
3925 - 12000	-100	10 kHz

Additionally, the PSD mask shall be satisfying following requirements:

Frequency (kHz)	PSD level (dBm/Hz)	Measurement Bandwidth
3925	-100	1 MHz
4545	-110	1 MHz
7225	-112	1 MHz
12000	-112	1 MHz

NOTE 1 –	All PSD measurements are in 100 Ω ; the POTS band total	power measurement is in 600 Ω .
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- NOTE 2 The breakpoint frequencies and PSD values are exact; the indicated slopes are approximate. The breakpoints in the tables shall be connected by linear straight lines on a dB/log(f) plot.
- NOTE 3 MBW specifies the Measurement Bandwidth. The MBW specified for a certain breakpoint with frequency fi is applicable for all frequencies satisfying $fi < f \le fj$, where fj is the frequency of the next specified breakpoint.
- NOTE 4 The power in a 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency i.e. power in the [f, f + 1 MHz] window shall conform to the specification at frequency f.
- 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.

Figure Q.14: Overlapped Downstream Channel PSD Mask.

Q.4.8.3 Spectral Shaping of the In-Band Region of the PSD Spectrum

In order to shape the ATU-C PSD, frequency dependent gains, called spectral shaping values (ssv_i), shall be applied on each tone during initialization and showtime. The ssv_i values shall be represented with 1 bit before and 10 bits after the decimal point.

Table Q.2 defines the corner points for the nominal PSD shape of the inband region as gain in dB, i.e. log_ssv_i . Log_ssv_i on other tones shall be linearly interpolated between corner points on a logarithmic scale for the gain (dB) and a linear scale for the frequency (Hz). Note that the corner points defined in Table Q.2 are relative values. Table Q.3 defines the similar corner points for the overlapped spectrum.

The spectral shaping values shall be converted from logarithmic scale (log_ssv_i , dB values) to linear ssv_i values according to:

$$ssv_i = \frac{Round\left(1024 \times 10^{\frac{\log_s ssv_i}{20}}\right)}{1024}$$

These points are not passed at initialization for the nominal PSD shape but are provided here for reference. However, for additional spectral shaping (see Q.4.8.5), parameters are passed during G.994.1.

The combined accuracy of the process of linear interpolation of the log_ssvi values and the process of conversion to linear ssv_i values shall be strictly less than one half lsb of the 10 bit after the decimal point format of the linear ssvi values. No error shall be introduced when log_ssv_i equals 0dB or is interpolated between log_ssv_i values, which equal 0dB.

- NOTE 1: The above definition ensures that the maximum deviation between ssv_i values used by transmitter and receiver is one lsb.
- NOTE 2: The above needs an accuracy that is strictly < 1/2 lsb. An accuracy of = 1/2 lsb, will lead to inaccurate results.

Tone Index	$Log_ssv_i(dB)$	Comments
nl	0	f1 kHz defines the beginning of the inband region. No shaping is applied in the
		low stop band.
256	0	1104 kHz
376	-10	1622 kHz (-10 = -50 - Nominal PSD lowband)
869	-13.5	3750 kHz (-13.5 = -53.5 - Nominal_PSD_lowband)

Table Q.2: Corner points for the non-overlapped nominal in-band PSD shape.

Tone Index	$Log_ssv_i(dB)$	Comments
6	0	25.875 kHz defines the beginning of the inband region. No shaping is applied
		in the low stop band.
256	0	1104 kHz
376	-10	1622 kHz (-10 = -50 - Nominal PSD lowband)
869	-13.5	3750 kHz (-13.5 = -53.5 - Nominal_PSD_lowband)

Table Q.3: Corner points for the overlapped nominal in-band PSD shape

The absolute values of the transmit PSD are obtained by scaling the relative shaping values with a NOMINAL_PSD_lowband, defined for the lower in-band frequencies. Note that the nominal in-band transmit PSD is frequency dependent. The NOMINAL_PSD_lowband is -40 dBm/Hz (below 1104 kHz) for both the overlapped and non-overlapped spectra.

NOTE 3: In-band PSD spectral shaping is applied prior to the IFFT.

NOTE 4: The value of MAXNOMATPds may be limited by regional regulations.

Q.4.8.4 Transmit Signals with Limited Transmit Power

For cases where the transmit signal must be limited to a maximum aggregate transmit power (e.g. $ATP_{dsmax} = +20$ dBm), then

- c) During initialization the PSD transmit level is specified as an offset from the nominal value, i.e. (Nominal PSD_lowband + ssvi x power cutback) dB, and all values of gi = 1 for the offset value x and power cutback. The value of x shall be the greater of 0 dB and (21.1 ATPdsmax) dB for non-overlapped and (21.5 ATPdsmax) dB for overlapped. For ATPdsmax = 20 dBm, the corresponding value of x shall be 1.1 dB for non-overlapped and 1.5 dB for overlapped cases.
- b) If bi>0, then valid range for gi is [-14.5 to +2.5+x] (dB);
 If bi>0, then gi shall be in the [g_{sync} 2.5 to g_{sync} + 2.5] (dB) range;
 If bi=0, then gi shall be equal to 0 (linear) or in the [-14.5 to g_{sync}] (dB) range;
 For G.992.1 Annex Q-EU, g_{sync} <= x dB

The g_i values shall be constrainted by following relation:

Constraint on g _i values	$\sum_{i=32}^{2*NSCds-1} ssv_i^2 * g_i^2 \le \sum_{i=32}^{2*NSCds-1} ssv_i^2$
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Q.4.8.5 Additional inband spectral shaping

An ATU-R may request additional downstream inband spectral shaping by passing parameters to the ATU-C in a G.994.1 MP, or MS message. The ATU-C may select additional downstream inband spectral shaping by passing parameters to the ATU-R in a G.994.1 MS message. Within the framework of G.994.1, the ATU-C has the ability to make the final decision on the downstream inband PSD shape to be used.

The additional inband spectral shaping parameters are listed in Q.7.2.2 and defined in Q.7.3. If the Additional inband spectral shaping Spar(2) bit is set to ONE in Table Q.7.2, its associated Npar(3) octets in Tables Q.7.2.1 to Q.7.2.1.5 define the inband spectral shape. If the additional inband spectral shaping Spar(2) bit is set to ZERO, its associated Npar(3) octets are not transmitted and the nominal inband PSD shape defined in Q.4.8.3 shall be used. These Npar(3) octets define the downstream PSD levels in the low band (between f1 and 1104 kHz), at 1622 kHz and at 3750 kHz. The PSD levels between 1104 kHz and 1622 kHz, and between 1622 kHz and 3750 kHz are linearly interpolated in log scale. The defined values are the PSD level in dB below the NOMINAL_PSD_lowband of -40dBm/Hz. For example, if all three values are set to 20 dB, the result will be a flat PSD of -60dBm/Hz. If the three values are set to 2 dB, 12 dB and 15.5 dB, the result is the PSD defined in Q.4.8.1 reduced by 2dB. In order not to violate the PSD mask defined in Q.4.8.1, the second value shall be no less than 10 dB and the third value shall be no less than 13.5 dB.

Q.4.8.6 Egress control

G.992.1 Annex Q-EU equipment shall be able to reduce the PSD below -80 dBm/Hz for the Amateur radio bands between 1.81 MHz and 2.00 MHz, and between 3.5 MHz and 3.8 MHz. The ATU-C may apply additional spectral shaping as described in Q.4.8.5 to help achieve this requirement.

Q.4.9 Support of higher downstream bit rates with S = 1/2n (replaces 7.6.4)

With a rate of 4000 data frames per second and a maximum of 255 bytes (maximum RS codeword size) per data frame, the ADSL downstream line rate is limited to approximately 8 Mbit/s per latency path. The line rate limit can be increased beyond this for the interleaved path by mapping 2n RS codewords into one FEC data frame (i.e. by using S = 1/2n in the interleaved path). S = 1/2n shall be used in the downstream direction only over bearer channel AS0.

For a selected value of $n \ge 1$, the K_I data bytes per interleaved mux data frame shall be packed into 2n RS codewords, split into n equal parts, each consisting of 2 consecutive RS codewords. This forces rate adaptation to occur in 32n kbit/s increments. Each of the n parts of the data frame shall begin with a sync byte and shall obey the rules defined in Table Q.4 for insertion of dummy bytes. The smallest value of n that can support the K_I data bytes shall be used.

Support of S = 1/2 (i.e., n=1), S = 1/4 (i.e., n=2), S = 1/6 (i.e., n=3), and S = 1/8 (i.e., n=4), is mandatory.

The resulting data frame structure shall be as shown in Figure Q.15.

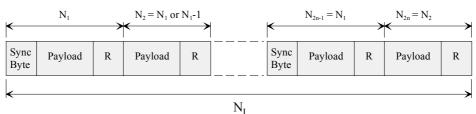


Figure Q.15 – Data frame for S = 1/2n mode

When K_I is divisible by 2n, the 2n codewords have the same length $N_{2i-1} = N_{2i} = (K_I/2n + R_I)$ for i = 1 to n, otherwise the odd numbered codewords are equal and are one byte longer than the even numbered codewords, i.e. $N_{2i-1} = (K_I + n)/2n + R_I$ bytes, and $N_{2i} = (K_I - n)/2n + R_I$ bytes for i = 1 to n. For the FEC output data frame, $N_I = \sum_{i=1}^n N_i$, with $N_I < 512n - 1$ bytes.

The convolutional interleaver requires all codewords to have the same odd length. To achieve the odd codeword length, insertion of dummy (not transmitted) bytes may be required. For S = 1/2n, the dummy byte addition to the odd numbered and/or even numbered codewords at the input of the interleaver shall be as in Table Q.4.

N_{2i-1}	N _{2i}	Dummy Byte Insertion Action			
Odd	Odd	No action			
Even	Even	Add one dummy byte at the beginning of all codewords			
Odd	Even	Add one dummy byte at the beginning of each even numbered codeword			
Even	Odd	Add one dummy byte at the beginning of each odd numbered codeword and two dummy bytes at the beginning of each even numbered codeword [the de-interleaver shall insert one dummy byte into the de-interleaver matrix on the first byte and the $(D + 1)$ th byte of the corresponding codeword to make the addressing work properly]			

Table Q.4/G.992.1 –Dummy byte insertion at interleaver input for S = 1/2n

Q.5 ATU-R Functional Characteristics (pertains to clause 8)

Q.5.1 Framing (pertains to 8.4)

Q.5.1.1 Superframe structure (replaces 8.4.1.1)

The superframe structure of ATU-R transmitter is identical to that of ATU-C transmitter, as specified in Q.4.3.1.

Q.5.1.2 Hyperframe structure (replaces 8.4.1.3)

The hyperframe structure of ATU-R transmitter is functionally similar to that of ATU-C transmitter, except that the inverse synch symbol is used in the 1st superframe (SPF#0) (see Figure Q.16). The hyperframe is composed of 345 DMT symbols, numbered from 0 to 344. Each symbol is under $FEXT_C$ or $NEXT_C$ duration (see Q.5.3), and the following numerical formula gives the information which duration N_{dmt}-th DMT symbol belongs to at ATU-R transmitter (see Figure Q.17).

For $N_{dmt} = 0, 1,, 344$	
$S = 272 \text{ x} \text{ N}_{dmt} \mod 2760$	
if $\{ (S > a) \text{ and } (S + 271 < a + b) \}$	then FEXT _C symbol
else	then NEXT _C symbol
where a = 1315, b = 1293	

128 DMT symbols are allocated in the FEXT_{C} duration, and 217 DMT symbols are allocated in the NEXT_{C} duration. The symbols are composed of:

FEXT _C symbol:				
Number of symbol using Bitmap- F_{C}	= 126			
Number of synch symbol	= 1			
Number of inverse synch symbol	= 1			
NEXT _C symbol:				
Number of symbol using Bitmap-N _C	= 214			
Number of synch symbol	= 3			

During FEXT Bitmapping mode, the ATU-R shall not transmit any signal.

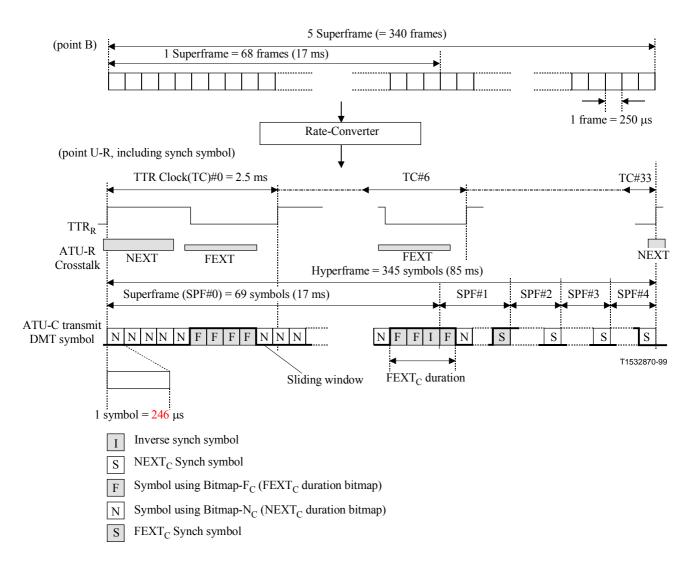


Figure Q.16/G.992.1 – Hyperframe structure for upstream

ттр	
TTR _R	
0	0 1 2 3 4 5 6 7 8 9
1	10 11 12 13 14 15 16 17 18 19
2	20 21 22 23 24 25 26 27 28 29
3	30 31 32 33 34 35 36 37 38 39 40
4	41 42 43 44 45 46 47 48 49 50
5	51 52 53 54 55 56 57 58 59 60
6	61 62 63 64 65 66 67 ISS 69 70
7	71 72 73 74 75 76 77 78 79 80
8	81 82 83 84 85 86 87 88 89 90
9	91 92 93 94 95 96 97 98 99 100 101
10	101 102 103 104 105 06 107 108 109 110 111
11	112 113 114 115 1 6 117 118 119 120 21
12	122 123 124 125 126 127 128 129 130 131
13	132 133 134 135 136 SS 138 139 140 141
14	142 143 144 145 146 147 148 149 150 151
15	152 153 154 155 156 157 158 159 160 161
16	162 163 164 165 166 167 168 169 170 171 172
17	173 174 175 176 77 178 179 180 181 82
18	183 184 185 186 187 188 189 190 191 92
19	193 194 195 196 197 198 199 200 201 202
20	203 204 205 SS 207 208 209 210 211 212
21	213 214 215 216 217 218 219 220 221 222
22	223 224 225 226 227 228 229 230 231 232
23	233 234 235 236 237 238 239 240 241 242 243
24	244 245 246 247 248 249 250 251 252 253
25	254 255 256 257 258 259 260 260 262 263
26	264 265 266 267 268 269 270 271 272 273
27	274 SS 276 277 278 279 280 281 282 283
28	284 285 286 287 288 289 290 291 292 293
29	294 295 296 297 298 299 300 301 302 303
30	304 305 306 307 308 309 310 311 312 313 314
31	<u>315</u> <u>316</u> <u>317</u> <u>318</u> <u>319</u> <u>320</u> <u>321</u> <u>322</u> <u>323</u> <u>324</u>
32	325 326 327 328 329 330 331 332 333 334
33	335 336 337 338 339 340 341 342 343 S5
	ISS Inverse synch symbol SS FEXT _R Synch symbol SS NEXT _R synch symbol
	FEXT _R data symbol NEXT _R data symbol T1535340-00

Figure Q.17/G.992.1 – Symbol pattern in a hyperframe with cyclic prefix – Upstream

Q.5.1.3 Subframe structure (replaces 8.4.1.4)

A subframe is 10 consecutive DMT symbols (except for synch symbols) as shown in Table Q.5. The 34 subframes form a hyperframe.

Subframe No.	DMT symbol No.	Note
0	0-9	
1	10-19	
2	20-29	
3	30-39	
4	40-49	
5	50-59	
6	60-70	#68 is Inverse Synch Symbol
7	71-80	
8	81-90	
9	91-100	
10	101-110	
11	111-120	
12	121-130	
13	131-141	#137 is Synch Symbol
14	142-151	
15	152-161	
16	162-171	
17	172-181	
18	182-191	
19	192-201	
20	202-212	#206 is Synch Symbol
21	213-222	
22	223-232	
23	233-242	
24	243-252	
25	253-262	
26	263-272	
27	273-283	#275 is Synch Symbol
28	284-293	
29	294-303	
30	304-313	
31	314-323	
32	324-333	
33	334-344	#344 is Synch Symbol

Table Q.5/G.992.1 – Subframe (upstream)

Q.5.2 Dual Bitmapping and rate conversion (replaces 8.15)

The function of the rate converter (see Q.5.2.2), tone ordering (see Q.5.4), constellation encoding, and gain scaling shall use one of two bitmaps stored in the ATU. This method is called the dual bitmap.

Q.5.2.1 Dual Bitmap (new)

The Dual Bitmap switching shall be the same as for the downstream data, specified in Q.4.4.1. The number of bits and the relative gains to be used for every tone are calculated in the bit loading algorithm during the initialization sequence, and transmitted in C-B&G.

Q.5.2.2 Rate Converter (new)

The rate converter buffering changes the data frame boundaries between the reference points B and C according to Bitmap- F_C , Bitmap- N_C and the Sliding Window. Two independent rate converters are prepared for fast data and interleaved data. The amounts of fast and interleaved data in Bitmap- F_C and Bitmap- N_C shall be calculated in the following formulae:

If $t_{Cf} \le n_{Cmax}$:

$$n_{Cf} = t_{Cf}$$
$$n_{Ci} = n_C - n_{Cf}$$
$$f_{Cf} = t_{Cf}$$
$$f_{Ci} = f_C - f_{Cf}$$

If $t_{Cf} > n_{Cmax}$:

$$n_{Cf} = n_{C \max}$$

$$n_{Ci} = 0$$

$$f_{Cf4} = \left[\frac{t_{Cf} \times 10 - n_{Cf} \times 6}{4}\right]$$

$$f_{Cf3} = \left[\frac{t_{Cf} \times 10 - n_{Cf} \times 7}{3}\right]$$

$$f_{Ci} = \begin{cases} f_{Ci4} = f_C - f_{C4} \\ f_{Ci3} = f_C - f_{Cf3} \end{cases}$$

Where:

^t Cf	is the number of allocated bits in one frame for fast bytes at the reference point B.
^t Ci	is the number of allocated bits for interleaved bytes at the reference point B.
f_{Cf} and n_{Cf}	are the numbers of fast bits in Bitmap- F_C and Bitmap- N_C , respectively.
f _{Cf3}	is the number of fast bits in Bitmap-F _C if the subframe (see Q.5.1.3) contains 3 Bitmap-F _C except
fCf4	for synch symbols. is the number of fast bits in Bitmap- F_C if the subframe contains 4 Bitmap- F_C except for synch
f_{Ci} and n_{Ci}	symbols. are the numbers of interleaved bits in Bitmap- F_C and Bitmap- N_C , respectively.
ⁿ C	is the number of total bits in Bitmap-N _C , which is specified in the B&G tables.

During FEXT Bitmap mode, n_{Cf} and n_{Ci} are zero.

To convert the bit rate to be a multiple of 32 kbit/s, the dummy bits for fast data are inserted to the tail of each subframe, and the dummy bits for interleaved data are inserted to the end of the Hyperframe. The number of the dummy bits shall be as follows:

If $t_{Cf} \le n_{Cmax}$:

$$dummy_{Cf} = 0$$
$$dummy_{Ci} = (f_{Ci} \times 126 + n_{Ci} \times 214) - t_{Ci} \times 340$$

If $t_{Cf} > n_{Cmax}$:

$$dummy_{Cf 4} = (f_{Cf} \times 4 + n_{Cf} \times 6) - t_{Cf} \times 10$$

$$dummy_{Cf 3} = (f_{Cf} \times 3 + n_{Cf} \times 7) - t_{Cf} \times 10$$

$$dummy_{Ci} = (f_{Ci4} \times 96 + f_{Ci3} \times 30) - t_{Ci} \times 340$$

If the fast data buffer uses single latency only, additional dummy bits are inserted at the tail of each FEXT symbol in the 4 Bitmap- F_C constructed subframe. The number of additional dummy bits inserted at the tail of each FEXT symbol shall be as follows:

$$dummy_{SCf} = f_{Cf3} - f_{Cf4}$$

The receiver shall determine Bitmap-F_C and Bitmap-N_C so that $dummy_{Ci}$ is less than 126, $dummy_{Cf4}$ is less than 4 and $dummy_{Cf3}$ is less than 3 in the initialization sequence. At the receiver, the inserted dummy bits shall be removed.

Q.5.3 FEXT Bitmapping (replaces 8.16)

The FEXT Bitmapping mode uses the Dual Bitmapping technique (Q.4.4) to transmit data only during FEXT. The ATU-C shall transmit only the pilot tone during the NEXT_R symbol. The ATU-R disables Bitmap-N_C and shall not transmit any signal during the NEXT_C symbol (see Figures Q.10 and Q.16).

Annex Q-EU does not support the FEXT Bitmapping mode.

Q.5.4 Tone Ordering (pertains to 8.7)

The tone ordering algorithm shall be the same as for the downstream data, specified in Q.4.4.

For Bitmap-F_C, the "tone-ordered" encoding shall first assign f_{Cf} bits from the rate converter (see Q.5.2.2) to the tones with the smallest number of bits assigned to them, and the remaining f_{Ci} bits to the remaining tones. For Bitmap-N_C, it shall first assign n_{Cf} bits from the rate converter to the tones with the smallest number of bits assigned to them, and the remaining n_{Ci} bits to the remaining tones. Two ordered bit tables for Bitmap-F_C and Bitmap-N_C shall be prepared.

Q.5.5 Modulation (pertains to 8.11)

Q.5.5.1 Inverse synchronization symbol (replaces 8.11.4)

Inverse Synchronization symbol shall be generated from a tone-by-tone 180 degree phase reversal of Synchronization symbol (i.e. + maps to -, and - maps to +, for each of the 4-QAM signal constellation).

Q.5.5.2 Gain scaling in synchronization symbol (new)

At initialization time, the sync symbol reference transmit PSD level shall be set at the nominal PSD level +10log(g_{sync}^2) dBm/Hz, with g_{sync}^2 defined as the average g_i^2 value over the used (i.e. $b_i > 0$) subcarriers in the NEXT or FEXT bitmap, whichever results in the highest average gain. The sync symbol reference transmit PSD shall not be updated with used subcarrier gain changes during SHOWTIME.

I.5.5.3 Nyquist frequency (supplements 8.11.1.2)

The upstream Nyquist frequency for Annex Q-EU shall be at subcarrier NSCus (f = 4.3125*NSCus kHz).

I.5.5.4 Modulation by the inverse discrete Fourier transform (supplements 8.11.2)

For Annex Q-EU, see A.2.1.

I.5.5.5 Synchronization symbol (supplements 8.11.3)

For Annex Q-EU, see A.2.2.

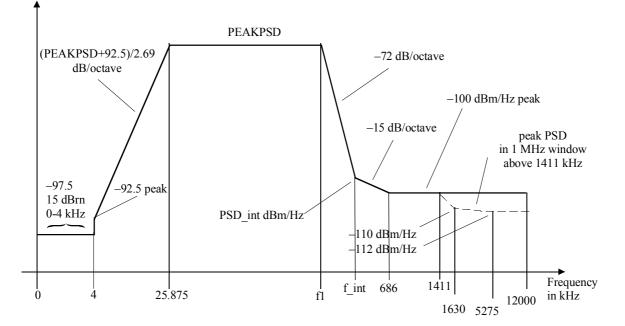
Q.5.6 ATU-R Upstream Transmit Spectral Mask (replaces 8.14)

The upstream PSD masks of Annex Q-EU are defined with absolute peak values in Figure Q.18. The low frequency stop band is defined for frequencies below 25.875 kHz; the high frequency stop band is defined at frequencies greater than f1 kHz (tone n1). The in-band region of these PSD masks is the frequency band from 25.875 kHz to f1 kHz.

ATU-x may optionally support upstream masks EU-36 to EU-64 specified in Figure Q.18

NOTE: The value of MAXNOMATPus may be limited by regional regulations.





Frequency band f (kHz)	Equation for line (dBm/Hz)
0 < f < 4	-97.5
4 < f < 25.875	-92.5+(PEAKPSD+92.5)* log ₂ (f/4)/log ₂ (25.875/4)
25.875 < f < f1	PEAKPSD
f1< f< f_int	$PEAKPSD-72*log_2(f/f1)$
f_int < f < 686	PSD_int-15*log2(f/f_int)
f > 686	-100

Frequency (kHz)	PSD level (dBm/Hz)	Measurement BW
0	-97.5	100 Hz
4	-97.5	100 Hz
4	-92.5	100 Hz
25.875	PEAKPSD	10 kHz
fl	PEAKPSD	10 kHz
f_int	PSD_int	10 kHz
686 - 12000	-100	10 kHz

Additionally the PSD masks shall satisfy the following requirements:

Frequency (kHz)	PSD level (dBm/Hz)	Measurement BW
1411	-100	1 MHz
1630	-110	1 MHz
5275	-112	1 MHz
12000	-112	1 MHz

NSCus is a function of the upstream mask parameters, which are defined as follows:

Designator (EU-nn)	NSCus	Template Nominal PSD P ₀ (dBm/Hz)	Template Maximum Aggregate Transmit Power (dBm)	PEAKPSD (dBm/Hz)	Frequency f1 (kHz)	Intercept Frequency f_int (kHz)	Intercept PSD Level PSD_int (dBm/Hz)
EU-32	32	-38.0	12.5	-34.5	138.00	242.92	-93.2
EU-36	64	-38.5	12.5	-35.0	155.25	274.03	-94.0
EU-40	64	-39.0	12.5	-35.5	172.50	305.06	-94.7
EU-44	64	-39.4	12.5	-35.9	189.75	336.33	-95.4
EU-48	64	-39.8	12.5	-36.3	207.00	367.54	-95.9
EU-52	64	-40.1	12.5	-36.6	224.25	399.07	-96.5
EU-56	64	-40.4	12.5	-36.9	241.50	430.58	-97.0
EU-60	64	-40.7	12.5	-37.2	258.75	462.04	-97.4
EU-64	64	-41.0	12.5	-37.5	276.00	493.45	-97.9

Parameters in FEXT bitmap for mode 1, both bitmaps for mode 2 (see §Q.7.3):

Parameters in NEXT bitmap for mode 1 (see §Q.7.3):

Designator (EU-nn)	NSCus	Template Nominal PSD P ₀ (dBm/Hz)	Template Maximum Aggregate Transmit Power (dBm)	PEAKPSD (dBm/Hz)	Frequency f1 (kHz)	Intercept Frequency f_int (kHz)	Intercept PSD Level PSD_int (dBm/Hz)
EU-32	32	-38.0	12.5	-34.5	138.00	242.92	-93.2
EU-36	64	-38.7	12.5	-35.2	155.25	273.47	-94.0
EU-40	64	-39.9	12.5	-36.4	172.50	302.26	-94.7
EU-44	64	-40.7	12.5	-37.2	189.75	331.87	-95.3
EU-48	64	-41.4	12.5	-37.9	207.00	361.55	-95.8
EU-52	64	-41.8	12.5	-38.3	224.25	392.16	-96.4
EU-56	64	-42.1	12.5	-38.6	241.50	423.12	-96.9
EU-60	64	-42.3	12.5	-38.8	258.75	454.51	-97.3
EU-64	64	-42.3	12.5	-38.8	276.00	486.91	-97.8

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. The breakpoints in the tables shall be connected by linear straight lines on a dB/log(f) plot.

NOTE 3 – MBW specifies the Measurement Bandwidth. The MBW specified for a certain breakpoint with frequency fi is applicable for all frequencies satisfying fi< $f \le fj$, where fj is the frequency of the next specified breakpoint.

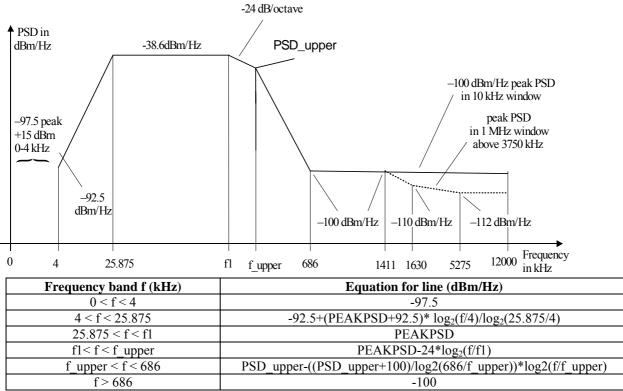
NOTE 4 – The power in a 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency i.e. power in the [f, f + 1 MHz] window shall conform to the specification at frequency f.

NOTE 5 – The step in the PSD mask at 4 kHz is to protect V.90 performance. Originally, the PSD mask continued the 21.5 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-R interface (see Figures Q.3 & Q.4).

Figure Q.18: Upstream Channel PSD Masks

When EU-S68 or beyond is used, only mode 2 shall be used. The PSD masks are defined in Figure Q.x1 and Table Q.x2. The frequency band from 25.875 kHz to f_upper can be used.



Note: PSD_upper=PEAKPSD-24*log2(f_upper/f1)

Frequency (kHz)	PSD level (dBm/Hz)	Measurement BW
0	-97.5	100 Hz
4	-97.5	100 Hz
4	-92.5	100 Hz
10	interpolated	10 kHz
25.875	-38.6	10 kHz
276	-38.6	10 kHz
f_upper	PSD_upper	10 kHz
686	-100	10 kHz
5275	-100	10 kHz
12000	-100	10 kHz

Figure Q.x1: Mask definition for EU-S68 to EU-S96

Designator	Template Maximum Aggregate Transmit Power (dBm)	Upper Frequency <i>f_upper</i> (kHz)	PSD_upper: PSD Level at f_upper (dBm/Hz)
EU-S68	12.5	293.25	-40.70
EU-S72	12.5	310.50	-42.68
EU-S76	12.5	327.75	-44.55
EU-S80	12.5	345.00	-46.33
EU-S84	12.5	362.25	-48.02
EU-S88	12.5	379.50	-49.63
EU-S92	12.5	396.75	-51.17
EU-S96	12.5	414.00	-52.64

Table Q.x2: Parameters for EU-S68 to EU-S96

Q.5.7 Forward error correction (supplements 8.6)

The minimum FEC coding capabilities (Table 8-3) for an ATU-R shall include the following interleave depths for the interleaved buffer:

D = 1, 2, 4, 8, and 16

Q.5.8 Cyclic prefix (supplements 8.12)

For Annex Q-EU, see A.2.3.

Q.6 EOC Operation and Maintenance (pertains to clause 9)

Q.6.1 ADSL line related primitives (supplements 9.3.1)

Q.6.1.1 ADSL line related near-end defects (supplements 9.3.1.3)

Two near-end defects are further defined:

- *Loss-of-signal (LOS)*: The ADSL power shall be measured only in the FEXT_C duration at ATU-C, or only in the FEXT_R duration at ATU-R.
- Severely errored frame (SEF): A SEF defect occurs when the content of two consecutively received ADSL synchronization symbols in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-R, does not correlate with the expected content over a subset of the tones. An SEF defect terminates when the content of two consecutively received ADSL synchronization symbols in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-C, or in the FEXT_R duration at ATU-R, does not consecutively received ADSL synchronization symbols in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-R, correlate with the expected contents over the same subset. The correlation method, the selected subset of tones, and the threshold for declaring these defect conditions are implementation discretionary.

Q.6.1.2 ADSL line related far-end defects (supplements 9.3.1.4)

Loss-of-signal is further defined:

• Loss-of-signal (LOS): The ADSL power shall be measured only in the FEXT_C duration at ATU-C, or only in the FEXT_R duration at ATU-R.

Q.6.2 Test Parameters (supplements 9.5)

Q.6.2.1 Near-end test parameters (supplements 9.5.1)

The near-end primitives are further defined:

- *Attenuation (ATN)*: The received signal power shall be measured only in the FEXT_C duration at ATU-C, or only in the FEXT_R duration at ATU-R.
- Signal-to-Noise ratio (SNR) margin: During FEXT Bitmap mode, this primitive represents the snr margin in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-R.

Q.6.2.2 Far-end test parameters (supplements 9.5.2)

The far-end primitives are further defined:

- *Attenuation (ATN)*: The received signal power shall be measured only in the FEXT_C duration at ATU-C, or only in the FEXT_R duration at ATU-R.
- Signal-to-Noise ratio SNR margin: During FEXT Bitmap mode, this primitive represents the snr margin in the

 FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-R.

Q.6.3 Data registers in the ATU-R (supplements 9.2.4)

For the S=1/2n framing mode (see §Q.4.9), the downstream RS_I shall be the number of parity bytes per sync byte, i.e., $RS_I = R_I/(n^*S)$.

Q.7 Initialization (pertains to clause 10)

Q.7.1 Initialization with Hyperframe (replaces 10.1.5)

The exchange of messages between ATU-C and ATU-R should be performed in FEXT_{C} and FEXT_{R} . The DMT symbol has two symbol rates: one is 4.3125 kbaud for the symbol without a cyclic prefix, and the other is 4 x 69/68 kbaud for the symbol with a cyclic prefix. 32 times of the TTR has the same period as 345 times of the 4.3125 kbaud, and 34 times of the TTR is the same as 345 times of 4 x 69/68 kHz.

During FEXT Bitmap mode, the ATU-R shall not transmit any signal during the NEXT_C symbols duration and the ATU-C shall transmit only the pilot tone as the NEXT_R signal except:

- C-PILOT1 (C-PILOT1A) which is accompanied by a signal to allow the ATU-C to indicate the phase of TTR_C to the ATU-R (see Q.7.4.1);
- C-QUIETn where no signal is transmitted.

The ATU-C begins transmitting C-PILOT1 at the beginning of the hyperframe without cyclic prefix. The ATU-C informs the phase of the TTR_C to ATU-R during C-PILOT1. The ATU-R begins transmitting R-REVERB1 at the beginning of the hyperframe without cyclic prefix. The ATU-R performs the training of any receiver equalizer using this phase information of the TTR_R generated from received TTR_C .

From C-PILOT1 to C-SEGUE1, the following numerical formula gives the information which duration N_{dmt}-th DMT symbol belongs to at ATU-R (see Figure Q.19).

In order to enter C-RATES1 at the beginning of the hyperframe with cyclic prefix, the number of symbols from C-PILOT1 to C-SEGUE1 shall be a multiple of 345 DMT symbols.

From R-REVERB1 to R-SEGUE1, the following numerical formula gives the information which duration N_{dmt}-th symbol belongs to at ATU-C (see Figure Q.20).

For $N_{dmt} = 0, 1,, 344$,	
$S = 256 \times N_{dmt} \mod 2760$	
if $\{ (S > a) \text{ and } (S + 255 < a + b) \}$	then $FEXT_C$ symbols
else	then NEXT _C symbols
where $a = 1315$, $b = 1293$	

From C-RATES1 to C-SEGUE3, the number of symbols is a multiple of 345 DMT symbols. The following numerical formula gives the information which duration N_{dmt} -th DMT symbol belongs to. ATU-C transmits the message data in FEXT_R symbols (see Figure Q.11).

 $\label{eq:states} \begin{array}{l} \mbox{For $N_{dmt}=0,1,...,344$} \\ \mbox{$S=272$ x N_{dmt} mod 2760} \\ \mbox{$if $\{$(S+271\geq a)$ and $(S\leq a+b)$ $\}$} \\ \mbox{$else$} \\ \mbox{$where $a=1243$, $b=1461$} \end{array} \qquad \begin{array}{l} \mbox{then $NEXT_R$ symbols $} \\ \mbox{$then $FEXT_R$ symbols $} \\ \mbox{$then $then $FEXT_R$ symbols $} \\ \mbox{$then $FEXT_R$ symbols $} \\ \mbox{$then $FEXT_R$ symbols $} \\ \mbox{$then $then $then $} \\ \mbox{$then $then $} \\ \mbox$

The ATU-R enters R-REVERB3 at the beginning of the hyperframe with cyclic prefix, which is extracted from received signal. From R-REVERB3 to R-SEGUE5, the number of symbols is a multiple of 345 DMT symbols. The following numerical formula gives the information which duration N_{dmt} -th DMT symbol belongs to. ATU-R transmits the message data in FEXT_C symbols (see Figure Q.17).

For $N_{dmt} = 0, 1, ..., 344$ $S = 272 \times N_{dmt} \mod 2760$ if { (S > a) and (S + 271 < a + b) } then FEXT_C symbols else then NEXT_C symbols where a = 1315, b = 1293

TTR	2

0	0	1	2	3		4		5	6		7		8		9		10
1	11	12	13	1		15		16		17	_	18	1	19	2		21
2	22	23	24		25	20		27		28		29		30		31	
3	32 33			35	36		37		38	<u> </u>	39	4	0	4		42	
4		-4	45	46		7	48		49		50		51		52		53
5	54 65	55 66	56 67	57	68	58 69		59 70	6	0 71	6	1 72	62	73	63	74	64
6 7	75 76	77		8	79			8		/ 1	2	83		84		85	╇
8	86 87		88	89	90		91		<u>1</u> 92	<u>т</u>	2 93	_	94)5	9	6
9		98	99	100		.01	10	2	103	3	104	<u> </u>	105	<u> </u>	106		07
10	108	109	110	11		112	_	113		14	-	15	11		11	7	118
11	119	120	12	1	122	12	3	124	4	125	5	126		127		128	Τ
12	129 130	13	31 1	32	133	1	34	1	35	1	36	13	37	13	8	139)
13	140 14	41	142	143	14	14	145	5	146		147		148	1	149	1:	50
14	151	152	153	154		155	1	56	15	7	15	8	159	9	160		61
15	162	163	164		65	166		167		168		169	_	70			172
16	173	17		75	176		77	17		17		180		181		182	
17	183 184			186	18	i .	188	_	189		190		91		92	19	
18 19	194 1 205	95 206	196 207	197		.98 209	19	9 210	200	/ 11	201		202 21		203 214		04 215
20	203	200			° 219	209	┷┯	221		222	┶┯─	223		224		+ 1 225	
21	226 227	217		29	230	-	31	_	32	-	33	223	_	23	<u> </u>	236	5
22	237 23		239	240	24		242		243		244		245	_	246		47
23	248	249	250	251	Т	252	2	53	25	4	25	5	256	5	257	12	258
24	259	260	261	26	52	263	<u> </u>	264	12	265	2	.66	2	67	26	58	269
25	270	271	1 27	2	273	27	4	27	5	27	6	277	7	278		279	
26	280 283		.82	283	284		285		286		287	2	88	28	89	29	0
27		92	293	294		95	29		297		298		299		300	_	01
28	302	303	304	305		306		307	_	08	30		31		31		312
29	313	314	315		16	317		318		319		320		321	_	22	1
	323 324	5		26	327	- <u>1</u> - 1- 1-	$\frac{28}{220}$		29	33		33		332		333	
31	334 33	5	336	337	33	0	339		340		341		342	3	343	32	44

Figure Q.19/G.992.1 – Symbol pattern in a hyperframe without cyclic prefix – Downstream

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R										. L										
0	0	1		2		3		4		5	5	6	5	7	7	8	3	ļ)	10
1	11		12	1	13	1	4		15		16		17		18		19		20	21
2	2	22	23		24		25		26	i l	27		28		29		30		31	
3	32	33	3		3		36		3	7		38	39							42
4	43	44		45		46		47		48		49		50		51		52		53
5	54		5	56		57		58			59		50		51	<u> </u>	52		53	64
6	6		66	╧	67		68	1	69		70	1	71		72		73		74	
7		76	77	20	78		79		80		8		8.		8		8			5
8 9	86 97	87 98		38 99		89		0	_	91 10		92	$\frac{1}{2}$	93 10		94		95 10	6	96 107
9 10	108		.09		10	100			12	-	2 113	10	<u> </u>	_	4	10	5 116		0 117	118
11		19	120		121		122		12	<u>.</u>	12	_	125	┹┯	126		12		12	- <u>-</u>
-	129	130	120	1	121		122	3	123	<u>. </u>	_	- 35	-	<u>,</u> 36	_	<u>,</u> 37	_	' 38	_	39
13	140	141	1	142		- 143	-	9 44		145	_	146		147		148	_	149		150
14	151	15		153		154		15		15			57	-	58	15			50	161
5	16	_	163	_	64	_	65	-	66		167	T	168		169		170		171	172
6		173	174	i T	175	_	176	<u> </u>	17	7	17	/8	17	9	18	_	18	31	18	32
7	183	184	1	85	18	86	18	37	1	88		189		190		191		192		193
18	194	195	5	196		197	Т	198		19	9	20	0	20	1	202	2	20	3	204
9	205	2	06	20)7	20	8	20)9	2	10	2	211	2	212	2	13	2	.14	215
20	21	16	217		218		219		220	Τ	221		222		223		224	ŀ	225	5
21	226	227	22	8	22	9	230)	23	1	2	32	2	33	2	34	2	35	2	36
22	239	238	2	239	2	240	2	41		242		243		244		245		246		247
23	248	24	.9	250)	251		252	2	25	53	25	54	25	55	25	56	2.		258
24	259		260	2	61		52	2	63		264		265		266	_	267		268	269
25		70	271		272		273		274		27		27		27		27		27	
26	280	281		82		83	28			85	_	286		287		288	_	289		290
27	291	292		293		294	_	295		296		297		298		299		300		301
28	302		03	30		30		30			07		210	3	09	3	10	$\frac{1}{3}$	11	312
29 20	31		314	_	315	_	316		317	<u>. </u>	318		319	20	320	21	321	22	322	
-	323 ±	324 335	32:	5 336	326		327		32		3.	29 340	33		33		<u> </u>	32 343	L <u>3</u> .	33 344
31	554	333		50	1 3	337	3	38	·	339		340		341		342		343		344
		FEX	T _C sy	mbo	1														T1	535360-0
			-																	
		J NEX	T _C sy	mbo	1															

Figure Q.20/G.992.1 – Symbol pattern in a hyperframe without cyclic prefix – Upstream

Q.7.2 Handshake – Non-standard information block (new)

This section defines the format of the G.994.1 non-standard information block to support Annex Q-EU, and tabulates the parameters used by Annex Q-EU. The use of these parameters is described in §Q.7.3 and §Q.7.4.

Q.7.2.1 Non-standard information block format (new)

Figure Q.21 defines the format of the non-standard information block.

8	7	6	5	4	3	2	1
		Non-stan		nation length ctet)	= M + 6		
				ntry code see Note 1)			
		Provid		ndor identifi see Note 2)	cation)		
		Ve		fic informati – Note 3)	on		

NOTE 1 – The value of this field shall be B5 00, the country code for USA

NOTE 2 – The value of this field shall be 43 45 4E 54, ASCII "CENT" for Centillium Communications

NOTE 3 – These octets are defined in Q.7.2.2. Formatting of these octets shall comply with the parsing rules defined in G.994.1 9.2.1 to 9.2.3

Figure Q.21 – Non-standard information block format

Q.7.2.2 Non-standard information block parameters (new)

The G.994.1 non-standard parameters for Annex Q-EU are listed in Tables Q.6 to Q.7.2.1.2.5 below.

In order to minimize message length, the parameters for additional inband spectral shaping (Spar(2) octet and its related Npar(3) octets) shall only be included in MP or MS messages, and shall not be included in CLR or CL messages. All Annex Q-EU modems shall support additional inband spectral shaping.

Note - This deviates from the rules specified in G.994.1 for standard information fields, where it is stated in §9.6:

"Once a Transaction C (see 10.1) has been completed, any subsequent MS message within the same G.994.1 session shall only contain those octets of the identification (I) and standard information (S) fields, and those blocks of non-standard information (NS) that were contained in both the CLR and CL messages of the previous Transaction C".

Bits								
8	7	6	5	4	3	2	1	NPar(1)s
x	x	х	х	х	х	х	1	Reserved for future use
х	х	х	Х	Х	Х	1	х	Reserved for future use
х	х	х	х	Х	1	х	Х	Reserved for future use
х	х	х	х	1	х	х	Х	Reserved for future use
х	х	х	1	Х	Х	х	х	Reserved for future use
х	х	1	Х	Х	Х	х	х	Reserved for future use
х	1	х	х	х	х	х	х	Reserved for future use
х	0	0	0	0	0	0	0	No parameters in this octet

 Table Q.6 – Non-standard information field – NPar(1) coding

Bits								
8	7	6	5	4	3	2	1	SPar(1)s
х	Х	Х	х	х	х	х	1	G.992.1 Annex Q (and Annex Q-EU)
х	х	х	х	х	х	1	х	G.992.1 Annex I-EU
х	х	х	х	х	1	х	х	G.992.1 Annex C-EU
х	х	х	х	1	х	х	х	Reserved for future use
х	х	х	1	х	х	х	х	Reserved for future use
х	х	1	х	х	х	х	х	Reserved for future use
х	1	х	х	х	х	х	х	Reserved for future use
x	0	0	0	0	0	0	0	No parameters in this octet

 $Table \ Q.7-Non-standard \ information \ field-SPar(1) \ coding$

Table Q.7.1 – Non-standard information field – G.992.1 Annex Q NPar(2) coding – Octet 1

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex Q NPar(2)s – Octet 1
Х	Х	х	Х	Х	Х	Х	1	$n_{\text{C-PILOT1}} = 64$
х	Х	х	х	Х	х	1	х	$n_{\text{C-PILOT1}} = 128$
х	х	х	х	х	1	х	х	$n_{\text{C-PILOT1}} = 256$
х	х	х	х	1	х	х	х	Amateur radio notch - 1.8 MHz band
Х	х	х	1	х	х	х	х	Amateur radio notch – 3.5 MHz band
Х	х	1	х	х	х	х	х	$n_{\text{C-PILOT1}} = 96$
х	х	0	0	0	0	0	0	No parameters in this octet
Since A4	48 is th	e only [TTR in	dication	n signal	l specifi	ied for	Annex Q-EU, there is no need to include it in G.994.1.

Bits												
8	7	6	5	4	3	2	1	G.992.1 Annex Q NPar(2)s – Octet 2				
x	х	х	х	х	х	х	1	R-ACK1				
х	Х	х	х	х	х	1	х	R-ACK2				
х	х	х	х	х	1	х	х	Reserved for future use				
х	х	х	х	1	х	х	х	Reserved for future use				
х	х	х	1	х	х	х	х	Reserved for future use				
х	х	1	х	х	х	х	х	G.997.1 – Clear EOC OAM				
х	х	0	0	0	0	0	0	No parameters in this octet				
	Since Annex Q-EU only supports ATM transport, STM and ATM parameters are not specified. Since FBM mode is not supported, the DBM bit is also not specified.											

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex Q SPar(2)s
х	х	х	х	х	Х	Х	1	Additional inband spectral shaping
х	х	х	х	х	х	1	х	Extended upstream
х	х	х	х	х	1	Х	Х	Reserved for future use
х	х	х	х	1	х	Х	х	Reserved for future use
х	х	х	1	х	х	Х	Х	Reserved for future use
х	х	1	х	х	х	Х	х	Reserved for future use
х	х	0	0	0	0	0	0	No parameters in this octet

Table Q.7.2 – Non-standard information field – G.992.1 Annex Q SPar(2) coding

Table Q.7.2.1 – Non-standard information field – G.992.1 Annex Q Additional inband spectral shaping Npar(3) coding Octet 1

Bits		1						G.992.1 Annex Q Additional inband spectral shaping
8	7	6	5	4	3	2	1	Npar(3)s Octet 1
х	х					х	х	NOMINAL_PSD_lowband (bits 8 & 7)
Х	х	х	Х	Х	х			Reserved for future use

Table Q.7.2.1.1 – Non-standard information field – G.992.1 Annex Q Additional inband spectral shaping Npar(3) coding Octet 2

Bits								G.992.1 Annex Q Additional inband spectral shaping
8	7	6	5	4	3	2	1	Npar(3)s Octet 2
х	х	х	х	х	х	х	х	NOMINAL PSD lowband (bits 6 to 1)

Table Q.7.2.1.2 – Non-standard information field – G.992.1 Annex Q Additional inband spectral shaping Npar(3) coding Octet 3

Bits 8	7	6	5	4	3	2	1	G.992.1 Annex Q Additional inband spectral shaping Npar(3)s Octet 3
X	x					х	Х	PSD level at 1622 kHz (bits 8 & 7)
x	Х	х	Х	Х	х			Reserved for future use

Table Q.7.2.1.3 – Non-standard information field – G.992.1 Annex Q Additional inband spectral shaping Npar(3) coding Octet 4

Bits								G.992.1 Annex Q Additional inband spectral shaping
8	7	6	5	4	3	2	1	Npar(3)s Octet 4
x	х	х	х	х	х	х	Х	PSD level at 1622 kHz (bits 6 to 1)

Table Q.7.2.1.4 – Non-standard information field – G.992.1 Annex Q Additional inband spectral shaping Npar(3) coding Octet 5

Bits 8	7	6	5	4	3	2	1	G.992.1 Annex Q Additional inband spectral shaping Npar(3)s Octet 5
х	Х					х	х	PSD level at 3750 kHz (bits 8 & 7)
х	Х	Х	Х	Х	х			Reserved for future use

Table Q.7.2.1.5 – Non-standard information field – G.992.1 Annex Q Additional inband spectral shaping Npar(3) coding Octet 6

Bits								G.992.1 Annex Q Additional inband spectral shaping
8	7	6	5	4	3	2	1	Npar(3)s Octet 6
х	Х	х	х	Х	х	х	Х	PSD level at 3750 kHz (bits 6 to 1)

Table Q.7.2.2 – Non-standard information field – G.992.1 Annex Q Extended upstream NPar(3) coding Octet 1

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex Q Extended upstream NPar(3)s Octet 1
x	х	x	х	х	Х	х	1	Mode 1 upstream mask
x	х	х	х	х	х	1	х	Mode 2 upstream mask
x	х	х	х	х	1	х	х	Optional upstream masks for non-overlapped spectrum
х	х	х	х	1	х	х	х	EU-64
х	х	х	1	х	х	х	х	EU-32
x	х	1	х	х	х	х	х	EU-36
х	х	0	0	0	0	0	0	No parameters in this octet

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex Q Extended upstream NPar(3)s Octet 2
x	х	х	х	Х	Х	х	1	EU-40
х	х	х	х	Х	Х	1	х	EU-44
х	х	х	х	Х	1	х	х	EU-48
х	х	х	х	1	х	х	х	EU-52
х	х	х	1	х	х	х	х	EU-56
х	х	1	х	х	Х	х	х	EU-60
x	х	0	0	0	0	0	0	No parameters in this octet

Table Q.7.2.2.1 – Non-standard information field – G.992.1 Annex Q Extended upstream NPar(3) coding Octet 2

Table Q.7.2.2.2 – Non-standard information field – G.992.1 Annex Q Extended upstream NPar(3) coding Octet 3

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex Q Extended upstream NPar(3)s Octet 3
x	х	х	Х	Х	Х	х	1	EU-S68
х	х	х	х	Х	х	1	х	EU-S72
х	х	х	х	Х	1	х	х	EU-S76
х	х	х	х	1	х	х	х	EU-S80
х	х	х	1	х	х	х	х	EU-S84
х	х	1	Х	х	х	х	х	EU-S88
х	х	0	0	0	0	0	0	No parameters in this octet

Table Q.7.2.2.3 – Non-standard information field – G.992.1 Annex Q Extended upstream NPar(3) coding Octet 4

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex Q Extended upstream NPar(3)s Octet 4
x	х	Х	Х	Х	Х	х	1	EU-S92
х	х	х	х	Х	х	1	х	EU-S96
х	х	х	х	Х	1	х	х	Reserved for future use
х	Х	х	Х	1	Х	Х	Х	Reserved for future use
х	Х	х	1	х	Х	Х	Х	Reserved for future use
х	х	1	Х	х	Х	х	Х	Reserved for future use
x	Х	0	0	0	0	0	0	No parameters in this octet

Q.7.3 Handshake – Parameter definitions (supplements 10.2)

Q.7.3.1 Handshake – ATU-C (supplements 10.2)

Q.7.3.1.1 CL messages (supplements 10.2.1)

See Table Q.8.

NSF parameter	Definition
G.992.1 Annex Q	If set to ONE, this Spar(1) bit indicates that the ATU-C is configured to support G.992.1 Annex Q, and possibly Annex Q-EU.
ⁿ C-PILOT1 ⁼⁶⁴	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 64.
ⁿ C-PILOT1 ⁼⁹⁶	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 96.
ⁿ C-PILOT1 ⁼¹²⁸	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 128.
ⁿ C-PILOT1 ⁼²⁵⁶	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 256.
Amateur radio notch – 1.8 MHz band	If set to ONE, this Npar(2) bit indicates that the ATU-C is configured to reduce its transmit power between 1.81 and 2.0 MHz to ≤ -80 dBm.
Amateur radio notch – 3.5 MHz band	If set to ONE, this Npar(2) bit indicates that the ATU-C is configured to reduce its transmit power between 3.5 and 3.8 MHz to ≤ -80 dBm.
Extended upstream	If set to ONE, this Spar(2) bit indicates that the ATU-C is configured to support extended upstream.
EU-xx	If the Extended upstream Spar(2) bit is set to ONE, these Npar(3) bits indicate the extended upstream masks that the ATU-C supports. For non-overlapped spectrum, extended upstream masks are associated with downstream masks according to Figure Q.13. For overlapped spectrum, any EU-xx may be used with the overlapped downstream spectrum specified in §Q.4.8.2.
Mode 1 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-C is configured to support upstream mask mode 1 (different masks during FEXT and NEXT periods).
Mode 2 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-C is configured to support upstream mask mode 2 (same mask during FEXT and NEXT periods).
Optional upstream masks for non- overlapped spectrum	If set to ONE, this NPar(3) bit indicates that the ATU-C is configured to support the optional upstream masks when using non-overlapped spectrum downstream.

Table Q.8/G.992.1 – ATU-C CL message NPar(2) bit definitions for Annex Q

Q.7.3.1.2 MS messages (supplements 10.2.2)

See Table Q.9.

NSF bit	Definition		
G.992.1 Annex Q	If set to ONE, this Spar(1) bit indicates that the ATU-C is selecting G.992.1 Annex Q, and possibly Annex Q-EU.		
ⁿ C-PILOT1 ⁼⁶⁴	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 64 (Note 1).		
ⁿ C-PILOT1 ⁼⁹⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 96 (Note 1).		
ⁿ C-PILOT1 ⁼¹²⁸	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 128 (Note 1).		
ⁿ C-PILOT1 ⁼²⁵⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 256 (Note 1).		
Amateur radio notch – 1.8 MHz band	If set to ONE, this Npar(2) bit indicates that the ATU-C shall reduce its transmit power between 1.81 and 2.0 MHz to ≤ -80 dBm.		
Amateur radio notch – 3.5 MHz band	If set to ONE, this Npar(2) bit indicates that the ATU-C shall reduce its transmit power between 3.5 and 3.8 MHz to ≤ -80 dBm.		
Additional inband spectral shaping	If set to ONE, this Spar(2) bit indicates that the ATU-C shall apply additional downstream inband spectral shaping as defined by the values of REDUCED_PSD_lowband, PSD level at 1622 kHz, and PSD level at 3750 kHz		
REDUCED_PSD_ lowband	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-C shall apply in the passband below 1104 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz.		
PSD level at 1622 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-C shall apply at 1622 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs between the REDUCED PSD lowband level at 1104 kHz and the PSD level at 1622 kHz.		
PSD level at 3750 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-C shall apply at 3750 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs between the PSD level at 1622 kHz and the PSD level at 3750 kHz.		
Extended upstream	If set to ONE, this Spar(2) bit indicates that the ATU-C is selecting extended upstream operation.		
EU-xx	If set to ONE, this Npar(3) bit indicates that the ATU-C is selecting upstream PSD mask US- xx. For non-overlapped spectrum, extended upstream masks are associated with downstream masks according to Figure Q.13. For overlapped spectrum, any EU-xx may be used with the overlapped downstream spectrum specified in §Q.4.8.2.		
Mode 1 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-C is selecting upstream mask mode 1 (different masks during FEXT and NEXT periods). (Note 2)		
Mode 2 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-C is selecting upstream mask mode 2 (same mask during FEXT and NEXT periods). (Note 2)		
Optional upstream masks for non- overlapped spectrum	If set to ONE, this NPar(3) bit indicates that the ATU-C is selecting one of the optional upstream masks when using non-overlapped spectrum downstream.		

Table Q.9/G.992.1 – ATU-C MS message NPar(2) bit definitions for Annex Q

Note 1: One and only one pilot tone bit shall be set in an MS message. Note 2: One and only one upstream mask mode bit shall be set in an MS message.

Q.7.3.2 Handshake – ATU-R (supplements 10.3)

Q.7.3.2.1 CLR messages (supplements 10.3.1)

See Table Q.10.

Table Q.10/G.992.1 – ATU-R CLR message NPar(2) bit definitions for Annex Q

NSF bit	Definition		
G.992.1 Annex Q	If set to ONE, this Spar(1) bit indicates that the ATU-R is configured to support G.992.1 Annex Q, and possibly Annex Q-EU.		
ⁿ C-PILOT1 ⁼⁶⁴	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 64.		
ⁿ C-PILOT1 ⁼⁹⁶	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 96.		
ⁿ C-PILOT1 ⁼¹²⁸	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 128.		
ⁿ C-PILOT1 ⁼²⁵⁶	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 256.		
Amateur radio notch - 1.8 MHz band	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports the 1.8 MHz Amateur radio band notch.		
Amateur radio notch - 3.5 MHz band	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports the 3.5 MHz Amateur radio band notch.		
Extended upstream	If set to ONE, this Spar(2) bit indicates that the ATU-R is configured to support extended upstream.		
EU-xx	If the Extended upstream Spar(2) bit is set to ONE, these Npar(3) bits indicate the extended upstream masks that the ATU-R supports. For non-overlapped spectrum, extended upstream masks are associated with downstream masks according to Figure Q.13. For overlapped spectrum, any EU-xx may be used with the overlapped downstream spectrum specified in §Q.4.8.2.		
Mode 1 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-R is configured to support upstream mask mode 1 (different masks during FEXT and NEXT periods).		
Mode 2 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-R is configured to support upstream mask mode 2 (same mask during FEXT and NEXT periods).		
Optional upstream masks for non- overlapped spectrum	If set to ONE, this NPar(3) bit indicates that the ATU-R is configured to support the optional upstream masks when using non-overlapped spectrum downstream.		

Q.7.3.2.2 MS messages (supplements 10.3.2)

Table Q.11.

NSF bit	Definition		
G.992.1 Annex Q	If set to ONE, this Spar(1) bit indicates that the ATU-R is selecting G.992.1 Annex Q, and possibly Annex Q-EU.		
ⁿ C-PILOT1 ⁼⁶⁴	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is selecting the pilot tone on subcarrier 64 (Note 1).		
ⁿ C-PILOT1 ⁼⁹⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is selecting the pilot tone on subcarrier 96 (Note 1).		
ⁿ C-PILOT1 ⁼¹²⁸	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is selecting the pilot tone on subcarrier 128 (Note 1).		
ⁿ C-PILOT1 ⁼²⁵⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is selecting the pilot tone on subcarrier 256 (Note 1).		
Amateur radio notch – 1.8 MHz band	This selection shall only be performed by the ATU-C. Therefore, this Npar(2) bit shall either be set to the same value as in a previous CL message or set to ONE.		
Amateur radio notch – 3.5 MHz band	This selection shall only be performed by the ATU-C. Therefore, this Npar(2) bit shall either be set to the same value as in a previous CL message or set to ONE.		
Additional inband spectral shaping	If set to ONE, this Spar(2) bit indicates that the ATU-R is selecting additional downstream inband spectral shaping as defined by the values of REDUCED_PSD_lowband, PSD level at 1622 kHz, and PSD level at 3750 kHz		
REDUCED_PSD_ lowband	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R wishes to have applied in the passband below 1104 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz.		
PSD level at 1622 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R wishes to have applied at 1622 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs between the REDUCED PSD lowband level at 1104 kHz and the PSD level at 1622 kHz.		
PSD level at 3750 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R wishes to have applied at 3750 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs between the PSD level at 1622 kHz and the PSD level at 3750 kHz.		
Extended	If set to ONE, this Spar(2) bit indicates that the ATU-R is selecting extended upstream		
upstream EU-xx	operation. If set to ONE, this Npar(3) bit indicates that the ATU-R is selecting upstream PSD mask US- xx. For non-overlapped spectrum, extended upstream masks are associated with downstream masks according to Figure Q.13. For overlapped spectrum, any EU-xx may be used with the overlapped downstream spectrum specified in §Q.4.8.2.		
Mode 1 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-R is selecting upstream mask mode 1 (different masks during FEXT and NEXT periods). (Note 2)		
Mode 2 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-R is selecting upstream mask mode 2 (same mask during FEXT and NEXT periods). (Note 2)		
Optional upstream masks for non- overlapped spectrum	If set to ONE, this NPar(3) bit indicates that the ATU-R is selecting one of the optional upstream masks when using non-overlapped spectrum downstream.		

Table Q.11/G.992.1 – ATU-R MS message NPar(2) bit definitions for Annex Q

Note 1: One and only one pilot tone bit shall be set in an MS message. Note 2: One and only one upstream mask mode bit shall be set in an MS message.

Q.7.3.2.3 MP messages (new)

Table Q.12.

Table Q.12/G.992.1 – ATU-R M	IP message NPar(2) bi	t definitions for Annex O

NSF bit	Definition		
G.992.1 Annex Q	If set to ONE, this Spar(1) bit indicates that the ATU-R is proposing G.992.1 Annex Q, and possibly Annex Q-EU.		
ⁿ C-PILOT1 ⁼⁶⁴	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the pilot tone on subcarrier 64 (Note 1).		
ⁿ C-PILOT1 ⁼⁹⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is proposing the pilot tone on subcarrier 96 (Note 1).		
ⁿ C-PILOT1 ⁼¹²⁸	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the pilot tone on subcarrier 128 (Note 1).		
ⁿ C-PILOT1 ⁼²⁵⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the pilot tone on subcarrier 256 (Note 1).		
Amateur radio notch – 1.8 MHz band	This selection shall only be performed by the ATU-C. Therefore, this Npar(2) bit shall either be set to the same value as in a previous CL message or set to ONE.		
Amateur radio notch – 3.5 MHz band	This selection shall only be performed by the ATU-C. Therefore, this Npar(2) bit shall either be set to the same value as in a previous CL message or set to ONE.		
Additional inband spectral shaping	If set to ONE, this Spar(2) bit indicates that the ATU-R is proposing additional downstream inband spectral shaping as defined by the values of REDUCED_PSD_lowband, PSD level at 1622 kHz, and PSD level at 3750 kHz		
REDUCED_PSD_l owband	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R wishes to have applied in the passband below 1104 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz.		
PSD level at 1622 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R wishes to have applied at 1622 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs between the REDUCED_PSD_lowband level at 1104 kHz and the PSD level at 1622 kHz.		
PSD level at 3750 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R wishes to have applied at 3750 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs between the PSD level at 1622 kHz and the PSD level at 3750 kHz.		
Extended upstream	If set to ONE, this Spar(2) bit indicates that the ATU-R is proposing extended upstream operation.		
EU-xx	If set to ONE, this Npar(3) bit indicates that the ATU-R is proposing upstream PSD mask US- xx. For non-overlapped spectrum, extended upstream masks are associated with downstream masks according to Figure Q.13. For overlapped spectrum, any EU-xx may be used with the overlapped downstream spectrum specified in §Q.4.8.2.		
Mode 1 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-R is proposing upstream mask mode 1 (different masks during FEXT and NEXT periods).		
Mode 2 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-R is proposing upstream mask mode 2 (same mask during FEXT and NEXT periods).		
Optional upstream masks for non- overlapped spectrum	If set to ONE, this NPar(3) bit indicates that the ATU-R is proposing one of the optional upstream masks when using non-overlapped spectrum downstream.		

Note 1: More than one pilot tone bit may be set in an MP message.

Q.7.4 Transceiver Training – ATU-C (supplements 10.4)

During transceiver training from C-REVERB1 to C-SEGUE1 except C-PILOTn and C-QUIETn, the ATU-C shall transmit both FEXT_R and NEXT_R symbols when Bitmap-N_R is enabled (Dual Bitmap mode), and shall not transmit the NEXT_R symbols except pilot tone when Bitmap-N_R is disabled (FEXT Bitmap mode). The duration of each state is defined as Figure Q.26.

Q.7.4.1 C-PILOT1 (supplements 10.4.2)

The ATU-C shall start the N_{SWF} (sliding window frame) counter from 0 immediately after entering C-PILOT1, and increment the N_{SWF} counter modulo 345 after transmission of each DMT symbol. According to the sliding window function and this counter, the ATU-C decides to transmit all of the subsequent symbols in either FEXT_R or NEXT_R symbols (for example, see Figures Q.11, Q.19 and Q.24).

C-PILOT1 has two signals.

The first signal is the pilot tone, a single frequency sinusoid at $f_{C-PILOT1}$ defined as:

$$X_{k} = \begin{cases} 0, & k \neq n_{C-PILOT1}, \ 0 \le k \le NSCds \\ A_{C-PILOT1}, & k = n_{C-PILOT1} \end{cases}$$

The frequency of the pilot tone shall be selected from one of the following choices during G.994.1 as:

*f*_{C-PILOT1} = 276 kHz (*n*_{C-PILOT1} = 64).
 *f*_{C-PILOT1} = 414 kHz (*n*_{C-PILOT1} = 96).
 *f*_{C-PILOT1} = 552 kHz (*n*_{C-PILOT1} = 128).
 *f*_{C-PILOT1} = 1104 kHz (*n*_{C-PILOT1} = 256).

Transmitters that support Annex Q-EU shall support all of these pilot tones.

The second signal is the TTR indication signal used to transmit $NEXT_R/FEXT_R$ information. The ATU-R can detect the phase information of the TTR_C from this signal. The TTR indication signal shall be selected during G.994.1 as:

A48 signal -the constellation encoding of the 48th carrier with 2-bit constellation as follows:

(+, +) to indicate a FEXT_R symbol;

(+, -) to indicate a NEXT_R symbol.

Q.7.4.2 C-PILOT1A (supplements 10.4.3)

C-PILOT1A has two signals and it is the same transmitted signal as C-PILOT1 (C.7.4.1).

Q.7.4.3 C-REVERB3 (supplements 10.4.11)

In order to synchronize the first symbol of C-RATES1 with the beginning of the hyperframe and to inform the entering timing of C-RATES1 to the ATU-R, the first symbol of C-SEGUE1 shall be transmitted inside of the FEXT_R duration as shown in Figure Q.22. Therefore, the duration of C-REVERB3 is 3628 DMT symbols.

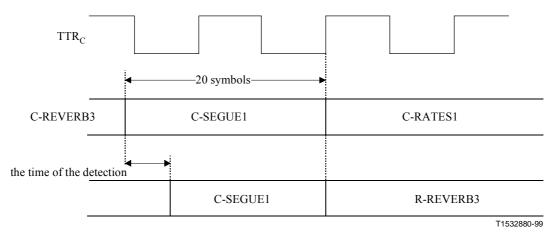


Figure Q.22/G.992.1 – Timing diagram from C-SEGUE1 to C-RATES1

Q.7.4.4 C-REVERB1 (replaces 10.4.5)

C-REVERB1 is a signal that allows the ATU-C and ATU-R receiver to adjust its automatic gain control (AGC) to an appropriate level. The data pattern used in C-REVERB1 shall be the pseudo-random downstream sequence (PRD), d_n for n = 1 to 2*NSCds, defined in Q.4.7.5 and repeated here for convenience:

$d_n = 1$	for $n = 1$ to 9	(10-1)
$d_n = d_{n-4} \oplus d_{n-9}$	for $n = 10$ to 2*NSCds	

The bits shall be used as follows: the first pair of bits (d_1 and d_2) is used for the DC and Nyquist subcarriers (the power assigned to them is, of course, zero, so the bits are effectively ignored); then the first and second bits of subsequent pairs are used to define the X_i and Y_i for i = 1 to NSCds-1 as defined in Table 7-13.

The period of PRD is only 511 bits, so d_{n+511} is equal to d_n . The bits d_1 to d_9 shall be re-initialized for each symbol, so each symbol of C-REVERB1 is identical.

The two bits that modulate the pilot carrier shall be overwritten by $\{0,0\}$: generating the $\{+,+\}$ constellation.

The duration of C-REVERB1 is 512 (repeating) symbols without cyclic prefix.

Q.7.4.4.1 Power Cut-back (supplements 10.4.5.1)

For Annex Q-EU, see A.3.1.

Q.7.5 Transceiver Training – ATU-R (supplements 10.5)

During transceiver training from R-REVERB1 to R-SEGUE1 except R-QUIETn, the ATU-R shall transmit both $FEXT_C$ and $NEXT_C$ symbols when Bitmap-N_C is enabled (Dual Bitmap mode) and shall not transmit $NEXT_C$ symbols when Bitmap-N_C is disabled (FEXT Bitmap mode). The duration of each state is defined as Figure Q.26.

Q.7.5.1 **R-QUIET2** (supplements 10.5.1)

The ATU-R enters R-REVERB1 after it completes timing recovery and Hyperframe synchronization from C-PILOT1/C-PILOT1A.

Q.7.5.2 R-REVERB1 (supplements 10.5.2)

The data pattern used in R-REVERB1 is the pseudo-random upstream sequence PRU defined in 8.11.3, repeated as

necessary for the the selected NSCus:

$$\begin{cases} d_n = 1 & \text{for } n = 1 \text{ to } 6 \\ d_n = d_{n-5} & \bigoplus d_{n-6} & \text{for } n = 7 \text{ to } 2*NSCus \end{cases}$$
(C.10-1)

The period of PRU is only 63 bits, so d_{n+63} is equal to d_n .

The ATU-R shall start its N_{SWF} counter immediately after entering R-REVERB1, and then increment the N_{SWF} counter with modulo 345 from 0 when it transmits each DMT symbol. The ATU-C and ATU-R shall have the same value since hyperframe alignment between the ATU-C and ATU-R shall be maintained. According to the sliding window and this counter, the ATU-R decides to transmit all of the subsequent symbols in either the FEXT_C or the NEXT_C symbol.

Q.7.5.3 R-QUIET3 (replaces 10.5.3)

The final symbol of R-QUIET3 accommodates the frame alignment of the transmitter to that of the receiver. It may be shortened by any number of samples. The maximum duration of R-QUIET3 is 6145 DMT symbols.

Q.7.5.4 R-REVERB2 (supplements 10.5.5)

After ATU-R detects C-SEGUE1, the ATU-R enters R-SEGUE1. The maximum duration of R-REVERB2 is 3643 DMT symbols.

Q.7.6 Channel analysis (ATU-C) (supplements 10.6)

ATU-C shall transmit only $FEXT_R$ symbols, and shall not transmit the $NEXT_R$ symbols except the pilot tone from C-RATES1 to C-CRC2. During C-MEDLEY, the ATU-C shall transmit both $FEXT_R$ and $NEXT_R$ symbols when Bitmap-N_R is enabled (Dual Bitmap mode). The ATU-C shall not transmit $NEXT_R$ symbols except the pilot tone, when Bitmap-N_R is disabled (FEXT Bitmap mode). The duration of each state is defined in Figure Q.26.

Q.7.6.1 C-SEGUE1 (supplements 10.6.1)

The duration of C-SEGUE1 is 20 symbols in order that the first symbol of C-SEGUE1 shall be inside of the FEXT_R duration.

Q.7.6.2 C-MEDLEY (replaces 10.6.6)

C-MEDLEY is a wideband pseudo-random signal used for estimation at the ATU-R of the downstream SNR. The data to be transmitted are derived from the pseudo-random sequence, PRD_m defined as:

d_n = 1 for n = 1 to 14 and d_n = d_{n-5}
$$\oplus$$
 d_{n-11} \oplus d_{n-12} \oplus d_{n-14} for n> 14,

and modulated as defined in 10.4.5. In contrast to C-REVERB1, the cyclic prefix is used and the data sequence continues from one symbol to the next (i.e. d_1 to d_{14} are not re-initialized for each symbol). Because the sequence is of length 2¹⁴-1, and far fewer bits are used for each symbol, the subcarrier vector for C-MEDLEY changes from one symbol period to the next. For non-overlapped spectrum, 2*(869-mm+1) bits are used each symbol, where mm is the minimum subcarrier specified for PSD mask DS-mm in Table Q.13. For overlapped spectrum, 2*864 bits are used each symbol. The pilot subcarrier is overwritten by the (+,+) signal constellation. The duration of C-MEDLEY is as shown in Figure Q.26. Following C-MEDLEY the ATU-C shall enter the state C-REVERB4.

With the periodical noise of TCM-ISDN, SNR also changes in the same cycle, as shown in Figure Q.23. The ATU-C transmits the signal in both of $NEXT_R$ and $FEXT_R$ symbols, and the ATU-R estimates two SNRs from the received $NEXT_R$ and $FEXT_R$ symbols, respectively, as defined in Figure Q.24.

The following formula gives the information that received N_{dmt}-th DMT symbol belongs to:

For $N_{dmt} = 0, 1, ..., 344$ $S = 272 \times N_{dmt} \mod 2760$ if { (S + 271 < a) or (S > d) } if { (S > b) and (S + 271 < c) } where a = 1243, b = 1403, c = 2613, d = 2704

then symbol for estimation of FEXT_R SNR then symbol for estimation of NEXT_R SNR

When Bitmap-N_R is disabled (FEXT Bitmap mode), ATU-C shall transmit only the pilot tone as NEXT_R symbol. The number of bits of NEXT_R shall be no more than the number of bits of FEXT_R.

At the transmitter, the PRD_m sequence generator shall continue to be updated during $NEXT_R$ symbols when Bitmap-N_R is disabled (FEXT Bitmap mode).

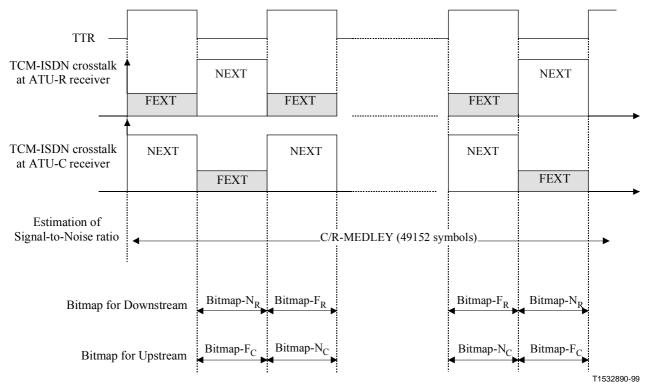


Figure Q.23/G.992.1 – Estimation of periodic Signal-to-Noise Ratio

TTR _C	
0	
1	
2	
3	30 31 32 33 34 35 36 36 37 39 40
4	41 42 43 44 45 46 47 48 49 50
5	51 52 53 54 55 56 57 58 59 60
6	61 62 63 64 65 66 67 58 70 70
7	71 72 73 74 75 76 76 80
8	81 82 83 84 85 36 87 88 89 99
9	91 92 93 94 95 96 97 98 99 100 101
10	101 102 103 104 105 106 107 108 109 111
11	112 113 114 115 116 117 120 121
12	122 123 124 125 26 27 78 129 131
13	132 133 134 135 136 137 138 139 141
14	142 143 144 145 146 147 148 149 151
15	152 153 154 155 156 157 158 159
16	162 163 164 165 166 167 168 169 170 172
17	173 174 175 176 177 178 179 188 182
18	183 184 185 186 187 188 189 199 192 102 104 105 106 107 100
19	193 194 195 196 197 198 1999 200 201 202
20 21	203 204 205 206 207 208 209 213 212
21	213 214 215 216 217 218 229 223 222 223 224 225 226 227 228 229 233
22	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$
23 24	233 234 235 237 238 249 238 249 253 244 245 246 247 248 249 258 253
25	244 245 246 246 246 260 262 263 254 255 256 257 258 259 269 262 263
26	264 265 266 267 268 269 279 277 273
27	274 275 276 277 278 279 288 288 283
28	284 285 286 287 288 289 299 299 299 293
29	294 295 296 297 298 299 300 300 300 300 300 300 300 300 300 3
30	304 305 306 307 308 309 334 334 332 333 314
31	315 316 317 318 319 324 324 324 324
32	325 326 327 328 329 336 333 332 333 334
33	335 336 337 338 339 340 344 342 343 344
	Symbol for estimation of FEXT _R S/N Symbol not used for S/N estimation
	Symbol for estimation of NEXT _R S/N T1535370-00

Figure Q.24/G.992.1 – Symbol pattern in a hyperframe for S/N estimation – Downstream

Q.7.6.3 C-RATES1 (supplements 10.6.2)

In order to support data rates greater than 32 Mbit/s, the B_I field has 11 bits. The RRSI fields shall use the same extended syntax as defined in Q.7.9.4 for C-RATES-RA.

For the S=1/2n framing mode (see §Q.4.9), the downstream RS_I shall be the number of parity bytes per sync byte, i.e., $RS_I = R_I/(n^*S)$.

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Table Q.13/G.992.1 – Assignment of 48 bits of C-MSG1			
Suffix(ces) of <i>m_i</i> (Note 1) Parameter (Note 3)			
47-44	Minimum required downstream SNR margin at initialization (Note 2)		
43-18	Reserved for future use		
17	Trellis coding option		
16	Overlapped spectrum option (Note 4)		
15	Unused (shall be set to "1")		
14-12	Reserved for future use		
11	NTR		
10-9	Framing mode		
8-6 Transmit PSD during initialization			
5 Reserved			
4-0	4-0 Maximum numbers of bits per subcarrier supported		
NOTE 1 – Within the separate fields	the least significant bits have the lowest subscripts.		
NOTE 2 – A positive number of dB;			
NOTE 3 – All reserved bits shall be set to "0".			
NOTE $4 -$ The initialization sequence allows for interworking of overlapped and non-overlapped spectrum			

Q.7.6.4 C-MSG1 (supplements 10.6.4)

T 11 0 12/0 002 1

NOTE 4 – The initialization sequence allows for interworking of overlapped and non-overlapped spectrum implementations. Therefore, this indication is for information only.

Q.7.6.4.1 Maximum numbers of bits per subcarrier supported – Bits 4-0 (replaces 10.6.4.8)

The N_{downmax} (transmit) capability shall be binary encoded onto $\{m_4, ..., m_0\}$ (e.g. $10001_2 = 17$). The maximum number of bits for the upstream data, N_{upmax} , that the ATU-C receiver can support need not be signalled to the ATU-R; it will be implicit in the bits and gains message, C-B&G, which is transmitted after channel analysis.

Q.7.7 Channel analysis (ATU-R) (supplements 10.7)

From R-RATES1 to R-CRC2, the ATU-R shall transmit only the FEXT_{C} symbols and shall not transmit the NEXT_{C} symbols. In R-SEGUE2 and R-MEDLEY, the ATU-R shall transmit both FEXT_{C} and NEXT_{C} symbols when Bitmap-N_C is enabled (Dual Bitmap mode) and shall not transmit NEXT_{C} symbols when Bitmap-N_C is disabled (FEXT Bitmap mode). The duration of each state is defined in Figure Q.26.

Q.7.8 R-SEGUE1 (supplements 10.7.1)

The maximum duration of R-SEGUE1 is 14 symbols (see Figure Q.22).

Q.7.8.1 R-REVERB3 (supplements 10.7.2)

The ATU-R shall start R-REVERB3 aligned with the beginning of a Hyperframe.

Q.7.8.2 R-SEGUE2 (supplements 10.7.3)

The duration of R-SEGUE2 is 13 symbols.

Q.7.8.3 R-MEDLEY (replaces 10.7.8)

R-MEDLEY is a wideband pseudo-random signal used for estimation of the upstream SNR at the ATU-C. The data to be transmitted are derived from the pseudo-random sequence PRU_m defined as:

d $_{n}$ = 1 for n = 1 to 23 and d $_{n}$ = d $_{n-18} \oplus$ d $_{n-23}$ for n> 23.

In contrast to R-REVERB1, the cyclic prefix is used and the data sequence continues from one symbol to the next (i.e.

 d_1 to d_{23} are not re-initialized for each symbol). Because the sequence is of length 2^{23} -1, and $2^*(nn-5)$ bits are used for each symbol (where nn is the maximum subcarrier specified for PSD mask EU-nn in Table Q.18), the subcarrier vector for R-MEDLEY changes from one symbol period to the next. Following R-MEDLEY the ATU-R enters signalling state R-REVERB4. The duration of R-MEDLEY is as shown in Figure Q.26.

With the periodical noise of TCM-ISDN, SNR also changes in the same cycle, as shown in Figure Q.23. ATU-R shall transmit the signal in both of $NEXT_C$ and $FEXT_C$ symbols, and ATU-C shall estimate two SNRs from the received $NEXT_C$ and $FEXT_C$ symbols, respectively, as defined in Figure Q.25.

The following numerical formula gives the information that received N_{dmt}-th DMT symbol belongs to:

For $N_{dmt} = 0, 1, ..., 344$ $S = 272 \times N_{dmt} \mod 2760$ if { (S > b) and (S + 271 < c) } then symbol for estimation of FEXT_C SNR if { (S + 271 < a) } then symbol for estimation of NEXT_C SNR where a = 1148, b = 1315, c = 2608

When Bitmap-N_C is disabled (FEXT Bitmap mode), the ATU-R shall not transmit NEXT_C symbol. The number of bits of NEXT_C shall be no more than the number of bits of FEXT_C.

At the transmitter, the PRU_m sequence generator shall continue to be updated during $NEXT_C$ symbols when Bitmap- N_C is disabled (FEXT Bitmap mode).

TTR _R _	
0	
1	
2	20 22 25 26 27 28 29
3	30 32 33 34 35 36 37 38 39 40 44 45 46 47 48 49 50
5	43 43 44 45 46 47 48 49 50 55 54 55 56 57 58 59 60
6	34 35 36 37 38 39 60 63 62 63 64 65 66 67 68 69 70
7	71 75 76 77 78 79 80
8	81 83 84 85 86 87 88 89 90
9	91 92 93 94 95 96 97 98 99 100 101
10	101 105 106 107 108 109 110 111
11	
12	127 128 129 130 131
13	<i>132 134 135</i> 136 137 138 139 140 14
14	142 143 145 146 147 148 149 150 151
15	152 333 344 355 156 157 158 159 160 161
16	162 63 64 65 165 167 168 169 170 171 172
17	176 77 178 179 180 181 182
18	183 184 185 186 187 188 189 190 191 92
19	193 194 195 196 19 198 199 200 201 202
20	203 204 205 206 207 208 209 210 211 212
21	213 214 215 217 218 219 220 221 222
22	223 224 227 228 229 230 231 232
23	233 234 235 238 239 240 241 242 243
24 25	244 245 246 247 248 249 250 251 252 253
25 26	254 255 257 238 259 260 260 262 263 264 265 265 268 269 270 271 272 273
26 27	203 203 203 203 211 212 213 234 235 235 278 279 280 281 282 283
27	284 285 286 287 288 289 290 291 292 293
20	294 295 296 297 298 299 300 301 302 303
30	304 305 306 307 308 309 310 311 312 313 314
31	<u>313</u> 316 317 318 319 320 321 322 323 324
32	325 326 327 328 329 330 331 332 333 34
33	335 336 337 338 339 340 341 342 343 344
	T1535290-00
	Symbol for estimation of FEXT _C S/N Symbol not used for S/N estimation
	Symbol for estimation of NEXT _C S/N

Figure Q.25/G.992.1 – Symbol pattern in a hyperframe for S/N estimation – Upstream

Q.7.8.4 R-MSG1 (supplements 10.7.6)

Suffix(ces) of m_i (Note 1)	Parameter (Note 2)		
47-18	Reserved for future use		
17	Trellis coding option		
16	Overlapped spectrum option (Note 3)		
15	Unused (shall be set to "1")		
14	Support of $S = 1/2$ mode (see Q.4.9) (Note 4)		
13	Support of dual latency downstream		
12	Support of dual latency upstream		
11	Network Timing Reference		
10, 9	Framing mode		
8-5	Reserved for future use		
4-0	Maximum numbers of bits per subcarrier supported		
NOTE 1 – Within the separate fields t	he least significant bits have the lowest subscripts.		
NOTE 2 – All reserved bits shall be set	et to "0".		
NOTE 3 - The initialization sequence	allows for interworking of overlapped and non-overlapped spectrum		
implementations. Therefore, this indication is for information only.			
Implementations. Institute this indication is for information only. NOTE 4. Since the $S = 1/2$ and is more letter for Amore O. a market suggesting Amore O shall set this bit to binary.			

Table Q.14/G.992.1 – Assignment of 48 bits of R-MSG1

NOTE 4 – Since the S=1/2 mode is mandatory for Annex Q, a modem supporting Annex Q shall set this bit to binary ONE.

Q.7.8.4.1 Maximum numbers of bits per subcarrier supported – Bits 4-0 (replaces 10.7.6.6)

The N_{upmax} (transmit) capability is encoded onto $\{m_4, ..., m_0\}$ with a conventional binary representation (e.g. $10001_2 = 17$).

Q.7.9 Exchange – ATU-C (supplements 10.8)

During C-RATESn, C-MSGn, C-B&G, and C-CRCn, the ATU-C shall transmit the FEXT_R symbol. In the other signals, the ATU-C shall transmit both $FEXT_R$ and $NEXT_R$ symbols when Bitmap-N_R is enabled (Dual Bitmap mode), and shall not transmit the $NEXT_R$ symbols except pilot tone when Bitmap-N_R is disabled (FEXT Bitmap mode). The duration of each state is defined in Figure Q.27.

Q.7.9.1 C-MSG2 (supplements 10.8.9)

Replace Table 10-13 with Table Q.15.

Suffix(ces) of m_i (Note 1)	Parameter (Note 2)	
31-26	Estimated average loop attenuation	
25-21	25-21 Reserved for future use	
20-16	Performance margin with selected rate option	
15-11 Reserved for future use		
10-0 Total number of bits supported		
NOTE 1 – Within the separate fields the least significant bits have the lowest subscripts.		
NOTE 2 – All reserved bits shall be set to "0".		

Table Q.15/G.992.1 -	Assignment of 32 bits of C-MSG2
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For NSCus=32,

 $n_{1C-MSG2} = 43$ $n_{2C-MSG2} = 91$

Otherwise,

 $n_{1C-MSG2} = 139$ $n_{2C-MSG2} = 187$

Q.7.9.1.1 Total number of bits per symbol supported (replaces 10.8.9.3)

The ATU-C receiver shall also calculate the maximum number of bits per symbol that the upstream channel can support with the performance margin defined in C-MSG-RA at an error rate of 10^{-7} .

The maximum number of bits per symbol is defined at the reference point B, that is calculated from the FEXT_C and NEXT_C downstream channel performance [e.g. if the maximum numbers of bits that can be supported in FEXT_C and NEXT_C symbols are 111 and 88 {Total number of bits per symbol supported} = $(111 \times 126 + 88 \times 214)/340 = 96$]. This number is encoded into bits 10-0 using a conventional binary representation [e.g. if the maximum number of bits that can be supported is 96 (data rate = 384 kbit/s), { m_{10} , ..., m_0 } = 000011111112].

NOTE – The number of symbols per hyperframe is 340. The number of FEXT symbols is 126. The number of NEXT symbols is 214.

Q.7.9.1.2 Estimated average upstream loop attenuation (supplements 10.8.9.1)

For Annex Q-EU, see A.3.2.

Q.7.9.2 C-B&G (replaces 10.8.13)

C-B&G shall be used to transmit to the ATU-R the bits and gains information, Bitmap-F_C { b_1 , g_1 , b_2 , g_2 , ... $b_{NSCus-1}$, $g_{NSCus-1}$ }, and Bitmap-N_C { $b_{NSCus+1}$, $g_{NSCus+1}$, $b_{NSCus+2}$, $g_{NSCus+2}$, ..., $b_{2*NSCus-1}$, $g_{2*NSCus-1}$ }, that are to be used on the upstream carriers. b_i of Bitmap-F_C indicates the number of bits to be coded by ATU-R transmitter onto the *i* th upstream carrier in FEXT_C symbols; g_i of Bitmap-F_C indicates the scale factor, relative to the gain that was used for that carrier during the transmission of R-MEDLEY, that shall be applied to the *i* th upstream carrier in FEXT_C symbols. Similarly, b_i of Bitmap-N_C indicates the number of bits onto the (*i* – NSCus) th upstream carrier in

NEXT_C symbols; g_i of Bitmap-N_C indicates the scale factor that shall be applied to the (*i* – NSCus) th upstream carrier in NEXT_C symbols.

Because no bits or energy will be transmitted at DC or one-half the sampling rate, b_0 , g_0 , b_{NSCus} , g_{NSCus} , $b_{2*NSCus}$, and $g_{2*NSCus}$ are all presumed to be zero and shall not be transmitted.

Each b_i shall be represented as an unsigned 5-bit integer, with valid b_i s lying in the range of zero to N_{upmax} , the maximum number of bits that the ATU-R is prepared to modulate onto any subcarrier, which is communicated in R-MSG1.

Each g_i shall be represented as an unsigned 11-bit fixed-point quantity, with the binary point assumed just to the right of

the third most significant bit. For example, a g_i with binary representation (most significant bit listed first)

 001.01000000_2 would instruct the ATU-R to scale the constellation for carrier *i*, by a gain factor of 1.25, so that the power in that carrier shall be 1.94 dB higher than it was during R-MEDLEY.

For subcarriers on which no data are to be transmitted, and the receiver will never allocate bits (e.g. out-of-band subcarriers) both b_i and g_i shall be set to zero (00000₂ and 00000000 000₂, respectively). For subcarriers on which no data are to be currently transmitted, but the receiver may allocate bits later (e.g. as a result of an SNR improvement), the b_i shall be set to zero and the g_i to a value in the 0.19 to 1.33 range (000.00110000₂ to 001.0101010₁).

Let NSCu=128, except when EU-32 is used where NSCu=32. The C-B&G information shall be mapped in a 32*(NSCu-1)-bit [4*(NSCu-1) byte] message *m* defined by:

 $m = \{m_{32}*(NSCu-1)-1, m_{32}(NSCu-1)-2, ..., m_1, m_0\} = \{g_2*NSCu-1, b_2*NSCu-1, ..., g_{NSCu+1}, b_{NSCu+1}, g_{NSCu-1}, ..., g_1, b_1\},$ (C.10-2)

with the MSB of b_i and g_i in the higher *m* index and m_0 being transmitted first. The message *m* shall be transmitted in 4*(NSCu-1) FEXT_R symbols. When NSCu=32, including C_CRC5, the total length is 336 symbols while for NSCu=128, the total length is 336+3*345=1371 symbols, using the transmission method as described in 10.8.9.

When Bitmap-N_C is disabled (FEXT Bitmap mode), b_i and g_i of Bitmap-N_C shall be set to zero. For index between NSCus+1 and 127, the m values are set to 0.

Q.7.9.3 C-SEGUE3 (replaces 10.8.16)

The duration of C-SEGUE3 is 18 symbols. Following C-SEGUE3, the ATU-C completes the initialization and enters C-SHOWTIME. In C-SHOWTIME, ATU-C shall transmit the signal using Bitmap- F_R and Bitmap- N_R with the sliding window.

When Bitmap-N_R is disabled (FEXT Bitmap mode), ATU-C shall transmit only the pilot tone as NEXT_R symbols.

	→ bits →							
fields	7	6	5	4	3	2	1	0
RS _F	$B_{10}(AS0)$	0	value of RS _F					
			MSB LSB					
RSI	$B_8(AS0)$	B ₉ (AS0)	value of RS _I					
			MSB LSB					
S	I9	I_8	value of S					
			MSB LSB					
Ι	I_7	I ₆	I_5	I_4	I ₃	I ₂	I ₁	I ₀
FS(LS2)	value of FS(LS2) <i>set to</i> {0000000 ₂ }							

Table Q.16/G.992.1 – RRSI fields of C-RATES-RA

The RS_I field has been extended to include bit B₉ of B_I (AS0) in bit 6, and The RS_F field has been extended to include the most significant bit B₁₀ of B_I (AS0) in bit 7, B_I (AS0) being the number of payload bytes in the AS0 bearer channel in the downstream interleave buffer. This is to support the higher data rates for the S=1/4, S=1/6 and S=1/8 modes.

The S field shall be coded $\{100100_2\}$ to indicate S=1/4, $\{100110_2\}$ to indicate S=1/6, and $\{101000_2\}$ to indicate S=1/8.

For the S=1/2n framing mode (see §Q.4.9), the downstream RS_I shall be the number of parity bytes per sync byte, i.e., $RS_I = R_I/(n^*S)$.

Q.7.10 Exchange – ATU-R (supplements 10.9)

ATU-R shall transmit only the FEXT_{C} symbols in R-MSGn, R-RATESn, R-B&G, R-CRCn. In other signals, the ATU-R shall transmit both FEXT_{C} and NEXT_{C} symbols when Bitmap-N_C is enabled (Dual Bitmap mode) and shall not transmit NEXT_{C} symbols when Bitmap-N_C is disabled (FEXT Bitmap mode). The duration of each state is defined in Figure Q.27.

Q.7.10.1 R-MSG-RA (supplements 10.9.2)

Replace Table 10-15 with Table Q.17.

Suffix(ces) of <i>m_i</i> Parameter				
(Note)	All reserved bits shall be set to 0			
79-72	Reserved for ITU-T			
71 - 70	Extension to number of RS payload bytes, K			
69, 68	Extension to number of tones carrying data (ncloaded)			
67-56	B _{fast-max}			
55-49	Number of RS overhead bytes, (R)			
48-40	Number of RS payload bytes, K			
39-32	Number of tones carrying data (ncloaded)			
31-25	31-25 Estimated average loop attenuation			
24-21 Coding gain				
20-16 Performance margin with selected rate option				
15 - 14 Extension to total number of bits per DMT symbol, B _{max}				
13-12	Maximum Interleave Depth downstream			
11-0	Total number of bits per DMT symbol, B _{max}			
NOTE – Within the sepa	NOTE – Within the separate fields the least significant bits have the lowest subscripts.			

Table Q.17/G.992.1 – Assignment of 80 bits of R-MSG-RA (Annex Q-EU)

Q.7.10.1.1 Total number of bits supported (B_{max}) (replaces 10.9.2.8)

This parameter shall be defined as in R-MSG2, see Q.7.9.1.

Q.7.10.1.2 B_{fast-max} (new)

 $B_{fast-max}$ is the maximum number of bits of the fast buffer for fast data transmitted on the condition that the bits of the fast data can be equally assigned to all FEXT-symbols and NEXT-symbols.

Fast Buffered Data Bfast-max is tf.

Q.7.10.2 R-MSG2 (supplements 10.9.8)

Table Q.10/0.772.1 – Assignment of 52 bits of R-M502			
Suffix(ces) of <i>m_i</i> (Note 1)	Parameter (Note 2)		
31-25	Estimated average loop attenuation		
24-21	Reserved for future use		
20-16	Performance margin with selected rate option		
15 - 14	Extension to total number of bits per DMT symbol, B _{max}		
13-12 Reserved for future use			
11-0 Total number of bits per DMT symbol, B _{max}			
NOTE 1 – Within the separate fields the least significant bits have the lowest subscripts.			
NOTE 2 – All reserved bits shall be set to "0".			

Table Q.18/G.992.1 – Assignment of 32 bits of R-MSG2

 $N_{1R-MSG2} = 10$ $N_{2R-MSG2} = 20$

Q.7.10.2.1 Total number of bits per symbol supported (supplements 10.9.8.3)

The maximum number of bits per symbol that the downstream channel can support is encoded into bits 15, 14 and 11 - 0.

The maximum number of bits per symbol is defined at the reference point B, that is calculated from the FEXT_R and NEXT_R downstream channel performance. For example, if the maximum numbers of bits that can be supported in FEXT_R and NEXT_R symbols are 111 and 88, the total number of bits per symbol supported is (111 x 126 + 88 x 214)/340 = 96.

NOTE – The number of symbols per hyperframe is 340, the number of FEXT symbols is 126, and the number of NEXT symbols is 214.

Q.7.10.2.2 Estimated average downstream loop attenuation (supplements 10.9.8.1)

For Annex Q-EU, see A.3.3.

Q.7.10.3 R-REVERB5 (supplement of 10.9.12)

The duration of R-REVERB5 is 345n-40, 3<=n<=19, when NSCu=128, or 3<=n<=16 when NSCu=32.

Q.7.10.4 R-B&G (replaces 10.9.14)

The purpose of R-B&G is to transmit to ATU-C the bits and gains information, Bitmap-F_R { b_1 , g_1 , b_2 , g_2 , ..., $b_{NSCds-1}$, $g_{NSCds-1}$ }, and Bitmap-N_R { $b_{NSCds+1}$, $g_{NSCds+1}$, $b_{NSCds+2}$, $g_{NSCds+2}$, ..., $b_{2*NSCds-1}$, $g_{2*NSCds-1}$ }, to be used on the downstream subcarriers. b_i of Bitmap-F_R indicates the number of bits to be coded by ATU-C transmitter onto the *i* th downstream subcarrier in FEXT_R symbols; g_i of Bitmap-F_R indicates the scale factor that shall be applied to the *i* th downstream subcarrier in FEXT_R symbols, relative to the gain that was used for that carrier during the transmission of C-MEDLEY. Similarly, b_i of Bitmap-N_R indicates the number of bits onto the (*i* – NSCds) th downstream carrier in NEXT_R symbols; g_i of Bitmap-N_R indicates the scale factor that shall be applied to the (*i* – NSCds) th downstream carrier in NEXT_R symbols. Because no bits or energy will be transmitted at DC or one-half the sampling rate, b_0 , g_0 , b_{NSCds} , g_{NSCds} , $b_{2*NSCds}$, and $g_{2*NSCds}$ are all presumed to be zero, and are not transmitted. When subcarrier 64 is reserved as the pilot tone, b_{64} and $b_{NSCds+64}$, shall be set to 0, g_{64} and $g_{NSCds+64}$ shall be set to g_{sync} . When subcarrier 128 is reserved as the pilot tone, b_{128} and $b_{NSCds+128}$, shall be set to 0, g_{128} and $g_{NSCds+128}$ shall be set to g_{sync} . When subcarrier 256 is reserved as the pilot tone, b_{256} and $b_{NSCds+256}$, shall be set to 0, g_{256} and $g_{NSCds+256}$ shall be set to 0, g_{256} and $g_{NSCds+256}$ shall be set to g_{sync} . The value g_{sync} represents the gain scaling applied to the sync symbol.

Each b_i is represented as an unsigned 5-bit integer, with valid b_i lying in the range of zero to N_{downmax} , the maximum number of bits that the ATU-C is prepared to modulate onto any subcarrier, which is communicated in C-MSG1.

Each g_i is represented as an unsigned 11-bit fixed-point quantity, with the binary point assumed just to the right of the

third most significant bit. For example, a g_i with binary representation (most significant bit listed first) 001.010000002 would instruct the ATU-C to scale the constellation for carrier *i* by a gain factor of 1.25, so that the power in that carrier shall be 1.94 dB higher than it was during C-MEDLEY.

For subcarriers on which no data are to be transmitted, and the receiver will never allocate bits (e.g. out-of-band subcarriers) both b_i and g_i shall be set to zero (00000₂ and 00000000 000₂, respectively). For subcarriers on which no data are to be currently transmitted, but the receiver may allocate bits later (e.g. as a result of an SNR improvement), the b_i shall be set to zero and the g_i to a value in the 0.19 to 1.33 range (000.00110000₂ to 001.0101010₁).

The R-B&G information shall be mapped in a (2*NSCds-2)*16-bit ((2*NSCds-2)*2 byte) message *m* defined by:

 $m = \{m_{(2*NSCds-2)*16-1}, m_{(2*NSCds-2)*16-2}, ..., m_1, m_0\} = \{g_{2*NSCds-1}, b_{2*NSCds-1}, ..., g_{NSCds+1}, b_{NSCds+1}, b_{NSCds+1}, b_{NSCds-1}, ..., g_{1}, b_{1}\},$ (Q.10-3)

with the MSB of b_i and g_i in the higher *m* index and m_0 being transmitted first. The message *m* shall be transmitted in (2*NSCds-2)*2 symbols, using the transmission method as described in 10.9.8.

When Bitmap-N_R is disabled (FEXT Bitmap mode), b_i and g_i of Bitmap-N_R shall be set to zero.

Q.7.10.5 R-SEGUE5 (replaces 10.9.17)

The duration of R-SEGUE5 is 13 symbols. Following R-SEGUE-5, ATU-R completes the initialization and enters R-SHOWTIME. In R-SHOWTIME, ATU-R shall transmit the signal using Bitmap- F_C and Bitmap- N_C with the sliding window.

When Bitmap-N_C is disabled (FEXT Bitmap mode), ATU-R shall not transmit NEXT_C symbols.

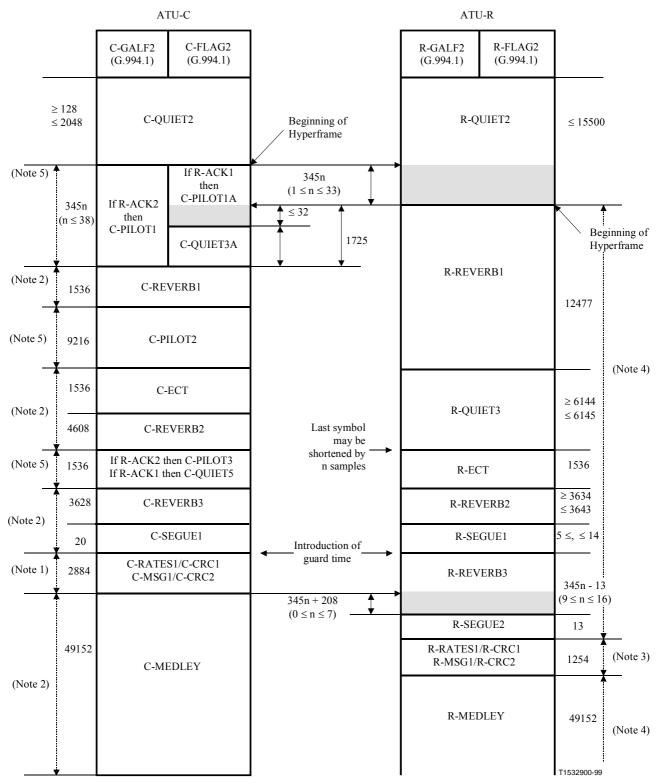
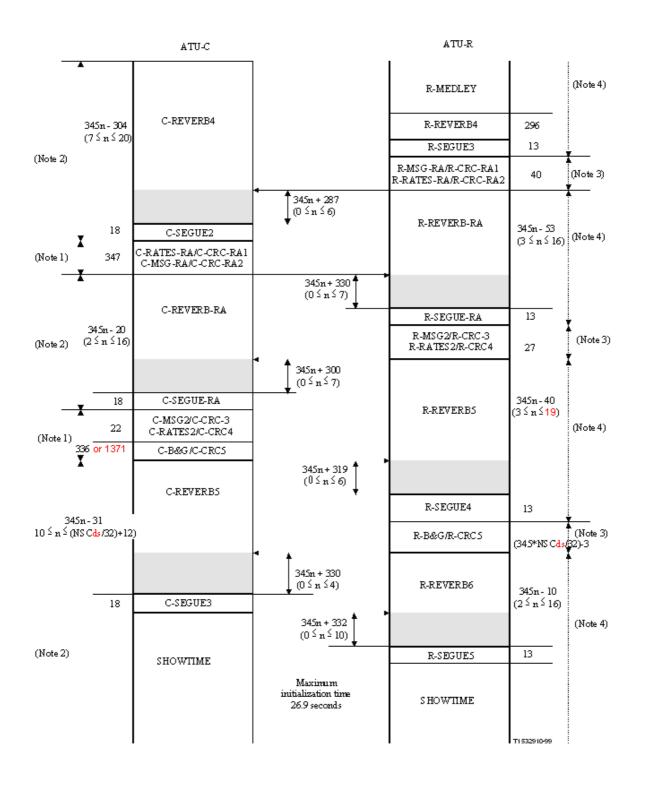


Figure Q.26/G.992.1 – Timing diagram of the initialization sequence – Part 1



- NOTE 1 The ATU-C shall transmit the FEXTR symbols, and shall not transmit as NEXTR symbols except the pilot tone.
- NOTE 2 The ATU-C shall transmit both FEXTR and NEXTR symbols, when Bitmap-NR is enabled (Dual Bitmap mode). ATU-C shall not transmit the NEXTR symbols except pilot tone, when Bitmap-NR is disabled (FEXT Bitmap mode).
- NOTE 3 The ATU-R shall transmit the FEXTC symbols, and shall not transmit the NEXTC symbols.
- NOTE 4 The ATU-R shall transmit both FEXTC symbols, when Bitmap-NC is enabled (Dual Bitmap mode). ATU-R shall not transmit NEXTC symbols, when Bitmap-NC is disabled (FEXT Bitmap mode).
- NOTE 5 The ATU-C shall transmit both FEXTR and NEXTR symbols.

Figure Q.27/G.992.1 – Timing diagram of the initialization sequence – Part 2

[Editor's note: updated Figure Q.27 to parameterize the length of C-B&G and the maximum length of R-REVERB5.]

Q.8 AOC On-line adaptation and reconfiguration (pertains to clause 11)

Q.8.1.1 Bit swap request (replaces 11.2.3)

The receiver shall initiate a bit swap by sending a bit swap request to the transmitter via the AOC channel. This request tells the transmitter which subcarriers are to be modified. The format of the request is shown in Table Q.19.

ĺ	Message header	Message field 1-4			
	$\{11111111_2\}$	Bitmap index Subchannel Command Subch			Subchannel
	(8 bits)	(1 bit)	index – bits 10	(5 bits)	index – bits 8
			& 9		to 1
			(2 bits)		(8 bits)

Table Q.19/G.992.1 -	Format of the bit swa	ap request message
----------------------	-----------------------	--------------------

The request shall comprise nine bytes as follows:

- an AOC message header consisting of 8 binary ones;
- message fields 1-4, each of which consists of a one-bit bitmap index, subchannel index bits 10 & 9, and a five-bit command followed by bits 8 to 1 of the subchannel index. One-bit bitmap index, subchannel index bits 10 & 9, and valid five-bit commands for the bit swap message shall be as shown in Table Q.20. In Table Q.20, the MSB for the bit swap request command represents the Bitmap index. For downstream data, Bitmap index equals 0 indicates Bitmap-F_R, and Bitmap index equals 1 indicates Bitmap-N_R. Similarly for upstream data, Bitmap index equals 0 indicates Bitmap-F_C, and 1 indicates Bitmap-N_C. The next 2 bits are subchannel index bits 10 & 9. The ten-bit subchannel index is counted from low to high frequencies with the lowest frequency subcarrier having the number zero. The subcarrier index zero shall not be used;
- the bit swap between $FEXT_{C/R}$ symbols and $NEXT_{C/R}$ symbols is not allowed.

Value (8 bit)	Interpretation			
yzz000002	Do nothing			
yzz000012	Increase the number of allocated bits by one			
yzz000102	Decrease the number of allocated bits by one			
yzz000112	Increase the transmitted power by 1 dB			
yzz001002	Increase the transmitted power by 2 dB			
yzz001012	Increase the transmitted power by 3 dB			
yzz00110 ₂	Reduce the transmitted power by 1 dB			
yzz001112	Reduce the transmitted power by 2 dB			
yzz01xxx ₂	Reserved for vendor discretionary commands			
NOTE – y is "0" for $FEXT_{C/R}$ symbols, and "1" for $NEXT_{C/R}$ symbols of the Sliding Window.				
NOTE – subchannel index = zz_2 *256 + subchannel index value from lower 8 bit field				

Table Q.20/G.992.1 - Bit swap request command

The bit swap request message (i.e. header and message fields) shall be transmitted five consecutive times.

To avoid g_i divergence between ATU-C and ATU-R after several bit swaps, for a g_i update of Δ dB the new g_i value should be given by:

$$g_i' = (1/256) \times round(256 \times g_i \times 10 \exp(\Delta/20))$$
 (Q.11-1)

Q.8.1.2 Extended bit swap request (supplements 11.2.4)

The format of the extended bit swap request is shown in Table Q.21.

Message header	Message field 1-6				
{11111100 ₂ }	Bitmap index (1 bit)	Subchannel index – bits 10	Command (5 bits)	Subchannel index – bits 8	
(8 bits)		& 9	(3 0108)	to 1	
		(2 bits)		(8 bits)	

Table Q.21/G.992.1 – Format of the bit swap request message

In the same manner as the bit swap request, each of the message fields of the extended bit swap request consists of one-bit bitmap index, a five-bit command followed by a related ten-bit subchannel index.

Q.8.1.3 Bit swap acknowledge (supplements 11.2.5)

The bit swap superframe counter number shall only indicate the last superframe (SPF#4) of a hyperframe.

The new bit and/or transmit power table(s) shall then take effect starting from the first frame (frame 0) of SPF#0 of a hyperframe.

If the bit swap superframe counter number contained in the received bit swap acknowledge message does not indicate SPF#4, then the new table(s) shall take effect starting from frame 0 of SPF#0 of the next hyperframe.

Q.9 POTS splitter

For operation according to G.992.1 Annex Q-EU, the Annex E.4/G.992.3 requirements applying over a frequency band up to 1104 kHz, shall be met over a frequency band up to 3750 kHz.

付属資料4

G.992.1 ANNEX Q-EU (REVISION 4.0) PROPRIETARY EXTENSION TO G.992.1 ANNEX I

This document defines G.992.1 Annex Q-EU (Quad spectrum downstream with extended upstream spectrum), a proprietary extension to G.992.1 Annex I to extend the data rate beyond 32 Mbit/s downstream and 5 Mbit/s upstream on short loops by way of:

- Increased downstream bandwidth → increased number of subcarriers, NSCds=1024 (used subcarriers up to 869)
- Increase upstream bandwidth \rightarrow increased number of subcarriers, NSCus=112
- Increased bit loading, beyond 15 bits/bin
- Extended framing \rightarrow S=1/2n, with support for n = 1 to 4

Due to the increase in upstream data rates, the upstream maximum interleave depth has been increased to 16. Support of this is mandatory.

The attached text is the approved text for Annex I, marked up with revision control to show the changes necessary to support the additional functionality.

Revision R4 has the following changes with respect to Revision R3.2:

- modified both downstream and upstream PSDs. Added EU-68 to 112.
- Modified timing diagram for initialization in Figure Q.27(Text in C-B&G and R-REVERB5 has been changed)
- added G.994.1 code points to support above changes

ANNEX Q-EU

Specific requirements for an ADSL system to support downstream data rates greater than 32 Mbit/s and upstream data rates greater than 5 Mbit/s on short loops operating in the same cable as ISDN as defined in ITU-T Recommendation G.961 Appendix III

Q.1 Scope

This annex describes those specifications that are unique to an ADSL system coexisting in the same binder as TCM-ISDN as defined Recommendation G.961 Appendix III. The subclauses in this annex provide supplementary and replacement material to the clauses in the main body. The nature of the material is parenthetically indicated in the subclause heading. The modifications described in this annex allow a performance improvement from the ADSL system specified in Annex C for short loops in an environment coexisting with TCM-ISDN in the same cable. Specifically, this Annex specifies extensions to downstream and upstream bandwidth, framing modes, and maximum bit loading to support downstream data rates greater than 32 Mbit/s and upstream data rates greater than 5 Mbit/s. This annex also defines those parameters of this ADSL system that have been left undefined in the main body of this Recommendation. An ADSL system implementing Annex Q-EU shall support Annex Q. It is recommended that an ADSL system implementing Annex SI and C.

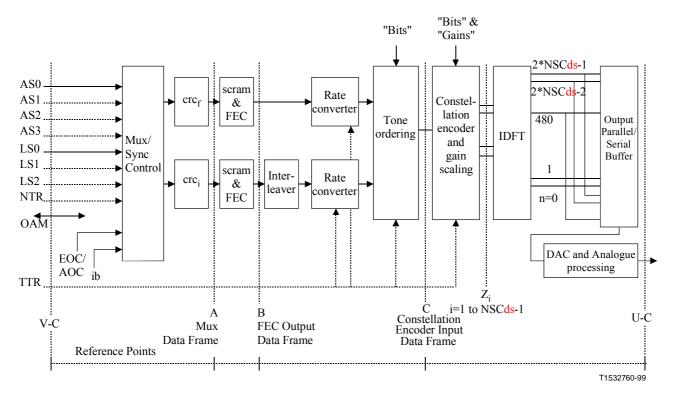
Q.2 Definitions

Bitmap-F _C	ATU-R transmitter bitmap under TCM-ISDN FEXT noise generated at ATU-C
Bitmap-F _R	ATU-C transmitter bitmap under TCM-ISDN FEXT noise generated at ATU-R
Bitmap-N _C	ATU-R transmitter bitmap under TCM-ISDN NEXT noise generated at ATU-C
Bitmap-N _R	ATU-C transmitter bitmap under TCM-ISDN NEXT noise generated at ATU-R
Dual Bitmap FEXT Bitmap	The Dual Bitmap method has dual bit rates under the FEXT and NEXT noise from TCM-ISDN Similar to the Dual Bitmap method however transmission only occurs during FEXT noise from TCM-ISDN
FEXT _C duration	TCM-ISDN FEXT duration at ATU-C estimated by the ATU-R
FEXT _C symbol	DMT symbol transmitted by ATU-R during TCM-ISDN FEXT
FEXT _R duration	TCM-ISDN FEXT duration at ATU-R estimated by the ATU-C
FEXT _R symbol	DMT symbol transmitted by ATU-C during TCM-ISDN FEXT
Hyperframe NEXT _C duration	5 Superframes structure which synchronized TTR TCM-ISDN NEXT duration at ATU-C estimated by the ATU-R
NEXT _C symbol	DMT symbol transmitted by ATU-R during TCM-ISDN NEXT
NEXT _R duration	TCM-ISDN NEXT duration at ATU-R estimated by the ATU-C
NEXT _R symbol	DMT symbol transmitted by ATU-C during TCM-ISDN NEXT
NSCds	The highest subcarrier index that can be used for downstream transmission (i.e., the subcarrier index corresponding to the Nyquist frequency) For example, $NSCds = 256$ for a downstream channel using the frequency band up to $1.104MHz$; $NSCds = 512$ for a downstream channel using the frequency band up to $2.208MHz$.
NSCus	The highest subcarrier index that can be used for upstream transmission (i.e., the subcarrier index corresponding to the Nyquist frequency) For example, $NSCus = 64$ for an upstream channel using the frequency band up to 276 kHz.
N _{SWF}	Sliding Window frame counter
Subframe TTR	10 consecutive DMT symbols (except for sync symbols) according to TTR timing
TTR _C	TCM-ISDN Timing Reference Timing reference used in ATU-C
TTRR	Timing reference used in ATU-R
UI	Unit Interval

Q.3 Reference Models

Q.3.1 ATU-C transmitter reference model (replaces figures in 5.1)

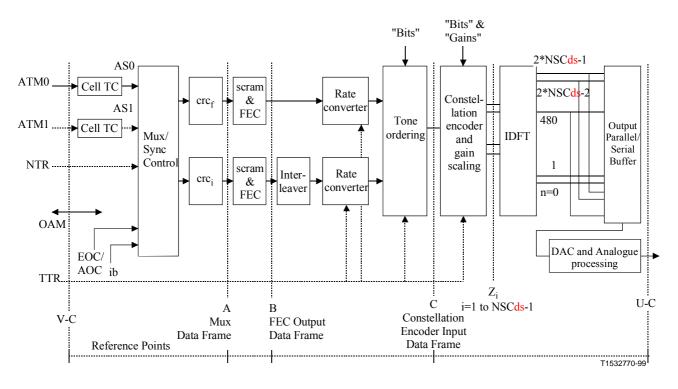
See Figure Q.1 and Figure Q.2.



NOTE - The TTR may be generated in ATU-C without being provided from the TCM-ISDN clock.

Figure Q.1/G.992.1 – ATU-C transmitter reference model for STM transport

Annex Q-EU does not currently support STM transport. It only supports ATM transport.

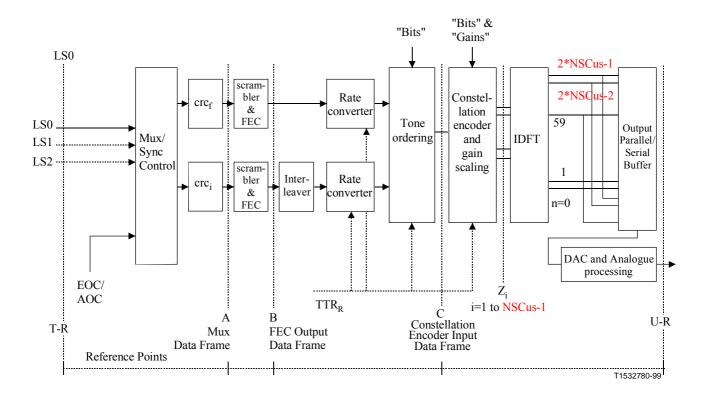


NOTE - The TTR may be generated in ATU-C without being provided from the TCM-ISDN clock.

Figure Q.2/G.992.1 – ATU-C transmitter reference model for ATM transport

Q.3.2 ATU-R transmitter reference model (replaces figures in 5.2)

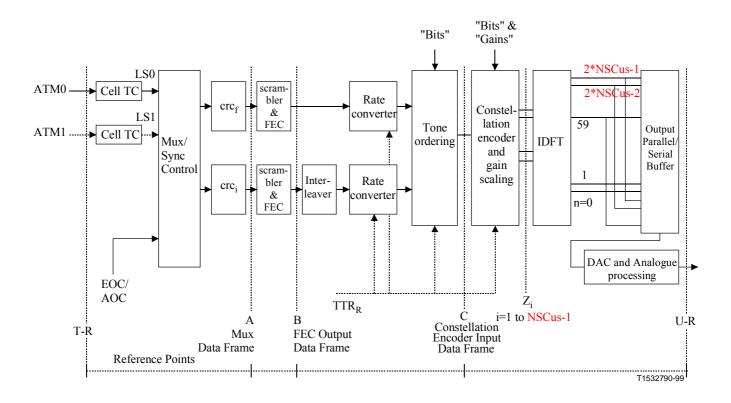
See Figure Q.3 and Figure Q.4.



NOTE – The TTR_R shall be generated in ATU-R from the received TTR_C signal, and it is locked to 690 periods of upstream sampling clock (1.104 MHz).

Figure Q.3/G.992.1 – ATU-R transmitter reference model for STM transport

Annex Q-EU does not currently support STM transport. It only supports ATM transport.



NOTE – The TTR_R shall be generated in ATU-R from the received TTR_C signal, and it is locked to 690 periods of upstream sampling clock (1.104 MHz).



Q.3.3 ATU-C/R transmitter timing model (replacement for 5.3)

Q.3.3.1 TCM-ISDN crosstalk timing model (new)

Figure Q.5 shows the timing chart of the crosstalk from TCM-ISDN.

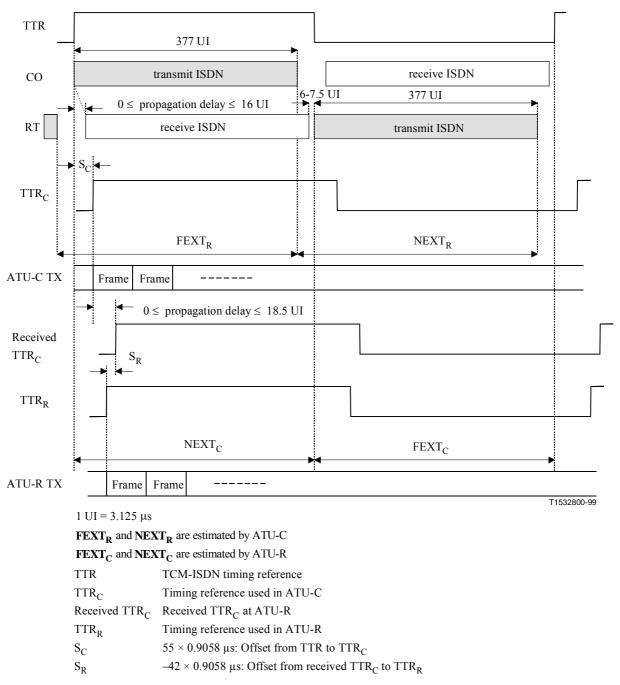


Figure Q.5/G.992.1 – Timing chart of the TCM-ISDN crosstalk

The data stream of TCM-ISDN is transmitted in TTR period. CO transmits the stream in the first half of the TTR period and RT transmits in the second half of the TTR period. ATU-C receives NEXT noise from the ISDN in the first half of the TTR period and FEXT noise from the ISDN in the second half of the TCM-ISDN period. On the other hand, ATU-R receives FEXT noise from the ISDN in the first half of the TTR period and NEXT noise from the ISDN in the second half of the TTR period.

As defined in Q.7.6.2 and Q.7.8.3, the ATU-C shall estimate the FEXT_R and NEXT_R duration at ATU-R, and the ATU-R shall estimate FEXT_C and NEXT_C duration at ATU-C taking propagation delay on the subscribe line into consideration.

The ATU-C shall transmit any symbols by synchronizing with the TTR_C . The ATU-R shall transmit any symbols synchronizing with the TTR_R generated from received TTR_C .

Q.3.3.2 Sliding window (new)

Figure Q.6 shows the timing chart of the transmission for the Annex Q-EU downstream at ATU-C.

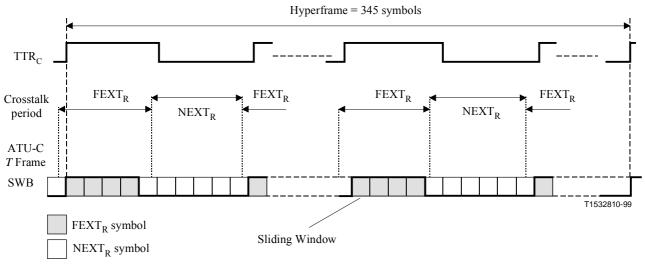


Figure Q.6/G.992.1 – Sliding window for downstream symbols

The Sliding Window defines the transmission symbols under the crosstalk noise environment synchronized to the period of TTR. The $\text{FEXT}_{C/R}$ symbol represents the symbol completely inside the $\text{FEXT}_{C/R}$ duration. The $\text{NEXT}_{C/R}$ symbol containing the $\text{NEXT}_{C/R}$ duration. Thus, there are more $\text{NEXT}_{C/R}$ symbols than $\text{FEXT}_{C/R}$ symbols.

The ATU-C decides which transmission symbol is FEXT_R or NEXT_R symbol according to the sliding window and transmits it with the corresponding bit table. Similarly, the ATU-R decides the transmission symbol is a FEXT_C or NEXT_C and transmits it with the corresponding bit table. Although the phase of the sliding window is asynchronous with $\text{TTR}_{C/R}$, the pattern is fixed to the 345 frames of the hyperframe.

Q.3.3.3 ATU-C Symbol Synchronization to TTR (new)

345 symbols are 34 cycles with cyclic prefix of TTR_C (or 32 cycles of TTR_C without cyclic prefix). This implies a PLL lock at the ATU-R.

Q.3.3.4 Dual Bitmap switching (new)

The ATU-C transmits FEXT_R symbols using Bitmap-F_R (in FEXT_R duration), and transmits NEXT_R symbols using Bitmap-N_R (in NEXT_R duration) according to the result of initialization. The ATU-R transmits FEXT_C symbols using Bitmap-F_C (in FEXT_C duration), and transmits NEXT_C symbols using Bitmap-N_C (in NEXT_C duration) in the same manner.

The ATU-C shall have the capability to disable Bitmap-N_C and Bitmap-N_R (see Q.4.5 and Q.5.3).

Q.3.3.5 Loop timing at ATU-R (new)

The phase relation between received symbol and transmitted symbol of ATU-R at the reference point U-R shall meet the phase tolerances as shown in Figure Q.7.

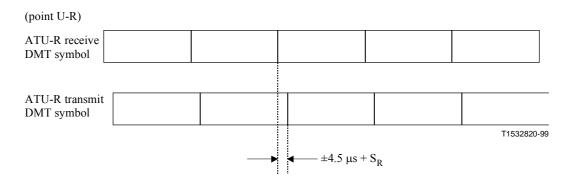
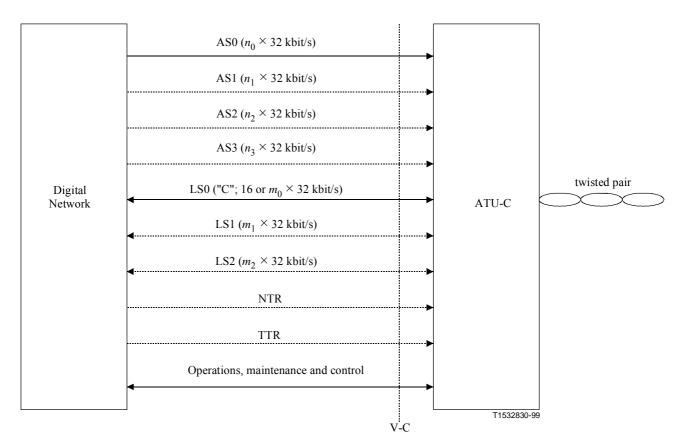


Figure Q.7/G.992.1 – Loop timing for ATU-R

- Q.4 ATU-C functional characteristics (pertains to clause 7)
- Q.4.1 STM transmission protocols specific functionality (pertains to 7.1)
- Q.4.1.1 ATU-C input and output V interface for STM transport (replaces figure in 7.1.1)

See Figure Q.8.



NOTE 1 – Optional bearer channels (both duplex and simplex) and features are shown with dotted lines. NOTE 2 – TTR may be generated in the ATU-C without being provided from the V-C reference point.

Figure Q.8/G.992.1 – ATU-C functional interfaces for STM transport at the V-C reference point

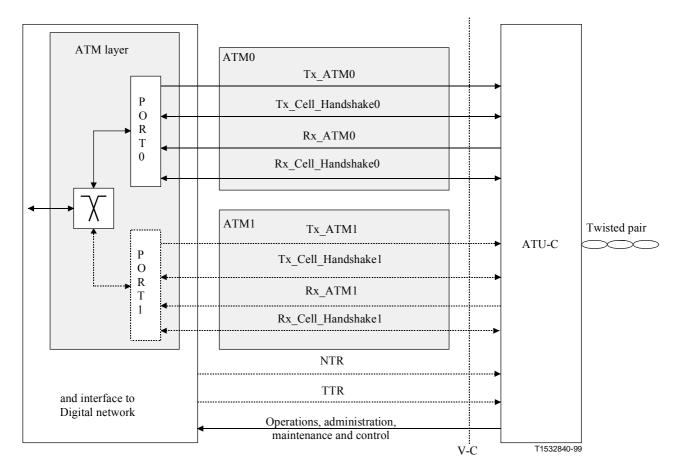
Q.4.1.2 Payload transfer delay (supplements 7.1.4)

Since Annex Q-EU uses a rate converter, the maximum payload transfer delay is longer than specified values in 7.1.4. The additional one-way transfer delay due to the rate converters shall be less than 1.7 ms for fast data and 13 ms for interleaved data.

Q.4.2 ATM transmission protocols specific functionalities (pertains to 7.2)

Q.4.2.1 ATU-C Input and Output V interface for ATM transport (replaces figure in 7.2.1)

See Figure Q.9.



NOTE - TTR can be generated in the ATU-C without being provided from the V-C reference point.

Figure Q.9/G.992.1 – ATU-C functional interfaces to the ATM layer at the V-C reference point

Q.4.2.2 Payload transfer delay (supplements 7.2.2)

Since Annex Q-EU uses a rate converter, the maximum payload transfer delay is longer than specified values in 7.2.2. The additional one-way transfer delay due to the rate converters shall be less than 1.7 ms for fast data and 13 ms for interleaved data.

Q.4.3 Framing (pertains to 7.4)

Q.4.3.1 Superframe structure (supplements 7.4.1.1)

Since the rate converter reorders the user data and overhead bit-level data to create hyperframes, the input data frames to the constellation encoder are different than those defined in 7.4.1.1.

Q.4.3.2 Hyperframe structure (replaces 7.4.1.3)

Annex Q-EU uses the hyperframe structure shown in Figure Q.10. Figure Q.10 shows the phase relationship between the TTR_C and the hyperframe at the point U-C. Each hyperframe is composed of 5 superframes, which are numbered from 0 to 4. In order to indicate the boundary of the hyperframe, the inverse synch symbol is used for the 4th superframe (SPF#3), which is generated from a tone-by-tone 180-degree phase reversal of the synchronization symbol (see Q.4.7.1) except for the pilot tone.

The bit-level data stream from the rate-converter is extracted according to the size of Bitmap- F_R and Bitmap- N_R using the Sliding Window (see Q.3.3.2).

In order to make the bit rate to be a multiple of 32 kbit/s, the dummy bits are inserted at the end of hyperframe by the

rate converter (see Q.4.4.2). The hyperframe is composed of 345 DMT symbols, numbered from 0 to 344. Each symbol is assigned as $FEXT_R$ or $NEXT_R$ or $NEXT_R$ or $NEXT_R$ duration (see Q.2), and the following numerical formula gives the information which duration N_{dmt}-th DMT symbol belongs to at ATU-C transmitter (see Figure Q.11).

 $\label{eq:states} \begin{array}{ll} \mbox{For $N_{dmt}=0,1,...,344$} \\ \mbox{$S=272$ x N_{dmt} mod 2760} \\ \mbox{$if $\{$ (S+271 < a)$ or $(S>a+b)$ $\}$} \\ \mbox{$else$} \\ \mbox{$then $FEXT_R$ symbol$} \\ \mbox{$then $NEXT_R$ symbol$} \\ \mbox{$where $a=1243$, $b=1461$} \\ \end{array}$

Thus, 128 DMT symbols are allocated in the FEXT_R duration, and 217 DMT symbols are allocated in the NEXT_R duration. The symbols are composed of:

FEXT _R symbol:				
Number of symbol using Bitmap-F _R	= 126			
Number of synch symbol	= 1			
Number of inverse synch symbol NEXT _R symbol:	= 1			
Number of symbol using Bitmap-N _R	= 214			
Number of synch symbol	= 3			

During FEXT Bitmap mode, the ATU-C shall transmit only the pilot tone in NEXT_R symbols.

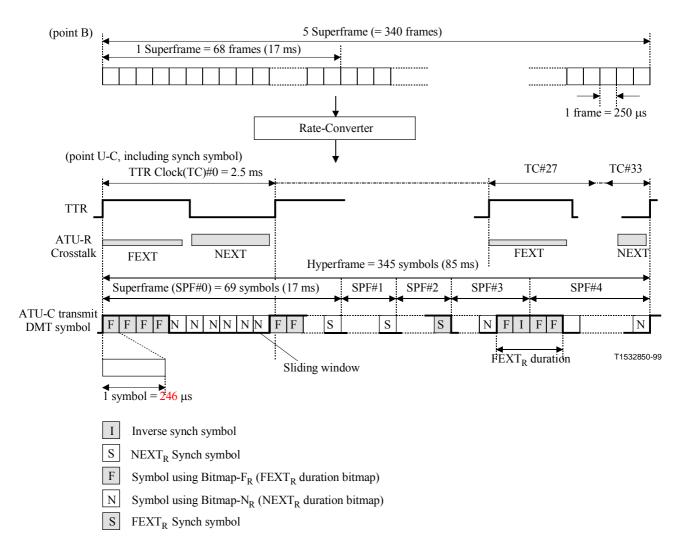


Figure Q.10/G.992.1 – Hyperframe structure for downstream

0	0 1 2	3	4	5		6	7	8	9
1	10 11 12	13	14	15	16	5 1	7 1	8 1	9
2	20 21 22	23	24	25	26	27	28	29	
3	30 31 32	33 3	4	35	36	37	38	39	40
4	41 42	43 44		45	46	47	48	49	50
5	51 52 53	3 54		55	56	57	58	59	60
6	61 62 63	64	6	5 6	6	67	SS	69	70
7	71 72 73	74	75	76	5 7	7 7	8 7	79 8	30
8	81 82 83	84	85	86	87	88	8 89) 9()
9	91 92 93	94	95	96	97	98	99	100	101
10	101 102 103	104 10)5	106	107	108	109	110	111
11	112 113 1	14 115	5	116	117	118	119	120	121
12	122 123 12				127	128	129	130	131
13	132 133 134	135	13						141
14	142 143 144	145	146						51
15	152 153 154	155	156		158				1
16	162 163 164		66	167	168	169	170	171	172
17		175 17	_	177	178	179	180	181	182
18		85 186		187	188	189	190	191	192
19	193 194 193				198	199	200	201	202
20	203 204 205	SS	20						212
21	213 214 215	216	217			<u> </u>	-		
22	223 224 225	226	227		229				
23 24	233 234 235	236 2 246 24	37	238 248	239 249	240	241	242	243 253
24 25		56 257		248	259	260	260	262	263
23 26	264 265 260				239	270	271	272	203
20 27	274 ISS 276	277	27						273
28	284 285 286	287	288			· · · · · · · · · · · · · · · · · · ·	<u> </u>	<u> </u>	
29	294 295 296		298	299	300	<u> </u>			- <u>-</u>
30	304 305 306		08	309	310	311	312	313	314
31		17 31		319	320	321	322	323	324
32	325 326 32			329	330	331	332	333	334
33	335 336 337						342	343	SS
	ISS Inverse synch sym	bol S	S F	EXT _R S	vnch svn	nbol SS		Γ _R synch	svmbol
	FEXT _R data symbol			EXT _R d	-				535330-00

Figure Q.11/G.992.1 – Symbol pattern in a hyperframe with cyclic prefix – Downstream

Q.4.3.3 Subframe Structure (replaces 7.4.1.4)

A subframe is 10 consecutive DMT symbols (except for synch symbols) as shown in Table Q.1. The 34 subframes form a hyperframe.

Subframe No.	DMT symbol No.	Note
0	0-9	
1	10-19	
2	20-29	
3	30-39	
4	40-49	
5	50-59	
6	60-70	#68 is Synch Symbol
7	71-80	
8	81-90	
9	91-100	
10	101-110	
11	111-120	
12	121-130	
13	131-141	#137 is Synch Symbol
14	142-151	
15	152-161	
16	162-171	
17	172-181	
18	182-191	
19	192-201	
20	202-212	#206 is Synch Symbol
21	213-222	
22	223-232	
23	233-242	
24	243-252	
25	253-262	
26	263-272	
27	273-283	#275 is Inverse Synch Symbol
28	284-293	
29	294-303	
30	304-313	
31	314-323	
32	324-333	
33	334-344	#344 is Synch Symbol

Table Q.1/G.992.1 – Subframe (downstream)

Q.4.3.4 Reduced overhead framing with merged fast and sync bytes (modifies 7.4.3.2)

In S=1/2n framing mode (see Q.4.9), there are n Sync bytes per symbol time. The contents of the Sync bytes is the same as in regular framing except that it repeats at n times the rate causing the superframe to be 68/n symbols in length. The contents of the sync bytes are shown in Table 7-6/G.992.1. In S=1/2n framing mode, "Frame Number" in column 1 in Table 7-6/G.992.1 is replaced by "Sync Byte Index Number".

As a result of the increase in superframe rate, the superframe contents is carried more frequently. For the case when N=2, the EOC and AOC bandwidth doubles, thereby transferring actual messages at twice the rate. The CRC byte is carried twice as frequently and therefore the maximum error rate rises from just over 58 per second to 117 per second. Where the duration of an error condition is measured, this needs to be taken into consideration. The indicator bits are also sent twice as often, which needs to be taken into consideration for statistics collection.

Q.4.4 Dual Bitmapping and Rate Conversion (replaces 7.15)

The functions of the rate converter (see Q.4.4.2), tone ordering (see Q.4.6), constellation encoding, and gain scaling shall use one of two bitmaps stored in the ATU. This method is called the dual bitmap.

Q.4.4.1 Dual Bitmap (new)

The Dual Bitmap method has individual bit rates under the FEXT and NEXT noise, and this needs an additional bit and gain table, $\{b_i, g_i\}$, and ordered bit table, b'_i , for the tone ordering. The dual bitmaps are switched synchronized with the sliding window pattern of NEXT/FEXT symbols. The number of bits and the relative gains to be used for every tone are calculated in the bit loading algorithm during the initialization sequence, and transmitted in R-B&G.

Q.4.4.2 Rate Converter (new)

The rate converter buffering changes the data frame boundaries between the reference points B and C according to Bitmap- F_R , Bitmap- N_R and the Sliding Window. Two independent rate converters are prepared for fast data and interleaved data. The amount of fast and interleaved data in Bitmap- F_R and Bitmap- N_R shall be calculated with the following formulae and illustrated in Figure Q.12:

If $t_{Rf} \le n_{Rmax}$:

$$n_{Rf} = t_{Rf}$$

$$n_{Ri} = n_R - n_{Rf}$$

$$f_{Rf} = t_{Rf}$$

$$f_{Ri} = f_R - f_{Rf}$$

If $t_{Rf} > n_{Rmax}$:

$$n_{Rf} = n_{R \max}$$

$$n_{Ri} = 0$$

$$f_{Rf} = \begin{cases} f_{Rf4} = \left\lceil \frac{t_{Rf} \times 10 - n_{Rf} \times 6}{4} \right\rceil$$

$$f_{Rf3} = \left\lceil \frac{t_{Rf} \times 10 - n_{Rf} \times 7}{3} \right\rceil$$

$$f_{Ri} = \begin{cases} f_{Ri4} = f_R = f_{Rf4} \\ f_{Ri3} = f_R - f_{Rf3} \end{cases}$$

Where:

^t Rf	is the number of allocated bits in one frame for fast bytes at the reference point B.
t _{Ri}	is the number of allocated bits for interleaved bytes at the reference point B.
f_{Rf} and n_{Rf}	are the numbers of fast bits in Bitmap- F_R and Bitmap- N_R , respectively.
f _{Rf3}	is the number of fast bits in Bitmap- F_R if the subframe (see Q.4.3.3) contains 3 Bitmap- F_R except
f _{Rf4}	for synch symbols. is the number of fast bits in Bitmap- F_R if the subframe contains 4 Bitmap- F_R except for synch
f _{Ri} and n _{Ri} ⁿ R	symbols. are the numbers of interleaved bits in Bitmap- F_R and Bitmap- N_R , respectively. is the number of total bits in Bitmap- N_R , which is specified in the B&G tables.

During FEXT Bitmap mode, n_{Rf} and n_{Ri} are zero.

To convert the bit rate to be a multiple of 32 kbit/s, the dummy bits for fast data are inserted to the tail of each subframe, and the dummy bits for interleaved data are inserted to the end of the Hyperframe. The number of the dummy bits shall be as follows:

If $t_{Rf} \le n_{Rmax}$:

$$dummy_{Rf} = 0$$

$$dummy_{Ri} = (f_{Ri} \times 126 + n_{Ri} \times 214) - t_{Ri} \times 340$$

If $t_{Rf} > n_{Rmax}$:

$$dummy_{Rf 4} = (f_{Rf} \times 4 + n_{Rf} \times 6) - t_{Rf} \times 10$$

$$dummy_{Rf 3} = (f_{Rf} \times 3 + n_{Rf} \times 7) - t_{Rf} \times 10$$

$$dummy_{Ri} = (f_{Ri4} \times 96 + f_{Ri3} \times 30) - t_{Ri} \times 340$$

If the fast data buffer uses single latency only, additional dummy bits are inserted at the tail of each FEXT symbol in the 4 Bitmap- F_R constructed subframe. The number of additional dummy bits inserted at the tail of each FEXT symbol shall be as follows:

$$dummy_{SRf} = f_{Rf3} - f_{Rf4}$$

The receiver shall determine Bitmap- F_R and Bitmap- N_R so that $dummy_{Ri}$ is less than 126, $dummy_{Rf4}$ is less than 4 and $dummy_{Rf3}$ is less than 3 in the initialization sequence. At the receiver, the inserted dummy bits shall be removed.

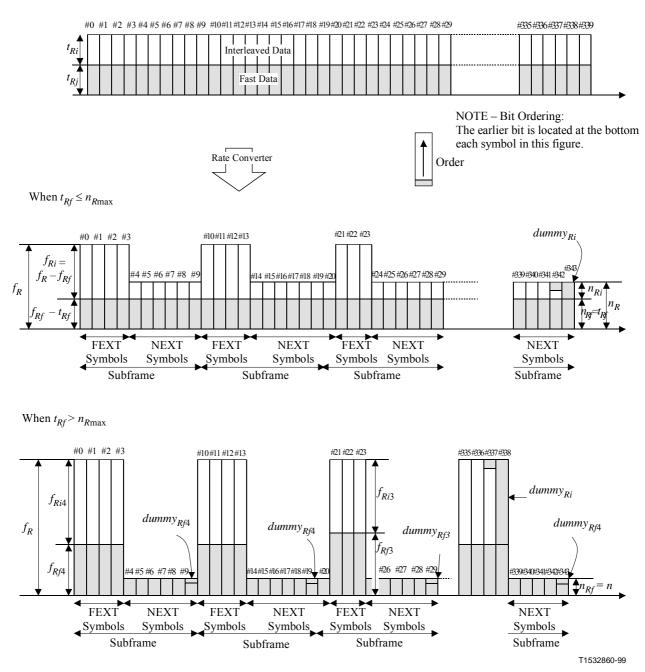


Figure Q.12/G.992.1 – Bit distribution for Rate Converter under Dual latency and Dual Bitmap mode

Q.4.5 FEXT Bitmapping (replaces 7.16)

The FEXT Bitmapping mode uses the Dual Bitmapping technique (Q.4.4) to transmit data only during FEXT. The ATU-C shall transmit only the pilot tone during the NEXT_R symbol. The ATU-R disables Bitmap-N_C and shall not transmit any signal during the NEXT_C symbol (see Figures Q.10 and Q.16).

Annex Q-EU does not support the FEXT Bitmapping mode.

Q.4.6 Tone Ordering (replacement for 7.7)

A DMT time-domain signal has a high peak-to-average ratio (its amplitude distribution is almost Gaussian), and large values may be clipped by the digital-to-analogue converter. The error signal caused by clipping can be considered as an additive negative impulse for the time sample that was clipped. The clipping error power is almost equally distributed across all tones in the symbol in which clipping occurs. Clipping is therefore most likely to cause errors on those tones

that, in anticipation of a higher received SNR, have been assigned the largest number of bits (and therefore have the densest constellations). These occasional errors can be reliably corrected by the FEC coding if the tones with the largest number of bits have been assigned to the interleave buffer.

The numbers of bits and the relative gains in two bitmaps to be used for every tone are calculated in ATU-R receiver, and sent back to ATU-C according to a defined protocol (see 10.9.14). The pairs of numbers are typically stored, in ascending order of frequency or tone numbers *i*, in bit and gain tables for Bitmap- F_R and Bitmap- N_R .

For Bitmap- F_R , the "tone-ordered" encoding shall first assign f_{Rf} bits from the rate converter (see Q.4.4.2) to the tones with the smallest number of bits assigned to them, and the remaining f_{Ri} bits to the remaining tones. For Bitmap- N_R , it shall first assign n_{Rf} bits from the rate converter to the tones with the smallest number of bits assigned to them, and the remaining n_{Ri} bits to the remaining tones.

All tones shall be encoded with the number of bits assigned to them; one tone in each bitmap may therefore have a mixture of bits from the fast and interleaved buffers.

The ordered bit tables b'_{iF} and b'_{iN} shall be based on the original bit tables b_{iF} and b_{iN} as follows:

For k = 0 to N_{downmax} {

From the bit table, find the set of all *i* with the number of bits per tone $b_i = k$

Assign b_i to the ordered bit allocation table in ascending order of i

```
}
```

Two ordered bit tables for Bitmap- F_R and Bitmap- N_R shall be prepared. A complementary de-ordering procedure should be performed in ATU-R receiver. It is not necessary, however, to send the results of the ordering process to the receiver because the bit tables F_R and N_R were originally generated in ATU-R, and therefore those tables have all the information necessary to perform the de-ordering.

Q.4.7 Modulation (pertains to 7.11)

Q.4.7.1 Inverse Synchronization Symbol (replaces 7.11.4)

Except for the pilot tone, Inverse Synchronization symbol shall be generated from a tone-by-tone 180 degree phase reversal of Synchronization symbol (i.e. + maps to -, and - maps to +, for each of the 4-QAM signal constellation).

Q.4.7.2 Data subcarriers (modifies 7.11.1.1)

The channel analysis signal defined in 10.6.6 allows for a maximum of NSCds-1 carriers (at frequencies $n\Delta f$, n = 1 to NSCds-1) to be used.

Q.4.7.3 Nyquist frequency (modifies 7.11.1.3)

The carrier at the Nyquist frequency (#NSCds) shall not be used for user data and shall be real valued; other possible uses are for further study.

Q.4.7.4 Modulation by the inverse discrete Fourier transform (replaces 7.11.2)

The modulating transform defines the relationship between the 2*NSCds real values x_n and the Z_i :

$$x_{n} = \sum_{i=0}^{2^{*}NSCds-1} \exp\left(\frac{j\pi ni}{NSCds}\right) Z_{i} \quad \text{for } n = 0 \text{ to } 2^{*}NSC-1$$
(7-21)

The value of NSCds shall be 1024 for this Annex. However, the highest used subcarrier index shall be limited to 869.

The constellation encoder and gain scaling generate only NSCds-1 complex values of Z_i . In order to generate real values of x_n , the input values (NSCds-1 complex values plus zero at DC and one real value for Nyquist if used) shall be augmented so that the vector Z has Hermitian symmetry. That is,

 $Z_i = \operatorname{conj} \left(Z'_{2*NSCds-i} \right) \quad \text{for } i = \operatorname{NSCds+1} \text{ to } 2*\operatorname{NSCds-1}$ (7-22)

Q.4.7.5 Synchronization symbol (modifies 7.11.3)

The synchronization symbol permits recovery of the frame boundary after micro-interruptions that might otherwise force retraining.

The data symbol rate, $f_{symb} = 4$ kHz, the carrier separation, $\Delta f = 4.3125$ kHz, and the IDFT size, N = 2*NSCds, are such that a cyclic prefix of 15.625%*NSCds samples could be used. That is, when NSCds = 256, there are 40 samples in the cyclic prefix.

$$(512+40) \times 4.0 = 512 \times 4.3125 = 2208 \tag{7-23}$$

The cyclic prefix shall, however, be shortened to 12.5%*NSCds samples, and a synchronization symbol (with a nominal length of NSCds*2.125 samples) is inserted after every 68 data symbols. That is,

$$(2 + 0.125)$$
*NSCds × 69 = $(2 + 0.15625)$ *NSCds × 68(7-24)

The data pattern used in the synchronization symbol shall be the pseudo-random sequence PRD, $(d_n, \text{ for } n = 1 \text{ to } 2*\text{NSCds})$ defined by:

$$d_n = 1$$
 for $n = 1$ to 9 (7-25)
 $d_n = d_{n-4} \oplus d_{n-9}$ for $n = 10$ to 2*NSCds (7-26)

The first pair of bits (d_1 and d_2) shall be used for the DC and Nyquist subcarriers (the power assigned to them is zero, so the bits are effectively ignored); the first and second bits of subsequent pairs are then used to define the X_i and Y_i for i = 1 to NSCds-1 as shown in Table 7-13.

The period of the PRD is only 511 bits, so d_{n+511} is equal to d_n . The d_1 - d_9 shall be re-initialized for each synchronization symbol, so each symbol uses the same data.

The two bits that modulate the pilot carrier, shall be overwritten by $\{0,0\}$: generating the $\{+,+\}$ constellation.

The minimum set of subcarriers to be used is the set used for data transmission (i.e. those for which $b_i > 0$); subcarriers for which $b_i = 0$ may be used at a reduced PSD as defined in transmit PSD paragraphs of Annexes A, B and C. The data modulated onto each subcarrier shall be as defined above; it shall not depend on which subcarriers are used.

Q.4.7.6 Cyclic prefix (replaces 7.12)

The last 12.5%*NSCds samples of the output of the IDFT (x_n for n = 2*NSCds-0.125*NSCds to 2*NSCds-1) shall be prepended to the block of 2*NSCds samples and read out to the digital-to-analogue converter (DAC) in sequence. For example, when NSCds=256, the subscripts, n, of the DAC samples in sequence are 480 ... 511, 0 ... 511.

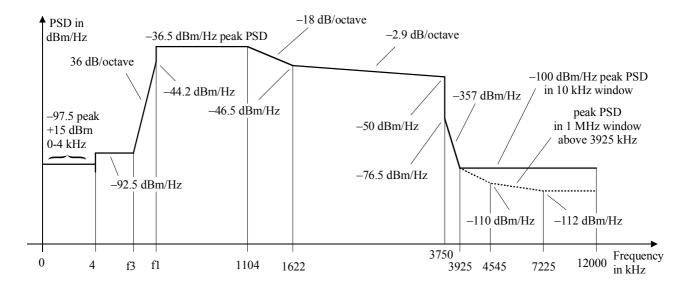
The cyclic prefix shall be used for all symbols beginning with the C-RATES1 segment of the initialization sequence, as defined in 10.6.2.

Q.4.8 ATU-C Downstream transmit spectral masks (replaces 7.14)

The downstream spectral masks of Annex Q-EU are as specified in this section. When C-MSG1 bit 16 is 0, the PSD mask as specified in § Q.4.8.1 shall be used. When C-MSG1 bit 16 is 1, the PSD mask as specified in § Q.4.8.2 shall be used.

Q.4.8.1 Downstream non-overlapped PSD mask definition

The non-overlapped PSD masks are defined with absolute peak values in Figure Q.13. The low frequency stop band is defined for frequencies below f1 kHz (tone n1); the high frequency stop band is defined at frequencies greater than 3750 kHz (tone 869). The in-band region of these PSD masks is the frequency band from f1 kHz to 3750 kHz.



Frequency band f (kHz)	Equation for line (dBm/Hz)
0 < f < 4	-97.5
4 < f < f3	-92.5
f3 < f < f1	$-92.5 + 36 \cdot \log 2(f/f3)$
f1 < f < 1104	-36.5
1104 < f < 1622	-36.5 - 18.0*log2(f/1104)
$1622 \le f \le 3750$	-46.5 - 2.9*log2(f/1622)
3750 < f < 3925	-76.5 - 357*log2(f/3750)
3925 < f < 12000	-100

Frequency (kHz)	PSD level (dBm/Hz)	Measurement BW
0	-97.5	100 Hz
4	-97.5	100 Hz
4	-92.5	100 Hz
f3	-92.5	10 kHz
fl	-44.2	10 kHz
fl	-36.5	10 kHz
1104	-36.5	10 kHz
1622	-46.5	10 kHz
3750	-50	10 kHz
3750	-76.5	10 kHz
3925 - 12000	-100	10 kHz

Additionally the PSD masks shall satisfy the following requirements:

Frequency (kHz)	PSD level (dBm/Hz)	Measurement BW
3925	-100	1 MHz
4545	-110	1 MHz
7225	-112	1 MHz
12000	-112	1 MHz

The corner frequencies f1 and f3 depend on the associated upstream PSD mask used, see §Q.5.6) and are defined as follows:

Mask designator (DS-mm)	Associated upstream mask	f1 (kHz)	f3 (kHz)
DS-32	EU-32	138	54.45
DS-36	EU-36	155.25	61.26
DS-40	EU-40	172.5	68.06
DS-44	EU-44	189.75	74.87
DS-48	EU-48	207	81.67
DS-52	EU-52	224.25	88.48
DS-56	EU-56	241.5	95.29
DS-60	EU-60	258.75	102.09
DS-64	EU-64	276	108.9

Mask designator	Associated upstream mask	Lower bound f1 (kHz)	Stopband f3(kHz)
DS-68	EU-68	293.25	115.71
DS-72	EU-72	310.5	122.51
DS-76	EU-76	327.75	129.32
DS-80	EU-80	345	136.12
DS-84	EU-84	362.25	142.93
DS-88	EU-88	379.5	149.74
DS-92	EU-92	396.75	156.54
DS-96	EU-96	414	163.35
DS-100	EU-100	431.25	170.16
DS-104	EU-104	448.5	176.96
DS-108	EU-108	465.75	183.77
DS-112	EU-112	483	190.57

NOTE 1 – All PSD measurements are in 100 Ω ; the POTS band total power measurement is in 600 Ω .

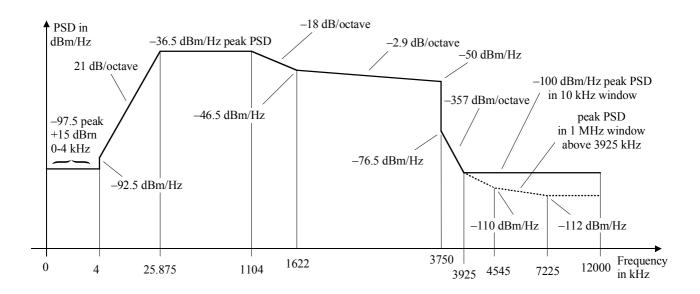
- NOTE 2 The breakpoint frequencies and PSD values are exact; the indicated slopes are approximate. The breakpoints in the tables shall be connected by linear straight lines on a dB/log(f) plot.
- NOTE 3 MBW specifies the Measurement Bandwidth. The MBW specified for a certain breakpoint with frequency fi is applicable for all frequencies satisfying fi< $f \le fj$, where fj is the frequency of the next specified breakpoint.
- NOTE 4 The power in a 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency i.e. power in the [f, f + 1 MHz] window shall conform to the specification at frequency f.
- 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.

Figure Q.13: Non-overlapped Downstream Channel PSD Masks

Spectral Shaping of the In-Band Region defined in Q.4.8.3 and Transmit Signals with Limited Transmit Power defined in Q.4.8.4 shall be applied.

Q.4.8.2 Downstream Overlapped PSD mask definition

The overlapped PSD mask is defined with absolute peak values in Figure Q.14. The low frequency stop band is defined for frequencies below 25.875 kHz (tone 6); the high frequency stop band is defined at frequencies greater than 3750 kHz (tone 869). The in-band region of this PSD mask is the frequency band from 25.875 kHz to 3750 kHz.



Frequency band f (kHz)	Equation for line (dBm/Hz)
0 < f < 4	-97.5
$4 \le f \le 25.875$	$-92.5 + 21*\log 2(f/4)$
25.875 < f < 1104	-36.5
1104 < f < 1622	-36.5 - 18.0*log2(f/1104)
1622 < f < 3750	-46.5 - 2.9*log2(f/1622)
3750 < f < 3925	-76.5 - 357*log2(f/3750)
3925 < f < 12000	-100

Frequency (kHz)	PSD level (dBm/Hz)	Measurement Bandwidth
0	-97.5	100 Hz
4	-97.5	100 Hz
4	-92.5	100 Hz
10	interpolated	10 kHz
25.875	-36.5	10 kHz
1104	-36.5	10 kHz
1622	-46.5	10 kHz
3750	-50.0	10 kHz
3750	-76.5	10 kHz
3925 - 12000	-100	10 kHz

Additionally, the PSD mask shall be satisfying following requirements:

Frequency (kHz)	PSD level (dBm/Hz)	Measurement Bandwidth
3925	-100	1 MHz
4545	-110	1 MHz
7225	-112	1 MHz
12000	-112	1 MHz

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. The breakpoints in the tables shall be connected by linear straight lines on a dB/log(f) plot.
- NOTE 3 MBW specifies the Measurement Bandwidth. The MBW specified for a certain breakpoint with frequency fi is applicable for all frequencies satisfying $fi < f \le fj$, where fj is the frequency of the next specified breakpoint.
- NOTE 4 The power in a 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency i.e. power in the [f, f + 1 MHz] window shall conform to the specification at frequency f.
- 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.

Figure Q.14: Overlapped Downstream Channel PSD Mask.

Q.4.8.3 Spectral Shaping of the In-Band Region of the PSD Spectrum

In order to shape the ATU-C PSD, frequency dependent gains, called spectral shaping values (ssv_i), shall be applied on each tone during initialization and showtime. The ssv_i values shall be represented with 1 bit before and 10 bits after the decimal point.

Table Q.2 defines the corner points for the nominal PSD shape of the inband region as gain in dB, i.e. log_ssv_i . Log_ssv_i on other tones shall be linearly interpolated between corner points on a logarithmic scale for the gain (dB) and a linear scale for the frequency (Hz). Note that the corner points defined in Table Q.2 are relative values. Table Q.3 defines the similar corner points for the overlapped spectrum.

The spectral shaping values shall be converted from logarithmic scale (log_ssv_i , dB values) to linear ssv_i values according to:

$$ssv_i = \frac{Round\left(1024 \times 10^{\frac{\log_s ssv_i}{20}}\right)}{1024}$$

These points are not passed at initialization for the nominal PSD shape but are provided here for reference. However, for additional spectral shaping (see Q.4.8.5), parameters are passed during G.994.1.

The combined accuracy of the process of linear interpolation of the log_ssvi values and the process of conversion to linear ssv_i values shall be strictly less than one half lsb of the 10 bit after the decimal point format of the linear ssvi values. No error shall be introduced when log_ssv_i equals 0dB or is interpolated between log_ssv_i values, which equal 0dB.

- NOTE 1: The above definition ensures that the maximum deviation between ssv_i values used by transmitter and receiver is one lsb.
- NOTE 2: The above needs an accuracy that is strictly < 1/2 lsb. An accuracy of = 1/2 lsb, will lead to inaccurate results.

Tone Index	$Log_ssv_i(dB)$	Comments
nl	0	fl kHz defines the beginning of the inband region. No shaping is applied in the
		low stop band.
256	0	1104 kHz
376	-10	1622 kHz (-10 = -50 - Nominal PSD lowband)
869	-13.5	3750 kHz (-13.5 = -53.5 - Nominal_PSD_lowband)

Table Q.2: Corner points for the non-overlapped nominal in-band PSD shape.

Table Q.3: Corner points for the overlapped nominal in-band PSD shape

Tone Index	$Log_ssv_i(dB)$	Comments
6	0	25.875 kHz defines the beginning of the inband region. No shaping is applied
		in the low stop band.
256	0	1104 kHz
376	-10	1622 kHz (-10 = -50 - Nominal PSD lowband)
869	-13.5	3750 kHz (-13.5 = -53.5 – Nominal_PSD_lowband)

The absolute values of the transmit PSD are obtained by scaling the relative shaping values with a NOMINAL_PSD_lowband, defined for the lower in-band frequencies. Note that the nominal in-band transmit PSD is frequency dependent. The NOMINAL_PSD_lowband is -40 dBm/Hz (below 1104 kHz) for both the overlapped and non-overlapped spectra.

NOTE 3: In-band PSD spectral shaping is applied prior to the IFFT.

NOTE 4: The value of MAXNOMATPds may be limited by regional regulations.

Q.4.8.4 Transmit Signals with Limited Transmit Power

For cases where the transmit signal must be limited to a maximum aggregate transmit power (e.g. $ATP_{dsmax} = +20$ dBm), then

- d) During initialization the PSD transmit level is specified as an offset from the nominal value, i.e. (Nominal PSD_lowband + ssvi x power cutback) dB, and all values of gi = 1 for the offset value x and power cutback. The value of x shall be the greater of 0 dB and (21.1 ATPdsmax) dB for non-overlapped and (21.5 ATPdsmax) dB for overlapped. For ATPdsmax = 20 dBm, the corresponding value of x shall be 1.1 dB for non-overlapped and 1.5 dB for overlapped cases.
- b) If bi>0, then valid range for gi is [-14.5 to +2.5+x] (dB);
 If bi>0, then gi shall be in the [g_{sync} 2.5 to g_{sync} + 2.5] (dB) range;
 If bi=0, then gi shall be equal to 0 (linear) or in the [-14.5 to g_{sync}] (dB) range;
 For G.992.1 Annex Q-EU, g_{sync} <= x dB

The g_i values shall be constrainted by following relation:

Constraint on g _i values	$\sum_{i=32}^{2*NSCds-1} ssv_i^2 * g_i^2 \le \sum_{i=32}^{2*NSCds-1} ssv_i^2$

Q.4.8.5 Additional inband spectral shaping

An ATU-R may request additional downstream inband spectral shaping by passing parameters to the ATU-C in a G.994.1 MP, or MS message. The ATU-C may select additional downstream inband spectral shaping by passing parameters to the ATU-R in a G.994.1 MS message. Within the framework of G.994.1, the ATU-C has the ability to make the final decision on the downstream inband PSD shape to be used.

The additional inband spectral shaping parameters are listed in Q.7.2.2 and defined in Q.7.3. If the Additional inband spectral shaping Spar(2) bit is set to ONE in Table Q.7.2, its associated Npar(3) octets in Tables Q.7.2.1 to Q.7.2.1.5 define the inband spectral shape. If the additional inband spectral shaping Spar(2) bit is set to ZERO, its associated

Npar(3) octets are not transmitted and the nominal inband PSD shape defined in Q.4.8.3 shall be used. These Npar(3) octets define the downstream PSD levels in the low band (between f1 and 1104 kHz), at 1622 kHz and at 3750 kHz. The PSD levels between 1104 kHz and 1622 kHz, and between 1622 kHz and 3750 kHz are linearly interpolated in log scale. The defined values are the PSD level in dB below the NOMINAL_PSD_lowband of -40dBm/Hz. For example, if all three values are set to 20 dB, the result will be a flat PSD of -60dBm/Hz. If the three values are set to 2 dB, 12 dB and 15.5 dB, the result is the PSD defined in Q.4.8.1 reduced by 2dB. In order not to violate the PSD mask defined in Q.4.8.1, the second value shall be no less than 10 dB and the third value shall be no less than 13.5 dB.

Q.4.8.6 Egress control

G.992.1 Annex Q-EU equipment shall be able to reduce the PSD below -80 dBm/Hz for the Amateur radio bands between 1.81 MHz and 2.00 MHz, and between 3.5 MHz and 3.8 MHz. The ATU-C may apply additional spectral shaping as described in Q.4.8.5 to help achieve this requirement.

Q.4.9 Support of higher downstream bit rates with S = 1/2n (replaces 7.6.4)

With a rate of 4000 data frames per second and a maximum of 255 bytes (maximum RS codeword size) per data frame, the ADSL downstream line rate is limited to approximately 8 Mbit/s per latency path. The line rate limit can be increased beyond this for the interleaved path by mapping 2n RS codewords into one FEC data frame (i.e. by using S = 1/2n in the interleaved path). S = 1/2n shall be used in the downstream direction only over bearer channel AS0.

For a selected value of $n \ge 1$, the K_I data bytes per interleaved mux data frame shall be packed into 2n RS codewords, split into n equal parts, each consisting of 2 consecutive RS codewords. This forces rate adaptation to occur in 32n kbit/s increments. Each of the n parts of the data frame shall begin with a sync byte and shall obey the rules defined in Table Q.4 for insertion of dummy bytes. The smallest value of n that can support the K_I data bytes shall be used.

Support of S = 1/2 (i.e., n=1), S = 1/4 (i.e., n=2), S = 1/6 (i.e., n=3), and S = 1/8 (i.e., n=4), is mandatory.

The resulting data frame structure shall be as shown in Figure Q.15.

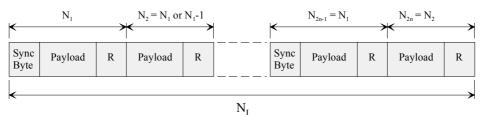


Figure Q.15 – Data frame for S = 1/2n mode

When K_I is divisible by 2n, the 2n codewords have the same length $N_{2i-1} = N_{2i} = (K_I/2n + R_I)$ for i = 1 to n, otherwise the odd numbered codewords are equal and are one byte longer than the even numbered codewords, i.e. $N_{2i-1} = (K_I + n)/2n + R_I$ bytes, and $N_{2i} = (K_I - n)/2n + R_I$ bytes for i = 1 to n. For the FEC output data frame, $N_I = \sum_{i=1}^{n} N_i$, with $N_I < 512n - 1$ bytes.

The convolutional interleaver requires all codewords to have the same odd length. To achieve the odd codeword length, insertion of dummy (not transmitted) bytes may be required. For S = 1/2n, the dummy byte addition to the odd numbered and/or even numbered codewords at the input of the interleaver shall be as in Table Q.4.

N _{2i-1}	N _{2i}	Dummy Byte Insertion Action
Odd	Odd	No action
Even	Even	Add one dummy byte at the beginning of all codewords
Odd	Even	Add one dummy byte at the beginning of each even numbered codeword
Even	Odd	Add one dummy byte at the beginning of each odd numbered codeword and two dummy bytes at the beginning of each even numbered codeword [the de-interleaver shall insert one dummy byte into the de-interleaver matrix on the first byte and the $(D + 1)$ th byte of the corresponding codeword to make the addressing work properly]

Table Q.4/G.992.1 –Dummy byte insertion at interleaver input for S = 1/2n

Q.5 ATU-R Functional Characteristics (pertains to clause 8)

Q.5.1 Framing (pertains to 8.4)

Q.5.1.1 Superframe structure (replaces 8.4.1.1)

The superframe structure of ATU-R transmitter is identical to that of ATU-C transmitter, as specified in Q.4.3.1.

Q.5.1.2 Hyperframe structure (replaces 8.4.1.3)

The hyperframe structure of ATU-R transmitter is functionally similar to that of ATU-C transmitter, except that the inverse synch symbol is used in the 1st superframe (SPF#0) (see Figure Q.16). The hyperframe is composed of 345 DMT symbols, numbered from 0 to 344. Each symbol is under $FEXT_C$ or $NEXT_C$ duration (see Q.5.3), and the following numerical formula gives the information which duration N_{dmt}-th DMT symbol belongs to at ATU-R transmitter (see Figure Q.17).

For $N_{dmt} = 0, 1,, 344$	
$S = 272 \times N_{dmt} \mod 2760$	
if $\{ (S > a) \text{ and } (S + 271 < a + b) \}$	then $FEXT_{C}$ symbol
else	then NEXT _C symbol
where a = 1315, b = 1293	

128 DMT symbols are allocated in the FEXT_{C} duration, and 217 DMT symbols are allocated in the NEXT_{C} duration. The symbols are composed of:

FEXT _C	symbol:
-------------------	---------

Number of symbol using Bitmap- F_{C}	= 126
Number of synch symbol	= 1
Number of inverse synch symbol	= 1
NEXT _C symbol:	
Number of symbol using Bitmap-N _C	= 214
Number of synch symbol	= 3

During FEXT Bitmapping mode, the ATU-R shall not transmit any signal.

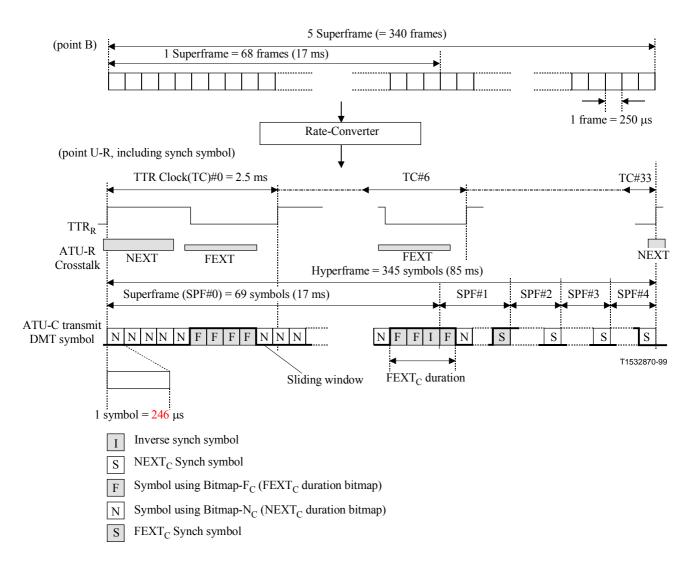


Figure Q.16/G.992.1 – Hyperframe structure for upstream

ттр	
TTR _R	
0	0 1 2 3 4 5 6 7 8 9
1	10 11 12 13 14 15 16 17 18 19
2	20 21 22 23 24 25 26 27 28 29
3	30 31 32 33 34 35 36 37 38 39 40
4	41 42 43 44 45 46 47 48 49 50
5	51 52 53 54 55 56 57 58 59 60
6	61 62 63 64 65 66 67 ISS 69 70
7	71 72 73 74 75 76 77 78 79 80
8	81 82 83 84 85 86 87 88 89 90
9	91 92 93 94 95 96 97 98 99 100 101
10	101 102 103 104 105 06 107 108 109 110 111
11	112 113 114 115 1 6 117 118 119 120 21
12	122 123 124 125 126 127 128 129 130 131
13	132 133 134 135 136 SS 138 139 140 141
14	142 143 144 145 146 147 148 149 150 151
15	152 153 154 155 156 157 158 159 160 161
16	162 163 164 165 166 167 168 169 170 171 172
17	173 174 175 176 77 178 179 180 181 82
18	183 184 185 186 187 188 189 190 191 92
19	193 194 195 196 197 198 199 200 201 202
20	203 204 205 SS 207 208 209 210 211 212
21	213 214 215 216 217 218 219 220 221 222
22	223 224 225 226 227 228 229 230 231 232
23	233 234 235 236 237 238 239 240 241 242 243
24	244 245 246 247 248 249 250 251 252 253
25	254 255 256 257 258 259 260 260 262 263
26	264 265 266 267 268 269 270 271 272 273
27	274 SS 276 277 278 279 280 281 282 283
28	284 285 286 287 288 289 290 291 292 293
29	294 295 296 297 298 299 300 301 302 303
30	304 305 306 307 308 309 310 311 312 313 314
31	<u>315</u> <u>316</u> <u>317</u> <u>318</u> <u>319</u> <u>320</u> <u>321</u> <u>322</u> <u>323</u> <u>324</u>
32	325 326 327 328 329 330 331 332 333 334
33	335 336 337 338 339 340 341 342 343 S5
	ISS Inverse synch symbol SS FEXT _R Synch symbol SS NEXT _R synch symbol
	FEXT _R data symbol NEXT _R data symbol T1535340-00

Figure Q.17/G.992.1 – Symbol pattern in a hyperframe with cyclic prefix – Upstream

Q.5.1.3 Subframe structure (replaces 8.4.1.4)

A subframe is 10 consecutive DMT symbols (except for synch symbols) as shown in Table Q.5. The 34 subframes form a hyperframe.

Subframe No.	DMT symbol No.	Note
0	0-9	
1	10-19	
2	20-29	
3	30-39	
4	40-49	
5	50-59	
6	60-70	#68 is Inverse Synch Symbol
7	71-80	
8	81-90	
9	91-100	
10	101-110	
11	111-120	
12	121-130	
13	131-141	#137 is Synch Symbol
14	142-151	
15	152-161	
16	162-171	
17	172-181	
18	182-191	
19	192-201	
20	202-212	#206 is Synch Symbol
21	213-222	
22	223-232	
23	233-242	
24	243-252	
25	253-262	
26	263-272	
27	273-283	#275 is Synch Symbol
28	284-293	
29	294-303	
30	304-313	
31	314-323	
32	324-333	
33	334-344	#344 is Synch Symbol

Table Q.5/G.992.1 – Subframe (upstream)

Q.5.2 Dual Bitmapping and rate conversion (replaces 8.15)

The function of the rate converter (see Q.5.2.2), tone ordering (see Q.5.4), constellation encoding, and gain scaling shall use one of two bitmaps stored in the ATU. This method is called the dual bitmap.

Q.5.2.1 Dual Bitmap (new)

The Dual Bitmap switching shall be the same as for the downstream data, specified in Q.4.4.1. The number of bits and the relative gains to be used for every tone are calculated in the bit loading algorithm during the initialization sequence, and transmitted in C-B&G.

Q.5.2.2 Rate Converter (new)

The rate converter buffering changes the data frame boundaries between the reference points B and C according to Bitmap- F_C , Bitmap- N_C and the Sliding Window. Two independent rate converters are prepared for fast data and interleaved data. The amounts of fast and interleaved data in Bitmap- F_C and Bitmap- N_C shall be calculated in the following formulae:

If $t_{Cf} \le n_{Cmax}$:

$$n_{Cf} = t_{Cf}$$
$$n_{Ci} = n_C - n_{Cf}$$
$$f_{Cf} = t_{Cf}$$
$$f_{Ci} = f_C - f_{Cf}$$

If $t_{Cf} > n_{Cmax}$:

$$n_{Cf} = n_{C \max}$$

$$n_{Ci} = 0$$

$$f_{Cf4} = \left[\frac{t_{Cf} \times 10 - n_{Cf} \times 6}{4} \right]$$

$$f_{Cf3} = \left[\frac{t_{Cf} \times 10 - n_{Cf} \times 7}{3} \right]$$

$$f_{Ci} = \begin{cases} f_{Ci4} = f_C - f_{C4} \\ f_{Ci3} = f_C - f_{Cf3} \end{cases}$$

Where:

^t Cf	is the number of allocated bits in one frame for fast bytes at the reference point B.
^t Ci	is the number of allocated bits for interleaved bytes at the reference point B.
f_{Cf} and n_{Cf}	are the numbers of fast bits in Bitmap- F_C and Bitmap- N_C , respectively.
f _{Cf3}	is the number of fast bits in Bitmap-F _C if the subframe (see Q.5.1.3) contains 3 Bitmap-F _C except
f _{Cf4}	for synch symbols. is the number of fast bits in Bitmap- F_C if the subframe contains 4 Bitmap- F_C except for synch
f_{Ci} and n_{Ci}	symbols. are the numbers of interleaved bits in Bitmap-F _C and Bitmap-N _C , respectively.
ⁿ C	is the number of total bits in Bitmap-N _C , which is specified in the B&G tables.

During FEXT Bitmap mode, n_{Cf} and n_{Ci} are zero.

To convert the bit rate to be a multiple of 32 kbit/s, the dummy bits for fast data are inserted to the tail of each subframe, and the dummy bits for interleaved data are inserted to the end of the Hyperframe. The number of the dummy bits shall be as follows:

If $t_{Cf} \le n_{Cmax}$:

$$dummy_{Cf} = 0$$
$$dummy_{Ci} = (f_{Ci} \times 126 + n_{Ci} \times 214) - t_{Ci} \times 340$$

If $t_{Cf} > n_{Cmax}$:

$$dummy_{Cf 4} = (f_{Cf} \times 4 + n_{Cf} \times 6) - t_{Cf} \times 10$$

$$dummy_{Cf 3} = (f_{Cf} \times 3 + n_{Cf} \times 7) - t_{Cf} \times 10$$

$$dummy_{Ci} = (f_{Ci4} \times 96 + f_{Ci3} \times 30) - t_{Ci} \times 340$$

,

If the fast data buffer uses single latency only, additional dummy bits are inserted at the tail of each FEXT symbol in the 4 Bitmap-F_C constructed subframe. The number of additional dummy bits inserted at the tail of each FEXT symbol shall be as follows:

$$dummy_{SCf} = f_{Cf3} - f_{Cf4}$$

The receiver shall determine Bitmap-F_C and Bitmap-N_C so that $dummy_{Ci}$ is less than 126, $dummy_{Cf4}$ is less than 4 and $dummy_{Cf3}$ is less than 3 in the initialization sequence. At the receiver, the inserted dummy bits shall be removed.

Q.5.3 FEXT Bitmapping (replaces 8.16)

The FEXT Bitmapping mode uses the Dual Bitmapping technique (Q.4.4) to transmit data only during FEXT. The ATU-C shall transmit only the pilot tone during the NEXT_R symbol. The ATU-R disables Bitmap-N_C and shall not transmit any signal during the NEXT_C symbol (see Figures Q.10 and Q.16).

Annex Q-EU does not support the FEXT Bitmapping mode.

Q.5.4 Tone Ordering (pertains to 8.7)

The tone ordering algorithm shall be the same as for the downstream data, specified in Q.4.4.

For Bitmap-F_C, the "tone-ordered" encoding shall first assign f_{Cf} bits from the rate converter (see Q.5.2.2) to the tones with the smallest number of bits assigned to them, and the remaining f_{Ci} bits to the remaining tones. For Bitmap-N_C, it shall first assign n_{Cf} bits from the rate converter to the tones with the smallest number of bits assigned to them, and the remaining n_{Ci} bits to the remaining tones. Two ordered bit tables for Bitmap-F_C and Bitmap-N_C shall be prepared.

Q.5.5 Modulation (pertains to 8.11)

Q.5.5.1 Inverse synchronization symbol (replaces 8.11.4)

Inverse Synchronization symbol shall be generated from a tone-by-tone 180 degree phase reversal of Synchronization symbol (i.e. + maps to -, and - maps to +, for each of the 4-QAM signal constellation).

Q.5.5.2 Gain scaling in synchronization symbol (new)

At initialization time, the sync symbol reference transmit PSD level shall be set at the nominal PSD level +10log(g_{sync}^2) dBm/Hz, with g_{sync}^2 defined as the average g_i^2 value over the used (i.e. $b_i > 0$) subcarriers in the NEXT or FEXT bitmap, whichever results in the highest average gain. The sync symbol reference transmit PSD shall not be updated with used subcarrier gain changes during SHOWTIME.

I.5.5.3 Nyquist frequency (supplements 8.11.1.2)

The upstream Nyquist frequency for Annex Q-EU shall be at subcarrier NSCus (f = 4.3125*NSCus kHz).

I.5.5.4 Modulation by the inverse discrete Fourier transform (supplements 8.11.2)

For Annex Q-EU, see A.2.1.

I.5.5.5 Synchronization symbol (supplements 8.11.3)

For Annex Q-EU, see A.2.2.

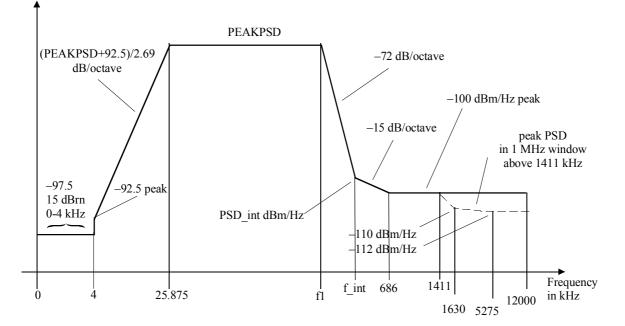
Q.5.6 ATU-R Upstream Transmit Spectral Mask (replaces 8.14)

The upstream PSD masks of Annex Q-EU are defined with absolute peak values in Figure Q.18. The low frequency stop band is defined for frequencies below 25.875 kHz; the high frequency stop band is defined at frequencies greater than f1 kHz (tone n1). The in-band region of these PSD masks is the frequency band from 25.875 kHz to f1 kHz.

ATU-x may optionally support upstream masks EU-36 to EU-64 specified in Figure Q.18

NOTE: The value of MAXNOMATPus may be limited by regional regulations.





Frequency band f (kHz)	Equation for line (dBm/Hz)
0 < f < 4	-97.5
4 < f < 25.875	-92.5+(PEAKPSD+92.5)* log ₂ (f/4)/log ₂ (25.875/4)
25.875 < f < f1	PEAKPSD
f1< f< f_int	$PEAKPSD-72*log_2(f/f1)$
f_int < f < 686	PSD_int-15*log2(f/f_int)
f > 686	-100

Frequency (kHz)	PSD level (dBm/Hz)	Measurement BW
0	-97.5	100 Hz
4	-97.5	100 Hz
4	-92.5	100 Hz
25.875	PEAKPSD	10 kHz
f1	PEAKPSD	10 kHz
f_int	PSD_int	10 kHz
686 - 12000	-100	10 kHz

Additionally the PSD masks shall satisfy the following requirements:

Frequency (kHz)PSD level (dBm/Hz)		Measurement BW
1411	-100	1 MHz
1630	-110	1 MHz
5275	-112	1 MHz
12000	-112	1 MHz

NSCus is a function of the upstream mask parameters, which are defined as follows:

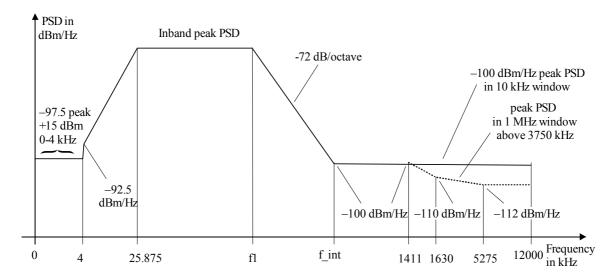
Designator (EU-nn)	NSCus	Template Nominal PSD P ₀ (dBm/Hz)	Template Maximum Aggregate Transmit Power (dBm)	PEAKPSD (dBm/Hz)	Frequency fl (kHz)	Intercept Frequency f_int (kHz)	Intercept PSD Level PSD_int (dBm/Hz)
EU-32	32	-38.0	12.5	-34.5	138.00	242.92	-93.2
EU-36	64	-38.5	12.5	-35.0	155.25	274.03	-94.0
EU-40	64	-39.0	12.5	-35.5	172.50	305.06	-94.7
EU-44	64	-39.4	12.5	-35.9	189.75	336.33	-95.4
EU-48	64	-39.8	12.5	-36.3	207.00	367.54	-95.9
EU-52	64	-40.1	12.5	-36.6	224.25	399.07	-96.5
EU-56	64	-40.4	12.5	-36.9	241.50	430.58	-97.0
EU-60	64	-40.7	12.5	-37.2	258.75	462.04	-97.4
EU-64	64	-41.0	12.5	-37.5	276.00	493.45	-97.9
EU-68	128	-41.8	12.5	-38.3	293.25	522.12	-98.2
EU-72	128	-42.1	12.5	-38.6	310.50	553.24	-98.6
EU-76	128	-42.3	12.5	-38.8	327.75	584.89	-99.0
EU-80	128	-42.6	12.5	-39.1	345.00	615.89	-99.3
EU-84	128	-42.8	12.5	-39.3	362.25	647.47	-99.6
EU-88	128	-43.0	12.5	-39.5	379.50	679.02	-99.9

Parameters in FEXT bitmap for mode 1, both bitmaps for mode 2 (see §Q.7.3):

When EU-68 or beyond is used, only mode 2 shall be used.

Mask definition for EU-92 to EU-112:

The same mask is used for both bitmaps (mode 2 only) and is defined in Figure Q.x1 and Table Q.x2.



Frequency (kHz)	PSD level (dBm/Hz)	Measurement BW
0	-97.5	100 Hz
4	-97.5	100 Hz
4	-92.5	100 Hz
10	interpolated	10 kHz
25.875	Inband_peak_PSD	10 kHz
fl	Inband_peak_PSD	10 kHz
f_int	-100	10 kHz
5275	-100	10 kHz
12000	-100	10 kHz

Designat o r	Template Nominal PSD P ₀ (dBm/Hz)	Template Maximum Aggregate Transmit Power (dBm)	Inband Peak PSD (dBm/Hz)	Frequency <i>f1</i> (kHz)	Intercept Frequency f_int (kHz)
EU-92	-43.2	12.5	-39.7	396.75	708.97
EU-96	-43.4	12.5	-39.9	414.00	738.37
EU-100	-43.7	12.5	-40.2	431.25	766.92
EU-104	-44.0	12.5	-40.5	448.50	795.30
EU-108	-44.5	12.5	-41.0	465.75	821.92
EU-112	-45.2	12.5	-41.7	483.00	846.64

Figure C.x1: Mask definition for EU-92 to EU-112

 Table C.x2: Parameters for EU-92 to EU-112

Parameters in NEXT bitmap for mode 1 (see §Q.7.3):

Designator (EU-nn)	NSCus	Template Nominal PSD P ₀ (dBm/Hz)	Template Maximum Aggregate Transmit Power (dBm)	PEAKPSD (dBm/Hz)	Frequency f1 (kHz)	Intercept Frequency f_int (kHz)	Intercept PSD Level PSD_int (dBm/Hz)
EU-32	32	-38.0	12.5	-34.5	138.00	242.92	-93.2
EU-36	64	-38.7	12.5	-35.2	155.25	273.47	-94.0
EU-40	64	-39.9	12.5	-36.4	172.50	302.26	-94.7
EU-44	64	-40.7	12.5	-37.2	189.75	331.87	-95.3
EU-48	64	-41.4	12.5	-37.9	207.00	361.55	-95.8
EU-52	64	-41.8	12.5	-38.3	224.25	392.16	-96.4
EU-56	64	-42.1	12.5	-38.6	241.50	423.12	-96.9
EU-60	64	-42.3	12.5	-38.8	258.75	454.51	-97.3
EU-64	64	-42.3	12.5	-38.8	276.00	486.91	-97.8

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. The breakpoints in the tables shall be connected by linear straight lines on a dB/log(f) plot.

NOTE 3 – MBW specifies the Measurement Bandwidth. The MBW specified for a certain breakpoint with frequency fi is applicable for all frequencies satisfying fi< $f \le fj$, where fj is the frequency of the next specified breakpoint.

NOTE 4 – The power in a 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency i.e. power in the [f, f + 1 MHz] window shall conform to the specification at frequency f.

NOTE 5 – The step in the PSD mask at 4 kHz is to protect V.90 performance. Originally, the PSD mask continued the 21.5 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-R interface (see Figures Q.3 & Q.4).

Figure Q.18: Upstream Channel PSD Masks

Q.5.7 Forward error correction (supplements 8.6)

The minimum FEC coding capabilities (Table 8-3) for an ATU-R shall include the following interleave depths for the

interleaved buffer:

D = 1, 2, 4, 8, and 16

Q.5.8 Cyclic prefix (supplements 8.12)

For Annex Q-EU, see A.2.3.

Q.6 EOC Operation and Maintenance (pertains to clause 9)

Q.6.1 ADSL line related primitives (supplements 9.3.1)

Q.6.1.1 ADSL line related near-end defects (supplements 9.3.1.3)

Two near-end defects are further defined:

- Loss-of-signal (LOS): The ADSL power shall be measured only in the FEXT_C duration at ATU-C, or only in the FEXT_R duration at ATU-R.
- Severely errored frame (SEF): A SEF defect occurs when the content of two consecutively received ADSL synchronization symbols in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-R, does not correlate with the expected content over a subset of the tones. An SEF defect terminates when the content of two consecutively received ADSL synchronization symbols in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-C, or in the FEXT_R duration at ATU-R, does not consecutively received ADSL synchronization symbols in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-R, correlate with the expected contents over the same subset. The correlation method, the selected subset of tones, and the threshold for declaring these defect conditions are implementation discretionary.

Q.6.1.2 ADSL line related far-end defects (supplements 9.3.1.4)

Loss-of-signal is further defined:

• Loss-of-signal (LOS): The ADSL power shall be measured only in the FEXT_C duration at ATU-C, or only in the FEXT_R duration at ATU-R.

Q.6.2 Test Parameters (supplements 9.5)

Q.6.2.1 Near-end test parameters (supplements 9.5.1)

The near-end primitives are further defined:

- *Attenuation (ATN)*: The received signal power shall be measured only in the FEXT_C duration at ATU-C, or only in the FEXT_R duration at ATU-R.
- Signal-to-Noise ratio (SNR) margin: During FEXT Bitmap mode, this primitive represents the snr margin in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-R.

Q.6.2.2 Far-end test parameters (supplements 9.5.2)

The far-end primitives are further defined:

- *Attenuation (ATN)*: The received signal power shall be measured only in the FEXT_C duration at ATU-C, or only in the FEXT_R duration at ATU-R.
- *Signal-to-Noise ratio SNR margin*: During FEXT Bitmap mode, this primitive represents the snr margin in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-R.

Q.6.3 Data registers in the ATU-R (supplements 9.2.4)

For the S=1/2n framing mode (see §Q.4.9), the downstream RS_I shall be the number of parity bytes per sync byte, i.e., $RS_I = R_I/(n^*S)$.

Q.7 Initialization (pertains to clause 10)

Q.7.1 Initialization with Hyperframe (replaces 10.1.5)

The exchange of messages between ATU-C and ATU-R should be performed in FEXT_{C} and FEXT_{R} . The DMT symbol has two symbol rates: one is 4.3125 kbaud for the symbol without a cyclic prefix, and the other is 4 x 69/68 kbaud for the symbol with a cyclic prefix. 32 times of the TTR has the same period as 345 times of the 4.3125 kbaud, and 34 times of the TTR is the same as 345 times of 4 x 69/68 kHz.

During FEXT Bitmap mode, the ATU-R shall not transmit any signal during the NEXT_C symbols duration and the ATU-C shall transmit only the pilot tone as the NEXT_R signal except:

- C-PILOT1 (C-PILOT1A) which is accompanied by a signal to allow the ATU-C to indicate the phase of TTR_C to the ATU-R (see Q.7.4.1);
- C-QUIETn where no signal is transmitted.

The ATU-C begins transmitting C-PILOT1 at the beginning of the hyperframe without cyclic prefix. The ATU-C informs the phase of the TTR_C to ATU-R during C-PILOT1. The ATU-R begins transmitting R-REVERB1 at the beginning of the hyperframe without cyclic prefix. The ATU-R performs the training of any receiver equalizer using this phase information of the TTR_R generated from received TTR_C .

From C-PILOT1 to C-SEGUE1, the following numerical formula gives the information which duration N_{dmt}-th DMT symbol belongs to at ATU-R (see Figure Q.19).

For $N_{dmt} = 0, 1, \dots 344$ $S = 256 \times N_{dmt} \mod 2760$ if { (S + 255 < a) or (S > a + b) } else where a = 1243, b = 1461

then FEXT_R symbols then NEXT_R symbols

In order to enter C-RATES1 at the beginning of the hyperframe with cyclic prefix, the number of symbols from C-PILOT1 to C-SEGUE1 shall be a multiple of 345 DMT symbols.

From R-REVERB1 to R-SEGUE1, the following numerical formula gives the information which duration N_{dmt}-th symbol belongs to at ATU-C (see Figure Q.20).

For $N_{dmt} = 0, 1,, 344$,	
$S = 256 \times N_{dmt} \mod 2760$	
if $\{ (S > a) \text{ and } (S + 255 < a + b) \}$	then $FEXT_{C}$ symbols
else	then NEXT _C symbols
where a = 1315, b = 1293	

From C-RATES1 to C-SEGUE3, the number of symbols is a multiple of 345 DMT symbols. The following numerical formula gives the information which duration N_{dmt} -th DMT symbol belongs to. ATU-C transmits the message data in FEXT_R symbols (see Figure Q.11).

 $\label{eq:states} \begin{array}{l} \mbox{For $N_{dmt}=0,\,1,\,...,\,344$} \\ S=272 \ x \ N_{dmt} \ mod \ 2760$} \\ if \ \{ \ (S+271\geq a) \ and \ (S\leq a+b) \ \} \\ else \\ \mbox{then $NEXT_R$ symbols} \\ \mbox{where $a=1243, b=1461$} \end{array}$

The ATU-R enters R-REVERB3 at the beginning of the hyperframe with cyclic prefix, which is extracted from received signal. From R-REVERB3 to R-SEGUE5, the number of symbols is a multiple of 345 DMT symbols. The

following numerical formula gives the information which duration N_{dmt} -th DMT symbol belongs to. ATU-R transmits the message data in FEXT_C symbols (see Figure Q.17).

 $\begin{array}{ll} \mbox{For $N_{dmt} = 0, 1, ..., 344$} \\ S = 272 \ x \ N_{dmt} \ mod \ 2760$} \\ if \ \{ \ (S > a) \ and \ (S + 271 < a + b) \ \} & then \ FEXT_C \ symbols \\ else & then \ NEXT_C \ symbols \\ where \ a = 1315, \ b = 1293 \end{array}$

тт	R -
11	IN _C

c_				8									
0	0 1	2	3	4	5	6		7		8	9)	10
1	11 12	13	14	15	16		17	18	3	19		20	21
2	22 23	24	25	26	2	27	28		29	3	0	31	
3	32 33 3	34 35	36	37	7	38	3	9	40		41	4	42
4	43 44	45 46	5 4	47	48	49		50	51	l	52		53
5	54 55	56	57	58	59	6	0	61		62		63	64
6	65 66	67	68	69	7	0	71	7	2	73	3	74	
7	75 76 7		79	80		81	82		83		84	8:	5
8	86 87	88 89	9			92		93	94		95		96
9	97 98				102	103		104	_	05	10		107
10	108 109	110	111	112	113		14	115		116		117	118
11	119 120	<u> </u>	122	123		24	125		26	12		128	<u>i</u> ,
12		31 132	133			135	13		137		138		39
13	140 141	142 14		E	45	146		147	14		149		150
14	151 152		54	155	156	15		158		59		60	161
15 16	162 163	164	165	166	16		168	16		170		171	172
	173 17		176	177		178	179		180		81	18	
17	183 184 1 194 195 1	185 186 196 19			199	189	19	201	191		192 20		193 204
18 19	205 206		208	209	210		, 11	201		213	L	<u>3</u> 214	215
20	216 217		208	209	210		222		23	213		225	<u> </u>
20		28 229	230			232	23		234	_	235	-	36
22		239 24			42	243	<u> </u>	244	24:		246		247
23	248 249		51	252	253	25		255		56		57	258
24	259 260	261	262	263	264		265	26		267		268	269
25	270 27		273	274		75	276	1 2	277	-	78	27	i
26	280 281 2	282 283	28			286	28	87	288		289	12	290
27	291 292	293 29	4 2	295	296	297		298	29	9	30	0	301
28	302 303	304	305	306	307	30	08	309		310	3	311	312
29	313 314	315	316	317	31	8	319	32	20	32	1	322	Ť
30	323 324 32	25 326	327	328		329	330		331	3	332	33	33
31	334 335	336 337	7 33	38 3	39	340	3	41	342	2	343		344
	FEXT _R S											T15	35350-0

Figure Q.19/G.992.1 – Symbol pattern in a hyperframe without cyclic prefix – Downstream

_	-	-	
Ľ	Ľ	υ.	
1	1.	IV.	D
-	•	••	к

[٦										
R												_	_		_	r	_	_	_	
0	0	1		2		3		4		5		(7	3	8		9	10
1	11		12		3		4	Ļ	15		16		17		18		19		20	21
2		2	23		24		25		26	i – L	27		28		29		30		3	<u> </u>
3	32	33	3.		3	5	30			7		38		39	┵┯	40	┵┯	41		42
4	43	44	5	45 56		46 57		47 5	0	48	59	49		50	(1	51		52		53
5	65		66	-	, 67	_	68	- 3 - T	8 69		70		50 71	<u> </u>	51 72		62 73	4	63 74	64
6 7		, 76	00 77		67 78		08 79	╧	69 80		70	1	/1	$\frac{1}{2}$		33	-	34		5
8	86	87		88	_	89	-	<u> </u>		91	0	1 92	0. 	2 93		94		95	c	96
9	97	98		<u>99</u>	<u> </u>	100		101	_	10	$\frac{1}{2}$	10	3	93 10	4	10	15	10)6	107
10	108		.09	11	0	11	1		12		- 113	_	<u> </u>		- 115		116		117	1118
11	11		120		121		122		123		12		12:		112		110	_	12	
12		130	13		13	32	13	3	13		_	35	_	36	_	37	_	.38	_	39
13	140	141	1	142	Т	143	_	44		145		146	;	147	_	148	_	149		150
4	151	15	2	153	;	154	1	15	5	15	56	1:	57	1	58	1:	59	1	60	161
5	162	2	163	1	64	1	65		166		167	T	168	Т	169	T	170		171	172
6	1	73	174	1	17	5	176		17	7	17	/8	17	'9	1	80	1	81	1	32
7	183	184	1	85	1	86	18	37	1	88		189		190	Τ	191		192		193
8	194	195	5	196		197	Τ	198		19	9	20	0	20	1	20	2	20	3	204
9	205	2	06	20	7	20	8	2	09	2	10	2	211	2	212	2	213		214	215
20	21	6	217		218		219		220		221		222	2	223	3	224	4	22:	5
21	226	227	22	8	22	29	23	0	23	1	2	32	2	33	2	234	2	235	2	.36
22	239	238	2	239	1	240		41		242		243		244		245		246	5	247
23	248	24	.9	250)	251		25		25	53	25		2:	55		56		57	258
24	259		260		61		62	2	263	<u>ال</u>	264	_	265		266		267		268	269
25		70	271		272		273		274	<u> </u>	27		27		27		27			'9
26	280	281		82	2	83	28			85	_	286	<u> </u>	287		288		289		290
27	291	292		293		294		295		296	-	293		298		299		30		301
28	302		03	30		30			$\frac{100}{217}$		07		308		309 220		310		311	312
29	31		314		315	_	316	_	317		_		319		320		321			22
	323 3 334	324 335	32:	5 336	32	6 337	327		32		3.	29 340	33	30 341		31 342		32 343		33
31	334	333	3	000		551	3	38	· ·	339		340		341		342		543		344
		FEX	T _C sv	mbo	1														T1	535360-0
			0.1																	
		NEX	¹ C Sy	mbo	I															

Figure Q.20/G.992.1 – Symbol pattern in a hyperframe without cyclic prefix – Upstream

Q.7.2 Handshake – Non-standard information block (new)

This section defines the format of the G.994.1 non-standard information block to support Annex Q-EU, and tabulates the parameters used by Annex Q-EU. The use of these parameters is described in §Q.7.3 and §Q.7.4.

Q.7.2.1 Non-standard information block format (new)

Figure Q.21 defines the format of the non-standard information block.

8	7	6	5	4	3	2	1
		Non-stan		nation length octet)	n = M + 6		
				ntry code see Note 1)			
		Provid		ndor identifi see Note 2)	cation)		
		Ve		fic informati – Note 3)	on		

NOTE 1 – The value of this field shall be B5 00, the country code for USA

NOTE 2 – The value of this field shall be 43 45 4E 54, ASCII "CENT" for Centillium Communications

NOTE 3 – These octets are defined in Q.7.2.2. Formatting of these octets shall comply with the parsing rules defined in G.994.1 9.2.1 to 9.2.3

Figure Q.21 – Non-standard information block format

Q.7.2.2 Non-standard information block parameters (new)

The G.994.1 non-standard parameters for Annex Q-EU are listed in Tables Q.6 to Q.7.2.1.2.5 below.

In order to minimize message length, the parameters for additional inband spectral shaping (Spar(2) octet and its related Npar(3) octets) shall only be included in MP or MS messages, and shall not be included in CLR or CL messages. All Annex Q-EU modems shall support additional inband spectral shaping.

Note - This deviates from the rules specified in G.994.1 for standard information fields, where it is stated in §9.6:

"Once a Transaction C (see 10.1) has been completed, any subsequent MS message within the same G.994.1 session shall only contain those octets of the identification (I) and standard information (S) fields, and those blocks of non-standard information (NS) that were contained in both the CLR and CL messages of the previous Transaction C".

Bits								
8	7	6	5	4	3	2	1	NPar(1)s
x	х	х	х	х	х	х	1	Reserved for future use
х	х	х	х	Х	х	1	х	Reserved for future use
х	х	х	х	х	1	х	х	Reserved for future use
х	х	х	х	1	х	х	х	Reserved for future use
х	х	х	1	Х	х	Х	х	Reserved for future use
х	х	1	х	х	х	Х	х	Reserved for future use
х	1	х	х	х	х	х	х	Reserved for future use
х	0	0	0	0	0	0	0	No parameters in this octet

 Table Q.6 – Non-standard information field – NPar(1) coding

Bits								
8	7	6	5	4	3	2	1	SPar(1)s
х	Х	х	х	х	х	х	1	G.992.1 Annex Q (and Annex Q-EU)
х	х	х	х	х	х	1	х	G.992.1 Annex I-EU
х	х	х	х	х	1	х	х	G.992.1 Annex C-EU
х	х	х	х	1	х	х	х	Reserved for future use
х	х	х	1	х	х	х	х	Reserved for future use
х	х	1	х	х	х	х	х	Reserved for future use
х	1	х	х	х	х	х	х	Reserved for future use
х	0	0	0	0	0	0	0	No parameters in this octet

 $Table \ Q.7-Non-standard \ information \ field-SPar(1) \ coding$

Table Q.7.1 – Non-standard information field – G.992.1 Annex Q NPar(2) coding – Octet 1

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex Q NPar(2)s – Octet 1
Х	Х	х	х	х	х	х	1	$n_{\text{C-PILOT1}} = 64$
х	х	х	х	х	х	1	х	$n_{\text{C-PILOT1}} = 128$
х	х	х	х	х	1	х	х	$n_{\text{C-PILOT1}} = 256$
х	х	х	х	1	х	х	х	Amateur radio notch – 1.8 MHz band
х	х	х	1	х	х	х	х	Amateur radio notch – 3.5 MHz band
х	х	1	х	х	х	х	х	$n_{\text{C-PILOT1}} = 96$
х	х	0	0	0	0	0	0	No parameters in this octet
Since A4	48 is th	e only	TTR in	dication	n signal	l specifi	ied for	Annex Q-EU, there is no need to include it in G.994.1.

Bits												
8	7	6	5	4	3	2	1	G.992.1 Annex Q NPar(2)s – Octet 2				
х	х	х	х	х	х	х	1	R-ACK1				
х	х	х	х	х	х	1	х	R-ACK2				
х	х	х	х	х	1	х	х	Reserved for future use				
х	х	х	х	1	х	х	Х	Reserved for future use				
х	х	х	1	х	х	х	х	Reserved for future use				
х	х	1	х	х	х	х	х	G.997.1 – Clear EOC OAM				
х	х	0	0	0	0	0	0	No parameters in this octet				
	Since Annex Q-EU only supports ATM transport, STM and ATM parameters are not specified. Since FBM mode is not supported, the DBM bit is also not specified.											

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex Q SPar(2)s
X	Х	х	х	х	Х	Х	1	Additional inband spectral shaping
х	х	х	х	х	х	1	х	Extended upstream
х	х	х	х	х	1	Х	Х	Reserved for future use
х	Х	х	х	1	х	Х	Х	Reserved for future use
х	х	х	1	х	х	х	х	Reserved for future use
х	Х	1	х	х	Х	Х	Х	Reserved for future use
х	Х	0	0	0	0	0	0	No parameters in this octet

Table Q.7.2 – Non-standard information field – G.992.1 Annex Q SPar(2) coding

Table Q.7.2.1 – Non-standard information field – G.992.1 Annex Q Additional inband spectral shaping Npar(3) coding Octet 1

Bits		1						G.992.1 Annex Q Additional inband spectral shaping
8	7	6	5	4	3	2	1	Npar(3)s Octet 1
х	х					х	х	NOMINAL_PSD_lowband (bits 8 & 7)
Х	х	х	Х	Х	х			Reserved for future use

Table Q.7.2.1.1 – Non-standard information field – G.992.1 Annex Q Additional inband spectral shaping Npar(3) coding Octet 2

Bits								G.992.1 Annex Q Additional inband spectral shaping
8	7	6	5	4	3	2	1	Npar(3)s Octet 2
х	х	х	Х	х	х	х	х	NOMINAL PSD lowband (bits 6 to 1)

Table Q.7.2.1.2 – Non-standard information field – G.992.1 Annex Q Additional inband spectral shaping Npar(3) coding Octet 3

Bits 8	7	6	5	4	3	2	1	G.992.1 Annex Q Additional inband spectral shaping Npar(3)s Octet 3
x	х					Х	Х	PSD level at 1622 kHz (bits 8 & 7)
x	Х	х	Х	Х	Х			Reserved for future use

Table Q.7.2.1.3 – Non-standard information field – G.992.1 Annex Q Additional inband spectral shaping Npar(3) coding Octet 4

Bits								G.992.1 Annex Q Additional inband spectral shaping
8	7	6	5	4	3	2	1	Npar(3)s Octet 4
x	х	х	х	х	х	х	Х	PSD level at 1622 kHz (bits 6 to 1)

Table Q.7.2.1.4 – Non-standard information field – G.992.1 Annex Q Additional inband spectral shaping Npar(3) coding Octet 5

Bits 8	7	6	5	4	3	2	1	G.992.1 Annex Q Additional inband spectral shaping Npar(3)s Octet 5
х	Х					х	х	PSD level at 3750 kHz (bits 8 & 7)
х	Х	Х	Х	Х	х			Reserved for future use

Table Q.7.2.1.5 – Non-standard information field – G.992.1 Annex Q Additional inband spectral shaping Npar(3) coding Octet 6

Bits								G.992.1 Annex Q Additional inband spectral shaping
8	7	6	5	4	3	2	1	Npar(3)s Octet 6
х	Х	х	х	Х	х	х	Х	PSD level at 3750 kHz (bits 6 to 1)

Table Q.7.2.2 – Non-standard information field – G.992.1 Annex Q Extended upstream NPar(3) coding Octet 1

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex Q Extended upstream NPar(3)s Octet 1
x	х	x	х	х	Х	х	1	Mode 1 upstream mask
x	х	х	х	х	х	1	х	Mode 2 upstream mask
x	х	х	х	х	1	х	х	Optional upstream masks for non-overlapped spectrum
х	х	х	х	1	х	х	х	EU-64
х	х	х	1	х	х	х	х	EU-32
x	х	1	х	х	х	х	х	EU-36
х	х	0	0	0	0	0	0	No parameters in this octet

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex Q Extended upstream NPar(3)s Octet 2
x	Х	х	Х	Х	Х	Х	1	EU-40
х	х	х	х	х	х	1	х	EU-44
х	х	х	х	х	1	х	х	EU-48
х	х	х	х	1	х	х	х	EU-52
х	х	х	1	Х	х	х	Х	EU-56
х	х	1	х	х	х	х	х	EU-60
x	Х	0	0	0	0	0	0	No parameters in this octet

Table Q.7.2.2.1 – Non-standard information field – G.992.1 Annex Q Extended upstream NPar(3) coding Octet 2

Table Q.7.2.2.2 – Non-standard information field – G.992.1 Annex Q Extended upstream NPar(3) coding Octet 3

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex Q Extended upstream NPar(3)s Octet 3
x	Х	х	Х	х	х	Х	1	EU-68
х	х	х	х	х	х	1	х	EU-72
х	х	х	х	х	1	х	х	EU-76
х	х	х	х	1	х	Х	Х	EU-80
х	х	х	1	х	х	х	х	EU-84
х	х	1	х	х	х	х	х	EU-88
х	х	0	0	0	0	0	0	No parameters in this octet

Table Q.7.2.2.3 – Non-standard information field – G.992.1 Annex Q Extended upstream NPar(3) coding Octet 4

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex Q Extended upstream NPar(3)s Octet 4
x	Х	х	Х	Х	Х	х	1	EU-92
х	х	х	х	х	Х	1	х	EU-96
х	х	х	х	х	1	х	х	EU-100
х	х	х	х	1	х	х	х	EU-104
х	х	х	1	х	х	х	х	EU-108
х	х	1	х	х	х	х	х	EU-112
х	Х	0	0	0	0	0	0	No parameters in this octet

Q.7.3 Handshake – Parameter definitions (supplements 10.2)

Q.7.3.1 Handshake – ATU-C (supplements 10.2)

Q.7.3.1.1 CL messages (supplements 10.2.1)

See Table Q.8.

NSF parameter	Definition
G.992.1 Annex Q	If set to ONE, this Spar(1) bit indicates that the ATU-C is configured to support G.992.1 Annex Q, and possibly Annex Q-EU.
ⁿ C-PILOT1 ⁼⁶⁴	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 64.
ⁿ C-PILOT1 ⁼⁹⁶	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 96.
ⁿ C-PILOT1 ⁼¹²⁸	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 128.
ⁿ C-PILOT1 ⁼²⁵⁶	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 256.
Amateur radio notch – 1.8 MHz band	If set to ONE, this Npar(2) bit indicates that the ATU-C is configured to reduce its transmit power between 1.81 and 2.0 MHz to ≤ -80 dBm.
Amateur radio notch – 3.5 MHz band	If set to ONE, this Npar(2) bit indicates that the ATU-C is configured to reduce its transmit power between 3.5 and 3.8 MHz to ≤ -80 dBm.
Extended upstream	If set to ONE, this Spar(2) bit indicates that the ATU-C is configured to support extended upstream.
EU-xx	If the Extended upstream Spar(2) bit is set to ONE, these Npar(3) bits indicate the extended upstream masks that the ATU-C supports. For non-overlapped spectrum, extended upstream masks are associated with downstream masks according to Figure Q.13. For overlapped spectrum, any EU-xx may be used with the overlapped downstream spectrum specified in §Q.4.8.2.
Mode 1 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-C is configured to support upstream mask mode 1 (different masks during FEXT and NEXT periods).
Mode 2 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-C is configured to support upstream mask mode 2 (same mask during FEXT and NEXT periods).
Optional upstream masks for non- overlapped spectrum	If set to ONE, this NPar(3) bit indicates that the ATU-C is configured to support the optional upstream masks when using non-overlapped spectrum downstream.

Table Q.8/G.992.1 – ATU-C CL message NPar(2) bit definitions for Annex Q

Q.7.3.1.2 MS messages (supplements 10.2.2)

See Table Q.9.

NSF bit	Definition
G.992.1 Annex Q	If set to ONE, this Spar(1) bit indicates that the ATU-C is selecting G.992.1 Annex Q, and
	possibly Annex Q-EU.
ⁿ C-PILOT1 ⁼⁶⁴	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 64 (Note 1).
ⁿ C-PILOT1 ⁼⁹⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 96 (Note 1).
ⁿ C-PILOT1 ⁼¹²⁸	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 128 (Note 1).
ⁿ C-PILOT1 ⁼²⁵⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 256 (Note 1).
Amateur radio notch – 1.8 MHz band	If set to ONE, this Npar(2) bit indicates that the ATU-C shall reduce its transmit power between 1.81 and 2.0 MHz to ≤ -80 dBm.
Amateur radio notch – 3.5 MHz band	If set to ONE, this Npar(2) bit indicates that the ATU-C shall reduce its transmit power between 3.5 and 3.8 MHz to ≤ -80 dBm.
Additional inband spectral shaping	If set to ONE, this Spar(2) bit indicates that the ATU-C shall apply additional downstream inband spectral shaping as defined by the values of REDUCED_PSD_lowband, PSD level at 1622 kHz, and PSD level at 3750 kHz
REDUCED_PSD_ lowband	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-C shall apply in the passband below 1104 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz.
PSD level at 1622 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-C shall apply at 1622 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs between the REDUCED PSD lowband level at 1104 kHz and the PSD level at 1622 kHz.
PSD level at 3750 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-C shall apply at 3750 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs between the PSD level at 1622 kHz and the PSD level at 3750 kHz.
Extended upstream	If set to ONE, this Spar(2) bit indicates that the ATU-C is selecting extended upstream operation.
EU-xx	If set to ONE, this Npar(3) bit indicates that the ATU-C is selecting upstream PSD mask US- xx. For non-overlapped spectrum, extended upstream masks are associated with downstream masks according to Figure Q.13. For overlapped spectrum, any EU-xx may be used with the overlapped downstream spectrum specified in §Q.4.8.2.
Mode 1 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-C is selecting upstream mask mode 1 (different masks during FEXT and NEXT periods). (Note 2)
Mode 2 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-C is selecting upstream mask mode 2 (same mask during FEXT and NEXT periods). (Note 2)
Optional upstream masks for non- overlapped spectrum	If set to ONE, this NPar(3) bit indicates that the ATU-C is selecting one of the optional upstream masks when using non-overlapped spectrum downstream.

Table Q.9/G.992.1 – ATU-C MS message NPar(2) bit definitions for Annex Q

Note 1: One and only one pilot tone bit shall be set in an MS message. Note 2: One and only one upstream mask mode bit shall be set in an MS message.

Q.7.3.2 Handshake – ATU-R (supplements 10.3)

Q.7.3.2.1 CLR messages (supplements 10.3.1)

See Table Q.10.

Table Q.10/G.992.1 – ATU-R CLR message NPar(2) bit definitions for Annex Q

NSF bit	Definition	
G 000 1 4 0		
G.992.1 Annex Q	If set to ONE, this Spar(1) bit indicates that the ATU-R is configured to support G.992.1	
n =61	Annex Q, and possibly Annex Q-EU. This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot	
ⁿ C-PILOT1 ⁼⁶⁴	tone on subcarrier 64.	
ⁿ C-PILOT1 ⁼⁹⁶	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot	
^{III} C-PILOTI ⁻⁹⁰	tone on subcarrier 96.	
ⁿ C-PILOT1 ⁼¹²⁸	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot	
C-HLOTI	tone on subcarrier 128.	
ⁿ C-PILOT1 ⁼²⁵⁶	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot	
e mile m	tone on subcarrier 256.	
Amateur radio notch	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports the 1.8 MHz	
- 1.8 MHz band	Amateur radio band notch.	
Amateur radio notch	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports the 3.5 MHz	
– 3.5 MHz band	Amateur radio band notch.	
Extended upstream	If set to ONE, this Spar(2) bit indicates that the ATU-R is configured to support extended	
Extended upsiteani	upstream.	
EU-xx	If the Extended upstream Spar(2) bit is set to ONE, these Npar(3) bits indicate the extended	
LO MA	upstream masks that the ATU-R supports. For non-overlapped spectrum, extended upstream	
	masks are associated with downstream masks according to Figure Q.13. For overlapped	
	spectrum, any EU-xx may be used with the overlapped downstream spectrum specified in	
	§Q.4.8.2.	
Mode 1 upstream	If set to ONE, this NPar(3) bit indicates that the ATU-R is configured to support upstream	
mask	mask mode 1 (different masks during FEXT and NEXT periods).	
Mode 2 upstream	If set to ONE, this NPar(3) bit indicates that the ATU-R is configured to support upstream	
mask	mask mode 2 (same mask during FEXT and NEXT periods).	
Optional upstream	If set to ONE, this NPar(3) bit indicates that the ATU-R is configured to support the optional	
masks for non-	upstream masks when using non-overlapped spectrum downstream.	
overlapped spectrum		

Q.7.3.2.2 MS messages (supplements 10.3.2)

Table Q.11.

NSF bit	Definition		
G.992.1 Annex Q	If set to ONE, this Spar(1) bit indicates that the ATU-R is selecting G.992.1 Annex Q, and possibly Annex Q-EU.		
ⁿ C-PILOT1 ⁼⁶⁴	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is selecting the pilot tone on subcarrier 64 (Note 1).		
ⁿ C-PILOT1 ⁼⁹⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is selecting the pilot tone on subcarrier 96 (Note 1).		
ⁿ C-PILOT1 ⁼¹²⁸	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is selecting the pilot tone on subcarrier 128 (Note 1).		
ⁿ C-PILOT1 ⁼²⁵⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is selecting the pilot tone on subcarrier 256 (Note 1).		
Amateur radio notch – 1.8 MHz band	This selection shall only be performed by the ATU-C. Therefore, this Npar(2) bit shall either be set to the same value as in a previous CL message or set to ONE.		
Amateur radio notch – 3.5 MHz band	This selection shall only be performed by the ATU-C. Therefore, this Npar(2) bit shall either be set to the same value as in a previous CL message or set to ONE.		
Additional inband spectral shaping	If set to ONE, this Spar(2) bit indicates that the ATU-R is selecting additional downstream inband spectral shaping as defined by the values of REDUCED_PSD_lowband, PSD level at 1622 kHz, and PSD level at 3750 kHz		
REDUCED_PSD_ lowband	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R wishes to have applied in the passband below 1104 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz.		
PSD level at 1622 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R wishes to have applied at 1622 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs between the REDUCED PSD lowband level at 1104 kHz and the PSD level at 1622 kHz.		
PSD level at 3750 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R wishes to have applied at 3750 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs between the PSD level at 1622 kHz and the PSD level at 3750 kHz.		
Extended	If set to ONE, this Spar(2) bit indicates that the ATU-R is selecting extended upstream		
upstream EU-xx	operation. If set to ONE, this Npar(3) bit indicates that the ATU-R is selecting upstream PSD mask US- xx. For non-overlapped spectrum, extended upstream masks are associated with downstream masks according to Figure Q.13. For overlapped spectrum, any EU-xx may be used with the overlapped downstream spectrum specified in §Q.4.8.2.		
Mode 1 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-R is selecting upstream mask mode 1 (different masks during FEXT and NEXT periods). (Note 2)		
Mode 2 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-R is selecting upstream mask mode 2 (same mask during FEXT and NEXT periods). (Note 2)		
Optional upstream masks for non- overlapped spectrum	If set to ONE, this NPar(3) bit indicates that the ATU-R is selecting one of the optional upstream masks when using non-overlapped spectrum downstream.		

Table Q.11/G.992.1 – ATU-R MS message NPar(2) bit definitions for Annex Q

Note 1: One and only one pilot tone bit shall be set in an MS message. Note 2: One and only one upstream mask mode bit shall be set in an MS message.

Q.7.3.2.3 MP messages (new)

Table Q.12.

Table Q.12/G.992.1 – ATU-R M	IP message NPar(2) bi	t definitions for Annex O

NSF bit	Definition		
G.992.1 Annex Q	If set to ONE, this Spar(1) bit indicates that the ATU-R is proposing G.992.1 Annex Q, and possibly Annex Q-EU.		
ⁿ C-PILOT1 ⁼⁶⁴	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the pilot tone on subcarrier 64 (Note 1).		
ⁿ C-PILOT1 ⁼⁹⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is proposing the pilot tone on subcarrier 96 (Note 1).		
ⁿ C-PILOT1 ⁼¹²⁸	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the pilot tone on subcarrier 128 (Note 1).		
ⁿ C-PILOT1 ⁼²⁵⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the pilot tone on subcarrier 256 (Note 1).		
Amateur radio notch – 1.8 MHz band	This selection shall only be performed by the ATU-C. Therefore, this Npar(2) bit shall either be set to the same value as in a previous CL message or set to ONE.		
Amateur radio notch – 3.5 MHz band	This selection shall only be performed by the ATU-C. Therefore, this Npar(2) bit shall either be set to the same value as in a previous CL message or set to ONE.		
Additional inband spectral shaping	If set to ONE, this Spar(2) bit indicates that the ATU-R is proposing additional downstream inband spectral shaping as defined by the values of REDUCED_PSD_lowband, PSD level at 1622 kHz, and PSD level at 3750 kHz		
REDUCED_PSD_l owband	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R wishes to have applied in the passband below 1104 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz.		
PSD level at 1622 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R wishes to have applied at 1622 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs between the REDUCED_PSD_lowband level at 1104 kHz and the PSD level at 1622 kHz.		
PSD level at 3750 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R wishes to have applied at 3750 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs between the PSD level at 1622 kHz and the PSD level at 3750 kHz.		
Extended upstream	If set to ONE, this Spar(2) bit indicates that the ATU-R is proposing extended upstream operation.		
EU-xx	If set to ONE, this Npar(3) bit indicates that the ATU-R is proposing upstream PSD mask US- xx. For non-overlapped spectrum, extended upstream masks are associated with downstream masks according to Figure Q.13. For overlapped spectrum, any EU-xx may be used with the overlapped downstream spectrum specified in §Q.4.8.2.		
Mode 1 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-R is proposing upstream mask mode 1 (different masks during FEXT and NEXT periods).		
Mode 2 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-R is proposing upstream mask mode 2 (same mask during FEXT and NEXT periods).		
Optional upstream masks for non- overlapped spectrum	If set to ONE, this NPar(3) bit indicates that the ATU-R is proposing one of the optional upstream masks when using non-overlapped spectrum downstream.		

Note 1: More than one pilot tone bit may be set in an MP message.

Q.7.4 Transceiver Training – ATU-C (supplements 10.4)

During transceiver training from C-REVERB1 to C-SEGUE1 except C-PILOTn and C-QUIETn, the ATU-C shall transmit both FEXT_R and NEXT_R symbols when Bitmap-N_R is enabled (Dual Bitmap mode), and shall not transmit the NEXT_R symbols except pilot tone when Bitmap-N_R is disabled (FEXT Bitmap mode). The duration of each state is defined as Figure Q.26.

Q.7.4.1 C-PILOT1 (supplements 10.4.2)

The ATU-C shall start the N_{SWF} (sliding window frame) counter from 0 immediately after entering C-PILOT1, and increment the N_{SWF} counter modulo 345 after transmission of each DMT symbol. According to the sliding window function and this counter, the ATU-C decides to transmit all of the subsequent symbols in either FEXT_R or NEXT_R symbols (for example, see Figures Q.11, Q.19 and Q.24).

C-PILOT1 has two signals.

The first signal is the pilot tone, a single frequency sinusoid at $f_{C-PILOT1}$ defined as:

$$X_{k} = \begin{cases} 0, & k \neq n_{C-PILOT1}, \ 0 \le k \le NSCds \\ A_{C-PILOT1}, & k = n_{C-PILOT1} \end{cases}$$

The frequency of the pilot tone shall be selected from one of the following choices during G.994.1 as:

12. $f_{C-PILOT1} = 276 \text{ kHz} (n_{C-PILOT1} = 64).$ 13. $f_{C-PILOT1} = 414 \text{ kHz} (n_{C-PILOT1} = 96).$ 14. $f_{C-PILOT1} = 552 \text{ kHz} (n_{C-PILOT1} = 128).$

15. $f_{\text{C-PILOT1}} = 1104 \text{ kHz} (n_{\text{C-PILOT1}} = 256).$

Transmitters that support Annex Q-EU shall support all of these pilot tones.

The second signal is the TTR indication signal used to transmit $NEXT_R/FEXT_R$ information. The ATU-R can detect the phase information of the TTR_C from this signal. The TTR indication signal shall be selected during G.994.1 as:

A48 signal -the constellation encoding of the 48th carrier with 2-bit constellation as follows:

(+, +) to indicate a FEXT_R symbol;

(+, -) to indicate a NEXT_R symbol.

Q.7.4.2 C-PILOT1A (supplements 10.4.3)

C-PILOT1A has two signals and it is the same transmitted signal as C-PILOT1 (C.7.4.1).

Q.7.4.3 C-REVERB3 (supplements 10.4.11)

In order to synchronize the first symbol of C-RATES1 with the beginning of the hyperframe and to inform the entering timing of C-RATES1 to the ATU-R, the first symbol of C-SEGUE1 shall be transmitted inside of the FEXT_R duration as shown in Figure Q.22. Therefore, the duration of C-REVERB3 is 3628 DMT symbols.

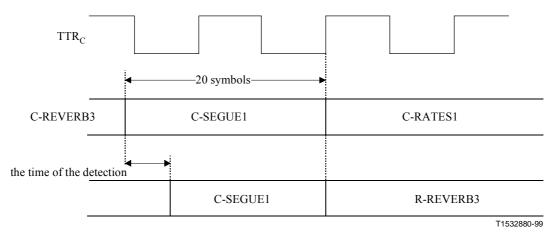


Figure Q.22/G.992.1 – Timing diagram from C-SEGUE1 to C-RATES1

Q.7.4.4 C-REVERB1 (replaces 10.4.5)

C-REVERB1 is a signal that allows the ATU-C and ATU-R receiver to adjust its automatic gain control (AGC) to an appropriate level. The data pattern used in C-REVERB1 shall be the pseudo-random downstream sequence (PRD), d_n for n = 1 to 2*NSCds, defined in Q.4.7.5 and repeated here for convenience:

$d_n = 1$	for $n = 1$ to 9	(10-1)
$d_n = d_{n-4} \oplus d_{n-9}$	for $n = 10$ to 2*NSCds	

The bits shall be used as follows: the first pair of bits (d_1 and d_2) is used for the DC and Nyquist subcarriers (the power assigned to them is, of course, zero, so the bits are effectively ignored); then the first and second bits of subsequent pairs are used to define the X_i and Y_i for i = 1 to NSCds-1 as defined in Table 7-13.

The period of PRD is only 511 bits, so d_{n+511} is equal to d_n . The bits d_1 to d_9 shall be re-initialized for each symbol, so each symbol of C-REVERB1 is identical.

The two bits that modulate the pilot carrier shall be overwritten by $\{0,0\}$: generating the $\{+,+\}$ constellation.

The duration of C-REVERB1 is 512 (repeating) symbols without cyclic prefix.

Q.7.4.4.1 Power Cut-back (supplements 10.4.5.1)

For Annex Q-EU, see A.3.1.

Q.7.5 Transceiver Training – ATU-R (supplements 10.5)

During transceiver training from R-REVERB1 to R-SEGUE1 except R-QUIETn, the ATU-R shall transmit both $FEXT_C$ and $NEXT_C$ symbols when Bitmap-N_C is enabled (Dual Bitmap mode) and shall not transmit $NEXT_C$ symbols when Bitmap-N_C is disabled (FEXT Bitmap mode). The duration of each state is defined as Figure Q.26.

Q.7.5.1 **R-QUIET2** (supplements 10.5.1)

The ATU-R enters R-REVERB1 after it completes timing recovery and Hyperframe synchronization from C-PILOT1/C-PILOT1A.

Q.7.5.2 R-REVERB1 (supplements 10.5.2)

The data pattern used in R-REVERB1 is the pseudo-random upstream sequence PRU defined in 8.11.3, repeated as

necessary for the the selected NSCus:

$$\begin{cases} d_n = 1 & \text{for } n = 1 \text{ to } 6 \\ d_n = d_{n-5} & \bigoplus d_{n-6} \text{ for } n = 7 \text{ to } 2*NSCus \end{cases}$$
(C.10-1)

The period of PRU is only 63 bits, so d_{n+63} is equal to d_n .

The ATU-R shall start its N_{SWF} counter immediately after entering R-REVERB1, and then increment the N_{SWF} counter with modulo 345 from 0 when it transmits each DMT symbol. The ATU-C and ATU-R shall have the same value since hyperframe alignment between the ATU-C and ATU-R shall be maintained. According to the sliding window and this counter, the ATU-R decides to transmit all of the subsequent symbols in either the FEXT_C or the NEXT_C symbol.

Q.7.5.3 R-QUIET3 (replaces 10.5.3)

The final symbol of R-QUIET3 accommodates the frame alignment of the transmitter to that of the receiver. It may be shortened by any number of samples. The maximum duration of R-QUIET3 is 6145 DMT symbols.

Q.7.5.4 R-REVERB2 (supplements 10.5.5)

After ATU-R detects C-SEGUE1, the ATU-R enters R-SEGUE1. The maximum duration of R-REVERB2 is 3643 DMT symbols.

Q.7.6 Channel analysis (ATU-C) (supplements 10.6)

ATU-C shall transmit only $FEXT_R$ symbols, and shall not transmit the $NEXT_R$ symbols except the pilot tone from C-RATES1 to C-CRC2. During C-MEDLEY, the ATU-C shall transmit both $FEXT_R$ and $NEXT_R$ symbols when Bitmap-N_R is enabled (Dual Bitmap mode). The ATU-C shall not transmit $NEXT_R$ symbols except the pilot tone, when Bitmap-N_R is disabled (FEXT Bitmap mode). The duration of each state is defined in Figure Q.26.

Q.7.6.1 C-SEGUE1 (supplements 10.6.1)

The duration of C-SEGUE1 is 20 symbols in order that the first symbol of C-SEGUE1 shall be inside of the FEXT_R duration.

Q.7.6.2 C-MEDLEY (replaces 10.6.6)

C-MEDLEY is a wideband pseudo-random signal used for estimation at the ATU-R of the downstream SNR. The data to be transmitted are derived from the pseudo-random sequence, PRD_m defined as:

d_n = 1 for n = 1 to 14 and d_n = d_{n-5}
$$\oplus$$
 d_{n-11} \oplus d_{n-12} \oplus d_{n-14} for n> 14,

and modulated as defined in 10.4.5. In contrast to C-REVERB1, the cyclic prefix is used and the data sequence continues from one symbol to the next (i.e. d_1 to d_{14} are not re-initialized for each symbol). Because the sequence is of length 2¹⁴-1, and far fewer bits are used for each symbol, the subcarrier vector for C-MEDLEY changes from one symbol period to the next. For non-overlapped spectrum, 2*(869-mm+1) bits are used each symbol, where mm is the minimum subcarrier specified for PSD mask DS-mm in Table Q.13. For overlapped spectrum, 2*864 bits are used each symbol. The pilot subcarrier is overwritten by the (+,+) signal constellation. The duration of C-MEDLEY is as shown in Figure Q.26. Following C-MEDLEY the ATU-C shall enter the state C-REVERB4.

With the periodical noise of TCM-ISDN, SNR also changes in the same cycle, as shown in Figure Q.23. The ATU-C transmits the signal in both of $NEXT_R$ and $FEXT_R$ symbols, and the ATU-R estimates two SNRs from the received $NEXT_R$ and $FEXT_R$ symbols, respectively, as defined in Figure Q.24.

The following formula gives the information that received N_{dmt}-th DMT symbol belongs to:

For $N_{dmt} = 0, 1, ..., 344$ $S = 272 \times N_{dmt} \mod 2760$ if { (S + 271 < a) or (S > d) } if { (S > b) and (S + 271 < c) } where a = 1243, b = 1403, c = 2613, d = 2704

then symbol for estimation of FEXT_R SNR then symbol for estimation of NEXT_R SNR

When Bitmap-N_R is disabled (FEXT Bitmap mode), ATU-C shall transmit only the pilot tone as NEXT_R symbol. The number of bits of NEXT_R shall be no more than the number of bits of FEXT_R.

At the transmitter, the PRD_m sequence generator shall continue to be updated during $NEXT_R$ symbols when Bitmap-N_R is disabled (FEXT Bitmap mode).

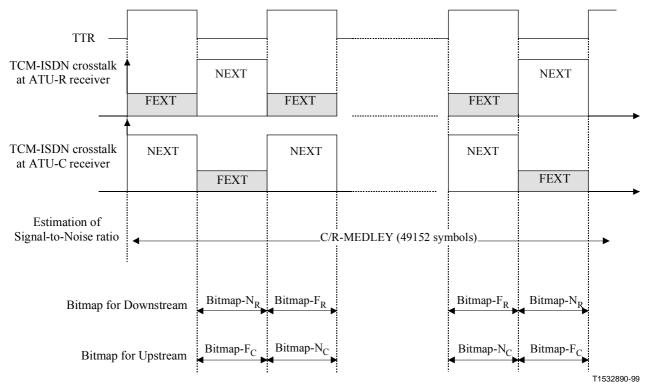


Figure Q.23/G.992.1 – Estimation of periodic Signal-to-Noise Ratio

TTR _C	
0	
1	
2	
3	30 31 32 33 34 35 36 36 37 39 40
4	41 42 43 44 45 46 47 48 49 50
5	51 52 53 54 55 56 57 58 59 60
6	61 62 63 64 65 66 67 58 70 70
7	71 72 73 74 75 76 76 80
8	81 82 83 84 85 36 87 88 89 99
9	91 92 93 94 95 96 97 98 99 100 101
10	101 102 103 104 105 106 107 108 109 111
11	112 113 114 115 116 117 120 121
12	122 123 124 125 26 27 78 129 131
13	132 133 134 135 136 137 138 139 141
14	142 143 144 145 146 147 148 149 151
15	152 153 154 155 156 157 158 159
16	162 163 164 165 166 167 168 169 170 172
17	173 174 175 176 177 178 179 188 182
18	183 184 185 186 187 188 189 199 192 102 104 105 106 107 100
19	193 194 195 196 197 198 1999 200 201 202
20 21	203 204 205 206 207 208 209 213 212
21	213 214 215 216 217 218 229 223 222 223 224 225 226 227 228 229 233
22	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$
23 24	233 234 235 237 238 249 238 249 253 244 245 246 247 248 249 258 253
25	244 245 246 246 246 260 262 263 254 255 256 257 258 259 269 262 263
26	264 265 266 267 268 269 279 277 273
27	274 275 276 277 278 279 288 288 283
28	284 285 286 287 288 289 299 299 299 293
29	294 295 296 297 298 299 300 300 300 300 300 300 300 300 300 3
30	304 305 306 307 308 309 334 334 332 333 314
31	315 316 317 318 319 324 324 324 324
32	325 326 327 328 329 336 333 332 333 334
33	335 336 337 338 339 340 344 342 343 344
	Symbol for estimation of FEXT _R S/N Symbol not used for S/N estimation
	Symbol for estimation of NEXT _R S/N T1535370-00

Figure Q.24/G.992.1 – Symbol pattern in a hyperframe for S/N estimation – Downstream

Q.7.6.3 C-RATES1 (supplements 10.6.2)

In order to support data rates greater than 32 Mbit/s, the B_I field has 11 bits. The RRSI fields shall use the same extended syntax as defined in Q.7.9.4 for C-RATES-RA.

For the S=1/2n framing mode (see §Q.4.9), the downstream RS_I shall be the number of parity bytes per sync byte, i.e., $RS_I = R_I/(n^*S)$.

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Table Q.13/G.992.1 – Assignment of 48 bits of C-MSG1					
Suffix(ces) of m_i (Note 1)	Parameter (Note 3)				
47-44	Minimum required downstream SNR margin at initialization (Note 2)				
43-18 Reserved for future use					
17	Trellis coding option				
16	Overlapped spectrum option (Note 4)				
15	Unused (shall be set to "1")				
14-12	Reserved for future use				
11	NTR				
10-9	Framing mode				
8-6	Transmit PSD during initialization				
5	Reserved				
4-0 Maximum numbers of bits per subcarrier supported					
NOTE 1 – Within the separate fields	the least significant bits have the lowest subscripts.				
NOTE 2 – A positive number of dB;					
NOTE 3 – All reserved bits shall be	set to "0".				
NOTE 4 – The initialization sequence allows for interworking of overlapped and non-overlapped spectrum					

Q.7.6.4 C-MSG1 (supplements 10.6.4)

T 11 0 12/0 002 1

NOTE 4 – The initialization sequence allows for interworking of overlapped and non-overlapped spectrum implementations. Therefore, this indication is for information only.

Q.7.6.4.1 Maximum numbers of bits per subcarrier supported – Bits 4-0 (replaces 10.6.4.8)

The N_{downmax} (transmit) capability shall be binary encoded onto $\{m_4, ..., m_0\}$ (e.g. $10001_2 = 17$). The maximum number of bits for the upstream data, N_{upmax} , that the ATU-C receiver can support need not be signalled to the ATU-R; it will be implicit in the bits and gains message, C-B&G, which is transmitted after channel analysis.

Q.7.7 Channel analysis (ATU-R) (supplements 10.7)

From R-RATES1 to R-CRC2, the ATU-R shall transmit only the FEXT_{C} symbols and shall not transmit the NEXT_{C} symbols. In R-SEGUE2 and R-MEDLEY, the ATU-R shall transmit both FEXT_{C} and NEXT_{C} symbols when Bitmap-N_C is enabled (Dual Bitmap mode) and shall not transmit NEXT_{C} symbols when Bitmap-N_C is disabled (FEXT Bitmap mode). The duration of each state is defined in Figure Q.26.

Q.7.8 R-SEGUE1 (supplements 10.7.1)

The maximum duration of R-SEGUE1 is 14 symbols (see Figure Q.22).

Q.7.8.1 R-REVERB3 (supplements 10.7.2)

The ATU-R shall start R-REVERB3 aligned with the beginning of a Hyperframe.

Q.7.8.2 **R-SEGUE2** (supplements 10.7.3)

The duration of R-SEGUE2 is 13 symbols.

Q.7.8.3 R-MEDLEY (replaces 10.7.8)

R-MEDLEY is a wideband pseudo-random signal used for estimation of the upstream SNR at the ATU-C. The data to be transmitted are derived from the pseudo-random sequence PRU_m defined as:

d $_{n}$ = 1 for n = 1 to 23 and d $_{n}$ = d $_{n-18} \oplus$ d $_{n-23}$ for n> 23.

In contrast to R-REVERB1, the cyclic prefix is used and the data sequence continues from one symbol to the next (i.e.

 d_1 to d_{23} are not re-initialized for each symbol). Because the sequence is of length 2^{23} -1, and $2^*(nn-5)$ bits are used for each symbol (where nn is the maximum subcarrier specified for PSD mask EU-nn in Table Q.18), the subcarrier vector for R-MEDLEY changes from one symbol period to the next. Following R-MEDLEY the ATU-R enters signalling state R-REVERB4. The duration of R-MEDLEY is as shown in Figure Q.26.

With the periodical noise of TCM-ISDN, SNR also changes in the same cycle, as shown in Figure Q.23. ATU-R shall transmit the signal in both of $NEXT_C$ and $FEXT_C$ symbols, and ATU-C shall estimate two SNRs from the received $NEXT_C$ and $FEXT_C$ symbols, respectively, as defined in Figure Q.25.

The following numerical formula gives the information that received N_{dmt}-th DMT symbol belongs to:

For $N_{dmt} = 0, 1, ..., 344$ $S = 272 \times N_{dmt} \mod 2760$ if { (S > b) and (S + 271 < c) } then symbol for estimation of FEXT_C SNR if { (S + 271 < a) } then symbol for estimation of NEXT_C SNR where a = 1148, b = 1315, c = 2608

When Bitmap-N_C is disabled (FEXT Bitmap mode), the ATU-R shall not transmit NEXT_C symbol. The number of bits of NEXT_C shall be no more than the number of bits of FEXT_C.

At the transmitter, the PRU_m sequence generator shall continue to be updated during $NEXT_C$ symbols when Bitmap- N_C is disabled (FEXT Bitmap mode).

TTR _R _	
0	
1	
2	20 22 25 26 27 28 29
3	30 32 33 34 35 36 37 38 39 40 44 45 46 47 48 49 50
5	43 43 44 45 46 47 48 49 50 55 54 55 56 57 58 59 60
6	34 35 36 37 38 39 60 63 62 63 64 65 66 67 68 69 70
7	71 75 76 77 78 79 80
8	81 83 84 85 86 87 88 89 90
9	91 92 93 94 95 96 97 98 99 100 101
10	101 105 106 107 108 109 110 111
11	
12	127 128 129 130 131
13	<i>132 134 135</i> 136 137 138 139 140 14
14	142 143 145 146 147 148 149 150 151
15	152 333 344 355 156 157 158 159 160 161
16	162 63 64 65 165 167 168 169 170 171 172
17	176 77 178 179 180 181 182
18	183 184 185 186 187 188 189 190 191 92
19	193 194 195 196 19 198 199 200 201 202
20	203 204 205 206 207 208 209 210 211 212
21	213 214 215 217 218 219 220 221 222
22	223 227 228 229 230 231 232
23	233 234 235 238 239 240 241 242 243
24 25	244 245 246 247 248 249 250 251 252 253
25 26	254 255 257 238 259 260 260 262 263 264 265 265 268 269 270 271 272 273
26 27	203 203 203 203 211 212 213 234 235 235 278 279 280 281 282 283
27	284 285 286 287 288 289 290 291 292 293
20	294 295 296 297 298 299 300 301 302 303
30	304 305 306 307 308 309 310 311 312 313 314
31	<u>313</u> 316 317 318 319 320 321 322 323 324
32	325 326 327 328 329 330 331 332 333 34
33	335 336 337 338 339 340 341 342 343 344
	T1535290-00
	Symbol for estimation of FEXT _C S/N Symbol not used for S/N estimation
	Symbol for estimation of NEXT _C S/N

Figure Q.25/G.992.1 – Symbol pattern in a hyperframe for S/N estimation – Upstream

Q.7.8.4 R-MSG1 (supplements 10.7.6)

Suffix(ces) of <i>m_i</i> (Note 1) Parameter (Note 2)				
47-18	Reserved for future use			
17	Trellis coding option			
16	Overlapped spectrum option (Note 3)			
15	Unused (shall be set to "1")			
14	Support of $S = 1/2$ mode (see Q.4.9) (Note 4)			
13 Support of dual latency downstream				
12	Support of dual latency upstream			
11 Network Timing Reference				
10,9 Framing mode				
8-5	Reserved for future use			
4-0 Maximum numbers of bits per subcarrier supported				
NOTE 1 – Within the separate fields t	he least significant bits have the lowest subscripts.			
NOTE 2 – All reserved bits shall be set	et to "0".			
NOTE 3 - The initialization sequence	allows for interworking of overlapped and non-overlapped spectrum			
implementations. Therefore, this indic	ation is for information only.			
1	auton is for minormation only.			

Table Q.14/G.992.1 – Assignment of 48 bits of R-MSG1

NOTE 4 – Since the S=1/2 mode is mandatory for Annex Q, a modem supporting Annex Q shall set this bit to binary ONE.

Q.7.8.4.1 Maximum numbers of bits per subcarrier supported – Bits 4-0 (replaces 10.7.6.6)

The N_{upmax} (transmit) capability is encoded onto $\{m_4, ..., m_0\}$ with a conventional binary representation (e.g. $10001_2 = 17$).

Q.7.9 Exchange – ATU-C (supplements 10.8)

During C-RATESn, C-MSGn, C-B&G, and C-CRCn, the ATU-C shall transmit the FEXT_R symbol. In the other signals, the ATU-C shall transmit both $FEXT_R$ and $NEXT_R$ symbols when Bitmap-N_R is enabled (Dual Bitmap mode), and shall not transmit the $NEXT_R$ symbols except pilot tone when Bitmap-N_R is disabled (FEXT Bitmap mode). The duration of each state is defined in Figure Q.27.

Q.7.9.1 C-MSG2 (supplements 10.8.9)

Replace Table 10-13 with Table Q.15.

Suffix(ces) of m_i (Note 1)	Parameter (Note 2)			
31-26	Estimated average loop attenuation			
25-21 Reserved for future use				
20-16	20-16 Performance margin with selected rate option			
15-11 Reserved for future use				
10-0 Total number of bits supported				
NOTE 1 – Within the separate fields the least significant bits have the lowest subscripts.				
NOTE 2 – All reserved bits shall be set to "0".				

Table Q.15/G.992.1 -	Assignment of 32 bits of C-MSG2
----------------------	---------------------------------

For NSCus=32,

 $n_{1C-MSG2} = 43$ $n_{2C-MSG2} = 91$

Otherwise,

 $n_{1C-MSG2} = 139$ $n_{2C-MSG2} = 187$

Q.7.9.1.1 Total number of bits per symbol supported (replaces 10.8.9.3)

The ATU-C receiver shall also calculate the maximum number of bits per symbol that the upstream channel can support with the performance margin defined in C-MSG-RA at an error rate of 10^{-7} .

The maximum number of bits per symbol is defined at the reference point B, that is calculated from the FEXT_C and NEXT_C downstream channel performance [e.g. if the maximum numbers of bits that can be supported in FEXT_C and NEXT_C symbols are 111 and 88 {Total number of bits per symbol supported} = $(111 \times 126 + 88 \times 214)/340 = 96$]. This number is encoded into bits 10-0 using a conventional binary representation [e.g. if the maximum number of bits that can be supported is 96 (data rate = 384 kbit/s), { m_{10} , ..., m_0 } = 000011111112].

NOTE – The number of symbols per hyperframe is 340. The number of FEXT symbols is 126. The number of NEXT symbols is 214.

Q.7.9.1.2 Estimated average upstream loop attenuation (supplements 10.8.9.1)

For Annex Q-EU, see A.3.2.

Q.7.9.2 C-B&G (replaces 10.8.13)

C-B&G shall be used to transmit to the ATU-R the bits and gains information, Bitmap-F_C { b_1 , g_1 , b_2 , g_2 , ... $b_{NSCus-1}$, $g_{NSCus-1}$ }, and Bitmap-N_C { $b_{NSCus+1}$, $g_{NSCus+1}$, $b_{NSCus+2}$, $g_{NSCus+2}$, ..., $b_{2*NSCus-1}$, $g_{2*NSCus-1}$ }, that are to be used on the upstream carriers. b_i of Bitmap-F_C indicates the number of bits to be coded by ATU-R transmitter onto the *i* th upstream carrier in FEXT_C symbols; g_i of Bitmap-F_C indicates the scale factor, relative to the gain that was used for that carrier during the transmission of R-MEDLEY, that shall be applied to the *i* th upstream carrier in FEXT_C symbols. Similarly, b_i of Bitmap-N_C indicates the number of bits onto the (*i* – NSCus) th upstream carrier in

NEXT_C symbols; g_i of Bitmap-N_C indicates the scale factor that shall be applied to the (*i* – NSCus) th upstream carrier in NEXT_C symbols.

Because no bits or energy will be transmitted at DC or one-half the sampling rate, b_0 , g_0 , b_{NSCus} , g_{NSCus} , $b_{2*NSCus}$, and $g_{2*NSCus}$ are all presumed to be zero and shall not be transmitted.

Each b_i shall be represented as an unsigned 5-bit integer, with valid b_i s lying in the range of zero to N_{upmax} , the maximum number of bits that the ATU-R is prepared to modulate onto any subcarrier, which is communicated in R-MSG1.

Each g_i shall be represented as an unsigned 11-bit fixed-point quantity, with the binary point assumed just to the right of

the third most significant bit. For example, a g_i with binary representation (most significant bit listed first)

 001.01000000_2 would instruct the ATU-R to scale the constellation for carrier *i*, by a gain factor of 1.25, so that the power in that carrier shall be 1.94 dB higher than it was during R-MEDLEY.

For subcarriers on which no data are to be transmitted, and the receiver will never allocate bits (e.g. out-of-band subcarriers) both b_i and g_i shall be set to zero (00000₂ and 00000000 000₂, respectively). For subcarriers on which no data are to be currently transmitted, but the receiver may allocate bits later (e.g. as a result of an SNR improvement), the b_i shall be set to zero and the g_i to a value in the 0.19 to 1.33 range (000.00110000₂ to 001.0101010₁).

Let NSCu=128, except when EU-32 is used where NSCu=32. The C-B&G information shall be mapped in a 32*(NSCu-1)-bit [4*(NSCu-1) byte] message *m* defined by:

 $m = \{m_{32}*(NSCu-1)-1, m_{32}(NSCu-1)-2, ..., m_1, m_0\} = \{g_2*NSCu-1, b_2*NSCu-1, ..., g_{NSCu+1}, b_{NSCu+1}, g_{NSCu-1}, ..., g_1, b_1\},$ (C.10-2)

with the MSB of b_i and g_i in the higher *m* index and m_0 being transmitted first. The message *m* shall be transmitted in 4*(NSCu-1) FEXT_R symbols. When NSCu=32, including C_CRC5, the total length is 336 symbols while for NSCu=128, the total length is 336+3*345=1371 symbols, using the transmission method as described in 10.8.9.

When Bitmap-N_C is disabled (FEXT Bitmap mode), b_i and g_i of Bitmap-N_C shall be set to zero. For index between NSCus+1 and 127, the m values are set to 0.

Q.7.9.3 C-SEGUE3 (replaces 10.8.16)

The duration of C-SEGUE3 is 18 symbols. Following C-SEGUE3, the ATU-C completes the initialization and enters C-SHOWTIME. In C-SHOWTIME, ATU-C shall transmit the signal using Bitmap- F_R and Bitmap- N_R with the sliding window.

When Bitmap-N_R is disabled (FEXT Bitmap mode), ATU-C shall transmit only the pilot tone as NEXT_R symbols.

	→ bits →							
fields	7	6	5	4	3	2	1	0
RS _F	$B_{10}(AS0)$	0		value of RS _F				
			MSB LSB					
RSI	$B_8(AS0)$	$B_9(AS0)$	value of RS ₁					
			MSB LSB					
S	I9	I ₈	value of S					
			MSB LSB					
Ι	I ₇	I ₆	I_5 I_4 I_3 I_2 I_1 I_0					
FS(LS2)	value of FS(LS2) <i>set to</i> {0000000 ₂ }							

Table Q.16/G.992.1 – RRSI fields of C-RATES-RA

The RS_I field has been extended to include bit B₉ of B_I (AS0) in bit 6, and The RS_F field has been extended to include the most significant bit B₁₀ of B_I (AS0) in bit 7, B_I (AS0) being the number of payload bytes in the AS0 bearer channel in the downstream interleave buffer. This is to support the higher data rates for the S=1/4, S=1/6 and S=1/8 modes.

The S field shall be coded $\{100100_2\}$ to indicate S=1/4, $\{100110_2\}$ to indicate S=1/6, and $\{101000_2\}$ to indicate S=1/8.

For the S=1/2n framing mode (see §Q.4.9), the downstream RS_I shall be the number of parity bytes per sync byte, i.e., $RS_I = R_I/(n^*S)$.

Q.7.10 Exchange – ATU-R (supplements 10.9)

ATU-R shall transmit only the FEXT_{C} symbols in R-MSGn, R-RATESn, R-B&G, R-CRCn. In other signals, the ATU-R shall transmit both FEXT_{C} and NEXT_{C} symbols when Bitmap-N_C is enabled (Dual Bitmap mode) and shall not transmit NEXT_{C} symbols when Bitmap-N_C is disabled (FEXT Bitmap mode). The duration of each state is defined in Figure Q.27.

Q.7.10.1 R-MSG-RA (supplements 10.9.2)

Replace Table 10-15 with Table Q.17.

Suffix(ces) of m_i	Parameter				
(Note)	All reserved bits shall be set to 0				
79-72	Reserved for ITU-T				
71 - 70	Extension to number of RS payload bytes, K				
69, 68	Extension to number of tones carrying data (ncloaded)				
67-56	B _{fast-max}				
55-49	Number of RS overhead bytes, (R)				
48-40	Number of RS payload bytes, K				
39-32	Number of tones carrying data (ncloaded)				
31-25	Estimated average loop attenuation				
24-21	24-21 Coding gain				
20-16	Performance margin with selected rate option				
15 - 14	Extension to total number of bits per DMT symbol, B _{max}				
13-12	Maximum Interleave Depth downstream				
11-0	Total number of bits per DMT symbol, B _{max}				
NOTE – Within the sepa	arate fields the least significant bits have the lowest subscripts.				

Table Q.17/G.992.1 – Assignment of 80 bits of R-MSG-RA (Annex Q-EU)

Q.7.10.1.1 Total number of bits supported (B_{max}) (replaces 10.9.2.8)

This parameter shall be defined as in R-MSG2, see Q.7.9.1.

Q.7.10.1.2 B_{fast-max} (new)

 $B_{fast-max}$ is the maximum number of bits of the fast buffer for fast data transmitted on the condition that the bits of the fast data can be equally assigned to all FEXT-symbols and NEXT-symbols.

Fast Buffered Data Bfast-max is tf.

Q.7.10.2 R-MSG2 (supplements 10.9.8)

Suffix(ces) of m; (Note 1) Parameter (Note 2)					
31-25					
24-21	Reserved for future use				
20-16					
15 - 14 Extension to total number of bits per DMT symbol, B _{max}					
13-12	13-12 Reserved for future use				
11-0 Total number of bits per DMT symbol, B _{max}					
NOTE 1 – Within the separate fi	elds the least significant bits have the lowest subscripts.				
NOTE 2 – All reserved bits shall be set to "0".					

Table Q.18/G.992.1 – Assignment of 32 bits of R-MSG2

 $N_{1R-MSG2} = 10$ $N_{2R-MSG2} = 20$

Q.7.10.2.1 Total number of bits per symbol supported (supplements 10.9.8.3)

The maximum number of bits per symbol that the downstream channel can support is encoded into bits 15, 14 and 11 - 0.

The maximum number of bits per symbol is defined at the reference point B, that is calculated from the FEXT_R and NEXT_R downstream channel performance. For example, if the maximum numbers of bits that can be supported in FEXT_R and NEXT_R symbols are 111 and 88, the total number of bits per symbol supported is $(111 \times 126 + 88 \times 214)/340 = 96$.

NOTE – The number of symbols per hyperframe is 340, the number of FEXT symbols is 126, and the number of NEXT symbols is 214.

Q.7.10.2.2 Estimated average downstream loop attenuation (supplements 10.9.8.1)

For Annex Q-EU, see A.3.3.

Q.7.10.3 R-REVERB5 (supplement of 10.9.12)

The duration of R-REVERB5 is 345n-40, 3<=n<=19, when NSCu=128, or 3<=n<=16 when NSCu=32.

Q.7.10.4 R-B&G (replaces 10.9.14)

The purpose of R-B&G is to transmit to ATU-C the bits and gains information, Bitmap-F_R { b_1 , g_1 , b_2 , g_2 , ..., $b_{NSCds-1}$, $g_{NSCds-1}$ }, and Bitmap-N_R { $b_{NSCds+1}$, $g_{NSCds+1}$, $b_{NSCds+2}$, $g_{NSCds+2}$, ..., $b_{2*NSCds-1}$, $g_{2*NSCds-1}$ }, to be used on the downstream subcarriers. b_i of Bitmap-F_R indicates the number of bits to be coded by ATU-C transmitter onto the *i* th downstream subcarrier in FEXT_R symbols; g_i of Bitmap-F_R indicates the scale factor that shall be applied to the *i* th downstream subcarrier in FEXT_R symbols, relative to the gain that was used for that carrier during the transmission of C-MEDLEY. Similarly, b_i of Bitmap-N_R indicates the number of bits onto the (*i* – NSCds) th downstream carrier in NEXT_R symbols; g_i of Bitmap-N_R indicates the scale factor that shall be applied to the (*i* – NSCds) th downstream carrier in NEXT_R symbols. Because no bits or energy will be transmitted at DC or one-half the sampling rate, b_0 , g_0 , b_{NSCds} , g_{NSCds} , b_2*_{NSCds} , and g_2*_{NSCds} are all presumed to be zero, and are not transmitted. When subcarrier 64 is reserved as the pilot tone, b_{64} and $b_{NSCds+64}$, shall be set to 0, g_{64} and $g_{NSCds+64}$ shall be set to g_{sync} . When subcarrier 128 is reserved as the pilot tone, b_{128} and $b_{NSCds+128}$, shall be set to 0, g_{128} and $g_{NSCds+128}$ shall be set to g_{sync} . When subcarrier 256 is reserved as the pilot tone, b_{256} and $b_{NSCds+256}$, shall be set to 0, g_{256} and $g_{NSCds+256}$ shall be set to 0, g_{256} and $g_{NSCds+256}$ shall be set to g_{sync} . The value g_{sync} represents the gain scaling applied to the sync symbol.

Each b_i is represented as an unsigned 5-bit integer, with valid b_i lying in the range of zero to N_{downmax} , the maximum number of bits that the ATU-C is prepared to modulate onto any subcarrier, which is communicated in C-MSG1.

Each g_i is represented as an unsigned 11-bit fixed-point quantity, with the binary point assumed just to the right of the

third most significant bit. For example, a g_i with binary representation (most significant bit listed first) 001.010000002 would instruct the ATU-C to scale the constellation for carrier *i* by a gain factor of 1.25, so that the power in that carrier shall be 1.94 dB higher than it was during C-MEDLEY.

For subcarriers on which no data are to be transmitted, and the receiver will never allocate bits (e.g. out-of-band subcarriers) both b_i and g_i shall be set to zero (00000₂ and 00000000 000₂, respectively). For subcarriers on which no data are to be currently transmitted, but the receiver may allocate bits later (e.g. as a result of an SNR improvement), the b_i shall be set to zero and the g_i to a value in the 0.19 to 1.33 range (000.00110000₂ to 001.0101010₁).

The R-B&G information shall be mapped in a (2*NSCds-2)*16-bit ((2*NSCds-2)*2 byte) message *m* defined by:

 $m = \{m_{(2*NSCds-2)*16-1}, m_{(2*NSCds-2)*16-2}, ..., m_1, m_0\} = \{g_{2*NSCds-1}, b_{2*NSCds-1}, ..., g_{NSCds+1}, b_{NSCds+1}, b_{NSCds-1}, ..., g_{1}, b_{1}\},$ (Q.10-3)

with the MSB of b_i and g_i in the higher *m* index and m_0 being transmitted first. The message *m* shall be transmitted in (2*NSCds-2)*2 symbols, using the transmission method as described in 10.9.8.

When Bitmap-N_R is disabled (FEXT Bitmap mode), b_i and g_i of Bitmap-N_R shall be set to zero.

Q.7.10.5 R-SEGUE5 (replaces 10.9.17)

The duration of R-SEGUE5 is 13 symbols. Following R-SEGUE-5, ATU-R completes the initialization and enters R-SHOWTIME. In R-SHOWTIME, ATU-R shall transmit the signal using Bitmap- F_C and Bitmap- N_C with the sliding window.

When Bitmap-N_C is disabled (FEXT Bitmap mode), ATU-R shall not transmit NEXT_C symbols.

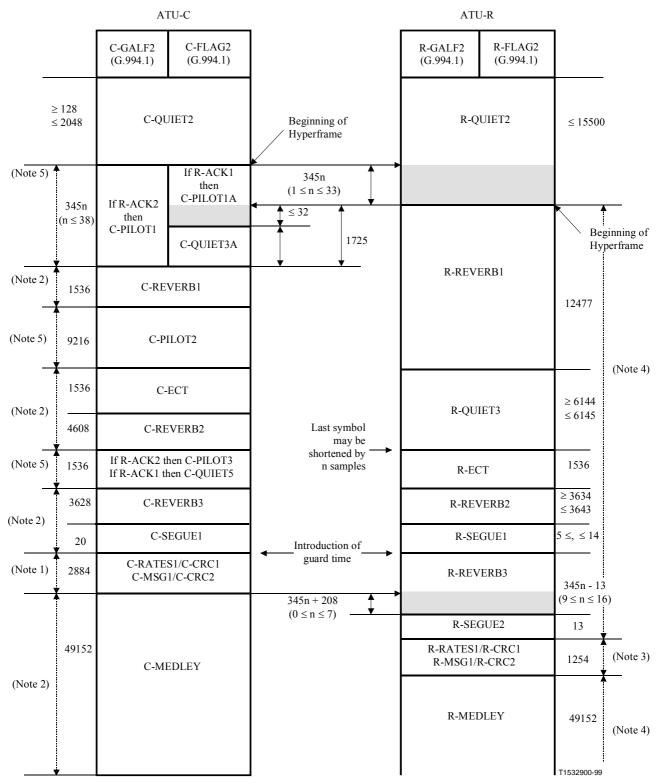
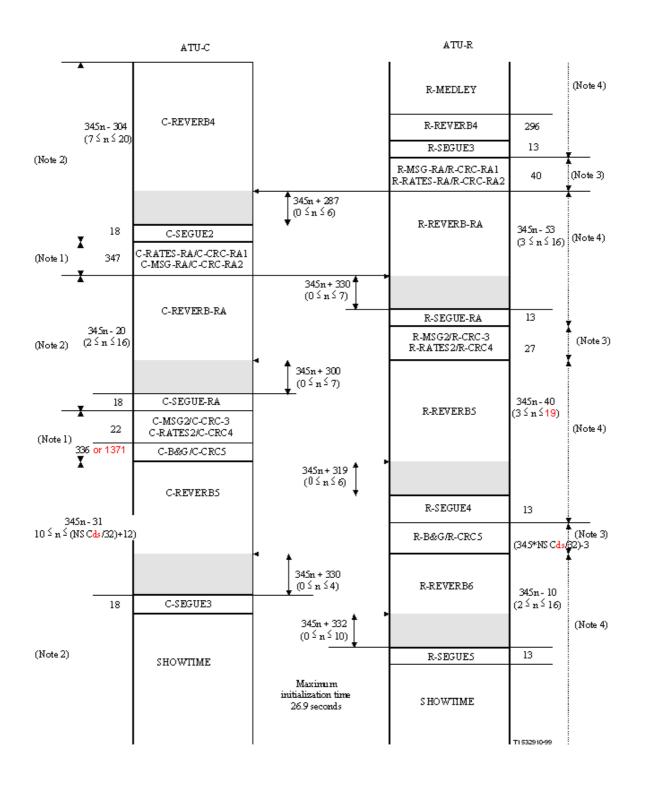


Figure Q.26/G.992.1 – Timing diagram of the initialization sequence – Part 1



- NOTE 1 The ATU-C shall transmit the FEXTR symbols, and shall not transmit as NEXTR symbols except the pilot tone.
- NOTE 2 The ATU-C shall transmit both FEXTR and NEXTR symbols, when Bitmap-NR is enabled (Dual Bitmap mode). ATU-C shall not transmit the NEXTR symbols except pilot tone, when Bitmap-NR is disabled (FEXT Bitmap mode).
- NOTE 3 The ATU-R shall transmit the FEXTC symbols, and shall not transmit the NEXTC symbols.
- NOTE 4 The ATU-R shall transmit both FEXTC symbols, when Bitmap-NC is enabled (Dual Bitmap mode). ATU-R shall not transmit NEXTC symbols, when Bitmap-NC is disabled (FEXT Bitmap mode).
- NOTE 5 The ATU-C shall transmit both FEXTR and NEXTR symbols.

Figure Q.27/G.992.1 – Timing diagram of the initialization sequence – Part 2

[Editor's note: Need to update Figure Q.27 to parameterize the length of C-B&G and the maximum length of R-REVERB5.]

Q.8 AOC On-line adaptation and reconfiguration (pertains to clause 11)

Q.8.1.1 Bit swap request (replaces 11.2.3)

The receiver shall initiate a bit swap by sending a bit swap request to the transmitter via the AOC channel. This request tells the transmitter which subcarriers are to be modified. The format of the request is shown in Table Q.19.

Message header	Message field 1-4			
$\{11111111_2\}$	Bitmap index (1 bit)	Subchannel index – bits 10	Command (5 bits)	Subchannel index – bits 8
(8 bits)		& 9	(5 61(3)	to 1
		(2 bits)		(8 bits)

Table Q.19/G.992.1 – Format of the bit swap request message

The request shall comprise nine bytes as follows:

- an AOC message header consisting of 8 binary ones;
- message fields 1-4, each of which consists of a one-bit bitmap index, subchannel index bits 10 & 9, and a five-bit command followed by bits 8 to 1 of the subchannel index. One-bit bitmap index, subchannel index bits 10 & 9, and valid five-bit commands for the bit swap message shall be as shown in Table Q.20. In Table Q.20, the MSB for the bit swap request command represents the Bitmap index. For downstream data, Bitmap index equals 0 indicates Bitmap-F_R, and Bitmap index equals 1 indicates Bitmap-N_R. Similarly for upstream data, Bitmap index equals 0 indicates Bitmap-F_C, and 1 indicates Bitmap-N_C. The next 2 bits are subchannel index bits 10 & 9. The ten-bit subchannel index is counted from low to high frequencies with the lowest frequency subcarrier having the number zero. The subcarrier index zero shall not be used;
- the bit swap between $FEXT_{C/R}$ symbols and $NEXT_{C/R}$ symbols is not allowed.

Value Interpretation (8 bit)					
yzz000002	Do nothing				
yzz000012	Increase the number of allocated bits by one				
yzz000102	Decrease the number of allocated bits by one				
yzz000112	Increase the transmitted power by 1 dB				
yzz001002	Increase the transmitted power by 2 dB				
yzz001012	Increase the transmitted power by 3 dB				
yzz00110 ₂ Reduce the transmitted power by 1 dB					
yzz001112	Reduce the transmitted power by 2 dB				
yzz01xxx ₂ Reserved for vendor discretionary commands					
NOTE – y is "0" for $FEXT_{C/R}$ symbols, and "1" for $NEXT_{C/R}$ symbols of the Sliding Window.					
NOTE – subchannel index = zz_2^{*256} + subchannel index value from lower 8 bit field					

Table Q.20/G.992.1 – Bit swap request command

The bit swap request message (i.e. header and message fields) shall be transmitted five consecutive times.

To avoid g_i divergence between ATU-C and ATU-R after several bit swaps, for a g_i update of Δ dB the new g_i value should be given by:

$$g_i' = (1/256) \times round(256 \times g_i \times 10 \exp(\Delta/20))$$
 (Q.11-1)

Q.8.1.2 Extended bit swap request (supplements 11.2.4)

The format of the extended bit swap request is shown in Table Q.21.

Message header	Message field 1-6			
{11111100 ₂ } (8 bits)	Bitmap index (1 bit)	Subchannel index – bits 10 & 9 (2 bits)	Command (5 bits)	Subchannel index – bits 8 to 1 (8 bits)

Table Q.21/G.992.1 – Format of the bit swap request message

In the same manner as the bit swap request, each of the message fields of the extended bit swap request consists of one-bit bitmap index, a five-bit command followed by a related ten-bit subchannel index.

Q.8.1.3 Bit swap acknowledge (supplements 11.2.5)

The bit swap superframe counter number shall only indicate the last superframe (SPF#4) of a hyperframe.

The new bit and/or transmit power table(s) shall then take effect starting from the first frame (frame 0) of SPF#0 of a hyperframe.

If the bit swap superframe counter number contained in the received bit swap acknowledge message does not indicate SPF#4, then the new table(s) shall take effect starting from frame 0 of SPF#0 of the next hyperframe.

Q.9 POTS splitter

For operation according to G.992.1 Annex Q-EU, the Annex E.4/G.992.3 requirements applying over a frequency band up to 1104 kHz, shall be met over a frequency band up to 3750 kHz.

付属資料5

G.992.1 ANNEX I-EU (REVISION 1.1) PROPRIETARY EXTENSION TO G.992.1 ANNEX I

This document defines G.992.1 Annex I-EU (Double spectrum downstream with extended upstream spectrum), a proprietary extension to G.992.1 Annex I to extend the data rate beyond 2 Mbit/s upstream by way of:

- Increase upstream bandwidth \rightarrow increased number of subcarriers, NSCus=64
- Increased bit loading, beyond 15 bits/bin

Due to the increase in upstream data rates, the upstream maximum interleave depth has been increased to 16. Support of this is mandatory.

The attached text is the approved text for Annex I, marked up with revision control to show the changes necessary to support the additional functionality.

Revision 1 text is based on G.992.1 Annex Q-EU Revision 3, and supports the following features:

- extended upstream to subcarrier 64
- high bit loading (HBL),
- overlapped spectrum,
- S=1/4 mandatory, S=1/3 not supported
- D=16 upstream mandatory

Revision 1.1 changes the following with respect to Revision 1:

- changes PRD and PRU polynomial for MEDLEY (REVERB is unchanged) by defining new PRD_m and PRU_m.
- specifies the non-overlapped downstream PSD mask.
- makes upstream masks EU-36 to EU-64 optional for use with non-overlapped spectrum as well as overlapped spectrum, and adds associated downstream masks DS-36 to DS-60 for non-overlapped spectrum.
- added a new G.994.1 NPar(3) code point to indicate support for the optional EU masks with non-overlapped spectrum. Changed the bit assignments for the mode 1 upstream masks and mode 2 upstream masks from NPar(2) to NPar(3) within the extended upstream branch of the tree. Changed bit assignments for the EU-32 to EU-64 NPar(3) code points.
- Modified timing diagram for initialization in Figure I.27(Text in C-B&G and R-REVERB5 has been change)

ANNEX I-EU

Specific requirements for an ADSL system to support upstream data rates greater than 2 Mbit/s with improved performance on short loops operating in the same cable as ISDN as defined in ITU-T Recommendation G.961 Appendix III

I.1 Scope

This annex describes those specifications that are unique to an ADSL system coexisting in the same binder as TCM-ISDN as defined Recommendation G.961 Appendix III. The subclauses in this annex provide supplementary and replacement material to the clauses in the main body. The nature of the material is parenthetically indicated in the subclause heading. The modifications described in this annex allow a performance improvement from the ADSL system specified in Annex C for short loops in an environment coexisting with TCM-ISDN in the same cable. Specifically, this Annex specifies extensions to upstream bandwidth and maximum bit loading to support upstream data rates greater than 2 Mbit/s. This annex also defines those parameters of this ADSL system that have been left undefined in the main body of this Recommendation. An ADSL system implementing Annex I-EU shall support Annex I. It is recommended that an ADSL system implementing Annex C.

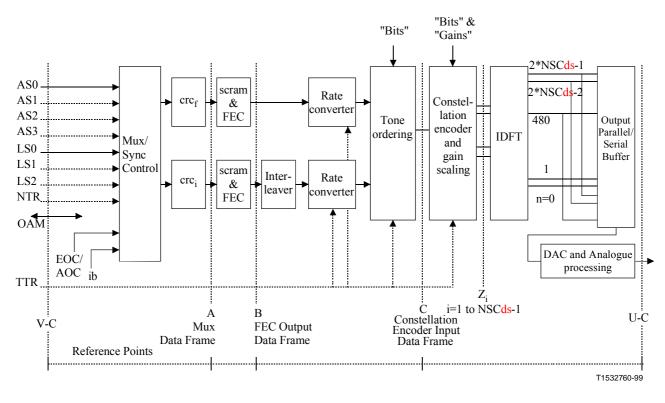
I.2 Definitions

Bitmap-F _C	ATU-R transmitter bitmap under TCM-ISDN FEXT noise generated at ATU-C
Bitmap-F _R	ATU-C transmitter bitmap under TCM-ISDN FEXT noise generated at ATU-R
Bitmap-N _C	ATU-R transmitter bitmap under TCM-ISDN NEXT noise generated at ATU-C
Bitmap-N _R	ATU-C transmitter bitmap under TCM-ISDN NEXT noise generated at ATU-R
Dual Bitmap FEXT Bitmap	The Dual Bitmap method has dual bit rates under the FEXT and NEXT noise from TCM-ISDN Similar to the Dual Bitmap method however transmission only occurs during FEXT noise from TCM-ISDN
FEXT _C duration	TCM-ISDN FEXT duration at ATU-C estimated by the ATU-R
FEXT _C symbol	DMT symbol transmitted by ATU-R during TCM-ISDN FEXT
FEXT _R duration	TCM-ISDN FEXT duration at ATU-R estimated by the ATU-C
FEXT _R symbol	DMT symbol transmitted by ATU-C during TCM-ISDN FEXT
Hyperframe NEXT _C duration	5 Superframes structure which synchronized TTR TCM-ISDN NEXT duration at ATU-C estimated by the ATU-R
NEXT _C symbol	DMT symbol transmitted by ATU-R during TCM-ISDN NEXT
NEXT _R duration	TCM-ISDN NEXT duration at ATU-R estimated by the ATU-C
NEXT _R symbol	DMT symbol transmitted by ATU-C during TCM-ISDN NEXT
NSCds	The highest subcarrier index that can be used for downstream transmission (i.e., the subcarrier index corresponding to the Nyquist frequency) For example, $NSCds = 256$ for a downstream channel using the frequency band up to $1.104MHz$; $NSCds = 512$ for a downstream channel using the frequency band up to $2.208MHz$.
NSCus	The highest subcarrier index that can be used for upstream transmission (i.e., the subcarrier index corresponding to the Nyquist frequency) For example, $NSCus = 64$ for an upstream channel using the frequency band up to 276 kHz.
N _{SWF}	Sliding Window frame counter
Subframe	10 consecutive DMT symbols (except for sync symbols) according to TTR timing
TTR TTR _C	TCM-ISDN Timing Reference Timing reference used in ATU-C
TTRR	Timing reference used in ATU-R
UI	Unit Interval

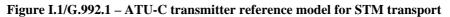
I.3 Reference Models

I.3.1 ATU-C transmitter reference model (replaces figures in 5.1)

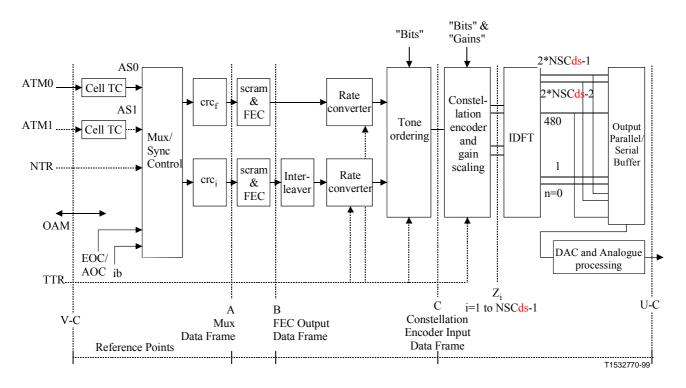
See Figure I.1 and Figure I.2.



NOTE - The TTR may be generated in ATU-C without being provided from the TCM-ISDN clock.



Annex I-EU does not currently support STM transport. It only supports ATM transport.

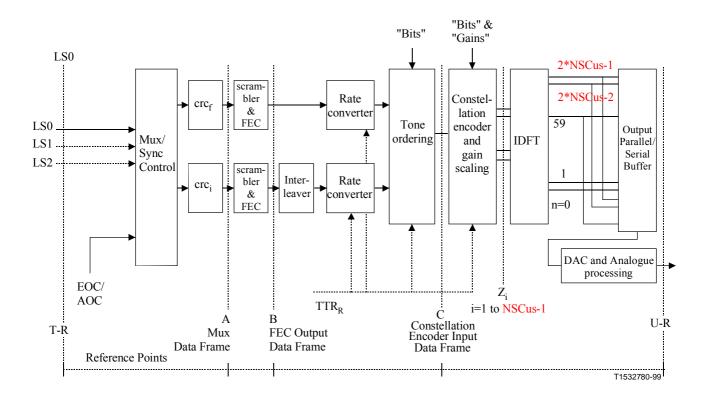


NOTE - The TTR may be generated in ATU-C without being provided from the TCM-ISDN clock.

Figure I.2/G.992.1 – ATU-C transmitter reference model for ATM transport

I.3.2 ATU-R transmitter reference model (replaces figures in 5.2)

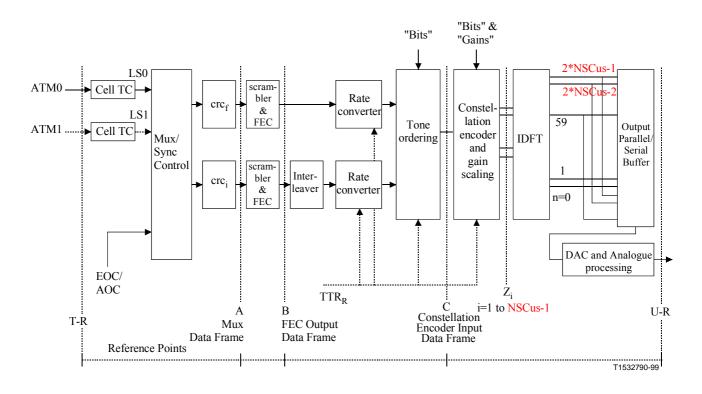
See Figure I.3 and Figure I.4.



NOTE – The TTR_R shall be generated in ATU-R from the received TTR_C signal, and it is locked to 690 periods of upstream sampling clock (1.104 MHz).

Figure I.3/G.992.1 – ATU-R transmitter reference model for STM transport

Annex I-EU does not currently support STM transport. It only supports ATM transport.



NOTE – The TTR_R shall be generated in ATU-R from the received TTR_C signal, and it is locked to 690 periods of upstream sampling clock (1.104 MHz).

Figure I.4/G.992.1 – ATU-R transmitter reference model for ATM transport

I.3.3 ATU-C/R transmitter timing model (replacement for 5.3)

I.3.3.1 TCM-ISDN crosstalk timing model (new)

Figure I.5 shows the timing chart of the crosstalk from TCM-ISDN.

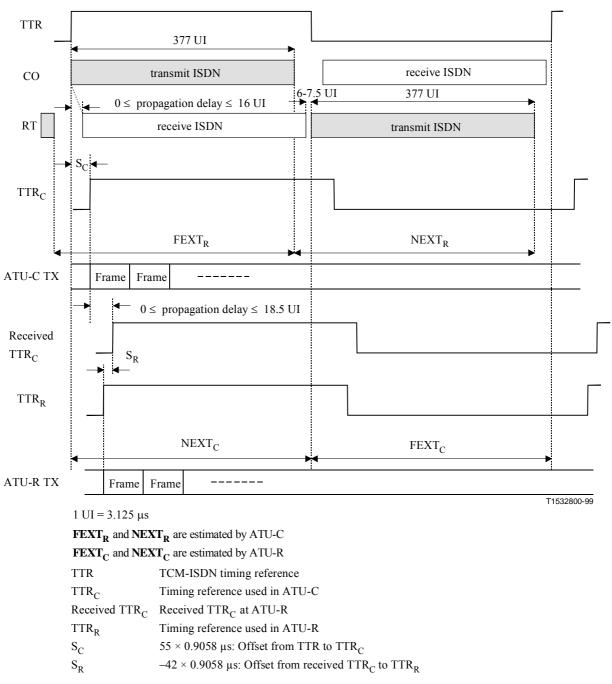


Figure I.5/G.992.1 – Timing chart of the TCM-ISDN crosstalk

The data stream of TCM-ISDN is transmitted in TTR period. CO transmits the stream in the first half of the TTR period and RT transmits in the second half of the TTR period. ATU-C receives NEXT noise from the ISDN in the first half of the TTR period and FEXT noise from the ISDN in the second half of the TCM-ISDN period. On the other hand, ATU-R receives FEXT noise from the ISDN in the first half of the TTR period and NEXT noise from the ISDN in the second half of the TTR period.

As defined in I.7.6.2 and I.7.8.3, the ATU-C shall estimate the FEXT_R and NEXT_R duration at ATU-R, and the ATU-R shall estimate FEXT_C and NEXT_C duration at ATU-C taking propagation delay on the subscribe line into consideration.

The ATU-C shall transmit any symbols by synchronizing with the TTR_C . The ATU-R shall transmit any symbols synchronizing with the TTR_R generated from received TTR_C .

I.3.3.2 Sliding window (new)

Figure I.6 shows the timing chart of the transmission for the Annex I-EU downstream at ATU-C.

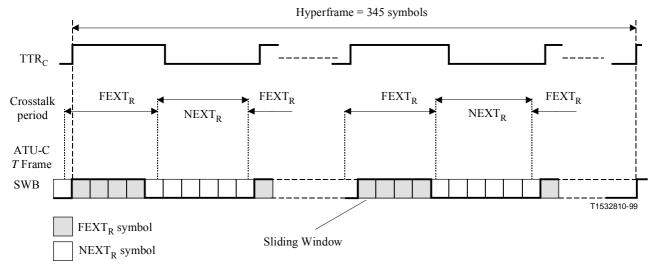


Figure I.6/G.992.1 – Sliding window for downstream symbols

The Sliding Window defines the transmission symbols under the crosstalk noise environment synchronized to the period of TTR. The $\text{FEXT}_{C/R}$ symbol represents the symbol completely inside the $\text{FEXT}_{C/R}$ duration. The $\text{NEXT}_{C/R}$ symbol represents any symbol containing the $\text{NEXT}_{C/R}$ duration. Thus, there are more $\text{NEXT}_{C/R}$ symbols than $\text{FEXT}_{C/R}$ symbols.

The ATU-C decides which transmission symbol is $FEXT_R$ or $NEXT_R$ symbol according to the sliding window and transmits it with the corresponding bit table. Similarly, the ATU-R decides the transmission symbol is a $FEXT_C$ or $NEXT_C$ and transmits it with the corresponding bit table. Although the phase of the sliding window is asynchronous with $TTR_{C/R}$, the pattern is fixed to the 345 frames of the hyperframe.

I.3.3.3 ATU-C Symbol Synchronization to TTR (new)

345 symbols are 34 cycles with cyclic prefix of TTR_C (or 32 cycles of TTR_C without cyclic prefix). This implies a PLL lock at the ATU-R.

I.3.3.4 Dual Bitmap switching (new)

The ATU-C transmits FEXT_R symbols using Bitmap-F_R (in FEXT_R duration), and transmits NEXT_R symbols using Bitmap-N_R (in NEXT_R duration) according to the result of initialization. The ATU-R transmits FEXT_C symbols using Bitmap-F_C (in FEXT_C duration), and transmits NEXT_C symbols using Bitmap-F_C (in NEXT_C duration), and transmits NEXT_C symbols using Bitmap-F_C (in NEXT_C duration), and transmits NEXT_C symbols using Bitmap-F_C (in NEXT_C duration), and transmits NEXT_C symbols using Bitmap-F_C (in NEXT_C duration) in the same manner.

The ATU-C shall have the capability to disable Bitmap-N_C and Bitmap-N_R (see I.4.5 and I.5.3).

I.3.3.5 Loop timing at ATU-R (new)

The phase relation between received symbol and transmitted symbol of ATU-R at the reference point U-R shall meet the phase tolerances as shown in Figure I.7.

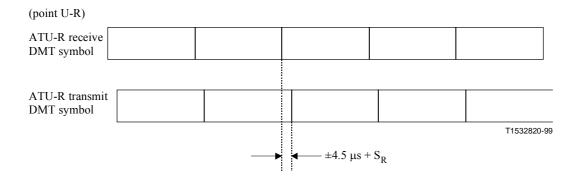


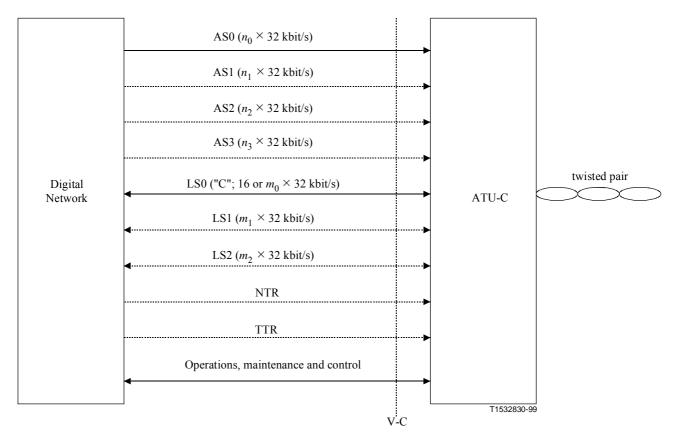
Figure I.7/G.992.1 – Loop timing for ATU-R

I.4 ATU-C functional characteristics (pertains to clause 7)

I.4.1 STM transmission protocols specific functionality (pertains to 7.1)

I.4.1.1 ATU-C input and output V interface for STM transport (replaces figure in 7.1.1)

See Figure I.8.



NOTE 1 – Optional bearer channels (both duplex and simplex) and features are shown with dotted lines. NOTE 2 – TTR may be generated in the ATU-C without being provided from the V-C reference point.

Figure I.8/G.992.1 – ATU-C functional interfaces for STM transport at the V-C reference point

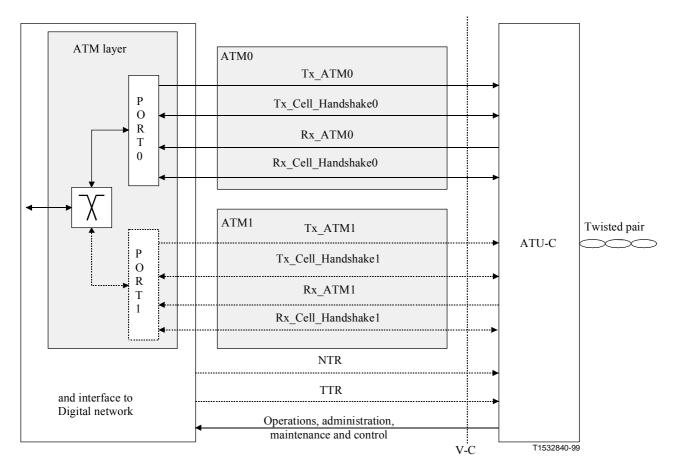
I.4.1.2 Payload transfer delay (supplements 7.1.4)

Since Annex I-EU uses a rate converter, the maximum payload transfer delay is longer than specified values in 7.1.4. The additional one-way transfer delay due to the rate converters shall be less than 1.7 ms for fast data and 13 ms for interleaved data.

I.4.2 ATM transmission protocols specific functionalities (pertains to 7.2)

I.4.2.1 ATU-C Input and Output V interface for ATM transport (replaces figure in 7.2.1)

See Figure I.9.



NOTE - TTR can be generated in the ATU-C without being provided from the V-C reference point.

Figure I.9/G.992.1 – ATU-C functional interfaces to the ATM layer at the V-C reference point

I.4.2.2 Payload transfer delay (supplements 7.2.2)

Since Annex I-EU uses a rate converter, the maximum payload transfer delay is longer than specified values in 7.2.2. The additional one-way transfer delay due to the rate converters shall be less than 1.7 ms for fast data and 13 ms for interleaved data.

I.4.3 Framing (pertains to 7.4)

I.4.3.1 Superframe structure (supplements 7.4.1.1)

Since the rate converter reorders the user data and overhead bit-level data to create hyperframes, the input data frames to the constellation encoder are different than those defined in 7.4.1.1.

I.4.3.2 Hyperframe structure (replaces 7.4.1.3)

Annex I-EU uses the hyperframe structure shown in Figure I.10. Figure I.10 shows the phase relationship between the TTR_C and the hyperframe at the point U-C. Each hyperframe is composed of 5 superframes, which are numbered from 0 to 4. In order to indicate the boundary of the hyperframe, the inverse synch symbol is used for the 4th superframe (SPF#3), which is generated from a tone-by-tone 180-degree phase reversal of the synchronization symbol (see I.4.7.1) except for the pilot tone.

The bit-level data stream from the rate-converter is extracted according to the size of Bitmap- F_R and Bitmap- N_R using the Sliding Window (see I.3.3.2).

In order to make the bit rate to be a multiple of 32 kbit/s, the dummy bits are inserted at the end of hyperframe by the rate converter (see I.4.4.2). The hyperframe is composed of 345 DMT symbols, numbered from 0 to 344. Each symbol is assigned as $FEXT_R$ or $NEXT_R$ symbol in a $FEXT_R$ or $NEXT_R$ duration (see I.2), and the following numerical formula gives the information which duration N_{dmt}-th DMT symbol belongs to at ATU-C transmitter (see Figure I.11).

For N _{dmt} = 0, 1,, 344	
$S = 272 \times N_{dmt} \mod 2760$	
if $\{ (S + 271 < a) \text{ or } (S > a + b) \}$	then FEXT _R symbol
else	then $NEXT_R$ symbol
where a = 1243, b = 1461	

Thus, 128 DMT symbols are allocated in the FEXT_R duration, and 217 DMT symbols are allocated in the NEXT_R duration. The symbols are composed of:

FEXT _R symbol:	
Number of symbol using Bitmap- F_R	= 126
Number of synch symbol	= 1
Number of inverse synch symbol	= 1
NEXT _R symbol:	
Number of symbol using Bitmap-N _R	= 214
Number of synch symbol	= 3

During FEXT Bitmap mode, the ATU-C shall transmit only the pilot tone in NEXT_R symbols.

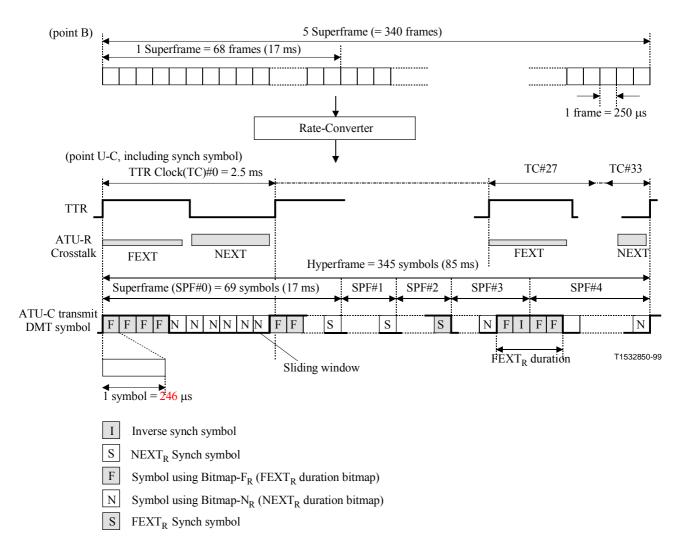


Figure I.10/G.992.1 – Hyperframe structure for downstream

2									
0	0 1 2	3	4	5		6	7	8	9
1	10 11 12	13	14	15	16	5 17	7 18	3 1	9
2	20 21 22	23	24	25	26	27	28	29	
3	30 31 32	33 3	34	35	36	37	38	39	40
4	41 42	43 44	4	45	46	47	48	49	50
5	51 52 5	3 54		55	56	57	58	59	60
6	61 62 63	64	6	5 6	6	67	SS	69	70
7	71 72 73	74	75	76	7	7 7	8 7	9 8	30
8	81 82 83	84	85	86	87	88	89) 9()
9	91 92 93	94	95	96	97	98	99	100	101
10	101 102 103	104 10	05	106	107	108	109	110	111
11		14 11:		116	117	118	119	120	121
12	122 123 12				127	128	129	130	131
13	132 133 134	135	13						141
14	142 143 144	145	146						51
15	152 153 154	155	156		158				
16	162 163 164		166	167	168	169	170	171	172
17			76	177	178	179	180	181	182
18	183 184 1 193 194 19	85 180 5 196		187 97 1	188 98	189 199	190 200	191 201	192
19 20	203 204 205	5 196 SS	20		· · ·		· · ·		202
20	203 204 203 213 214 215	216	217	· · · ·		<u> </u>			212 22
21	213 214 213 223 224 225	226	227		229	·			
22	233 234 235		227	238	239	240	241	242	243
23		246 24		248	249	250	251	252	253
25		56 257		258	259	260	260	262	263
26	264 265 26					270	271	272	273
27	274 ISS 276	277	27		9 2	80 2	81 2	82 2	283
28	284 285 286	287	288	289	29	0 29	1 29	2 29)3
29	294 295 296	297	298	299	300	301	302	303	;
30	304 305 306	307 3	08	309	310	311	312	313	314
31	315 316 3	317 31	8	319	320	321	322	323	324
32	325 326 32	27 328	3	329	330	331	332	333	334
33	335 336 337	7 338	3	39 3	40	341	342	343	SS
	ISS Inverse synch sym	ibol S	SS F	EXT _r Sy	/nch syn	nbol SS	NEXT	Г _R synch	symbol
	FEXT _R data symbol	ol 🗌	N	IEXT _R da	ata symb	ol		T1	535330-00

Figure I.11/G.992.1 – Symbol pattern in a hyperframe with cyclic prefix – Downstream

I.4.3.3 Subframe Structure (replaces 7.4.1.4)

A subframe is 10 consecutive DMT symbols (except for synch symbols) as shown in Table I.1. The 34 subframes form a hyperframe.

Subframe No.	DMT symbol No.	Note
0	0-9	
1	10-19	
2	20-29	
3	30-39	
4	40-49	
5	50-59	
6	60-70	#68 is Synch Symbol
7	71-80	
8	81-90	
9	91-100	
10	101-110	
11	111-120	
12	121-130	
13	131-141	#137 is Synch Symbol
14	142-151	
15	152-161	
16	162-171	
17	172-181	
18	182-191	
19	192-201	
20	202-212	#206 is Synch Symbol
21	213-222	
22	223-232	
23	233-242	
24	243-252	
25	253-262	
26	263-272	
27	273-283	#275 is Inverse Synch Symbol
28	284-293	
29	294-303	
30	304-313	
31	314-323	
32	324-333	
33	334-344	#344 is Synch Symbol

Table I.1/G.992.1 – Subframe (downstream)

I.4.3.4 Reduced overhead framing with merged fast and sync bytes (modifies 7.4.3.2)

In S=1/2n framing mode (see §I.4.9), there are n Sync bytes per symbol time. The contents of the Sync bytes is the same as in regular framing except that it repeats at n times the rate causing the superframe to be 68/n symbols in length. The contents of the sync bytes are shown in Table 7-6/G.992.1. In S=1/2n framing mode, "Frame Number" in column 1 in Table 7-6/G.992.1 is replaced by "Sync Byte Index Number".

As a result of the increase in superframe rate, the superframe contents is carried more frequently. For the case when N=2, the EOC and AOC bandwidth doubles, thereby transferring actual messages at twice the rate. The CRC byte is carried twice as frequently and therefore the maximum error rate rises from just over 58 per second to 117 per second. Where the duration of an error condition is measured, this needs to be taken into consideration. The indicator bits are also sent twice as often, which needs to be taken into consideration for statistics collection.

I.4.4 Dual Bitmapping and Rate Conversion (replaces 7.15)

The functions of the rate converter (see I.4.4.2), tone ordering (see I.4.6), constellation encoding, and gain scaling shall use one of two bitmaps stored in the ATU. This method is called the dual bitmap.

I.4.4.1 Dual Bitmap (new)

The Dual Bitmap method has individual bit rates under the FEXT and NEXT noise, and this needs an additional bit and gain table, $\{b_i, g_i\}$, and ordered bit table, b'_i , for the tone ordering. The dual bitmaps are switched synchronized with the sliding window pattern of NEXT/FEXT symbols. The number of bits and the relative gains to be used for every tone are calculated in the bit loading algorithm during the initialization sequence, and transmitted in R-B&G.

I.4.4.2 Rate Converter (new)

The rate converter buffering changes the data frame boundaries between the reference points B and C according to Bitmap- F_R , Bitmap- N_R and the Sliding Window. Two independent rate converters are prepared for fast data and interleaved data. The amount of fast and interleaved data in Bitmap- F_R and Bitmap- N_R shall be calculated with the following formulae and illustrated in Figure I.12:

If $t_{Rf} \le n_{Rmax}$:

$$n_{Rf} = t_{Rf}$$

$$n_{Ri} = n_R - n_{Rf}$$

$$f_{Rf} = t_{Rf}$$

$$f_{Ri} = f_R - f_{Rf}$$

If $t_{Rf} > n_{Rmax}$:

$$n_{Rf} = n_{R \max}$$

$$n_{Ri} = 0$$

$$f_{Rf} = \begin{cases} f_{Rf4} = \left\lceil \frac{t_{Rf} \times 10 - n_{Rf} \times 6}{4} \right\rceil$$

$$f_{Rf3} = \left\lceil \frac{t_{Rf} \times 10 - n_{Rf} \times 7}{3} \right\rceil$$

$$f_{Ri} = \begin{cases} f_{Ri4} = f_R = f_{Rf4} \\ f_{Ri3} = f_R - f_{Rf3} \end{cases}$$

Where:

^t Rf	is the number of allocated bits in one frame for fast bytes at the reference point B.
t _{Ri}	is the number of allocated bits for interleaved bytes at the reference point B.
f_{Rf} and n_{Rf}	are the numbers of fast bits in Bitmap- F_R and Bitmap- N_R , respectively.
f _{Rf3}	is the number of fast bits in Bitmap-F _R if the subframe (see I.4.3.3) contains 3 Bitmap-F _R except for
f _{Rf4}	synch symbols. is the number of fast bits in Bitmap- F_R if the subframe contains 4 Bitmap- F_R except for synch
f _{Ri} and n _{Ri} n _R	symbols. are the numbers of interleaved bits in Bitmap- F_R and Bitmap- N_R , respectively. is the number of total bits in Bitmap- N_R , which is specified in the B&G tables.

During FEXT Bitmap mode, n_{Rf} and n_{Ri} are zero.

To convert the bit rate to be a multiple of 32 kbit/s, the dummy bits for fast data are inserted to the tail of each subframe, and the dummy bits for interleaved data are inserted to the end of the Hyperframe. The number of the dummy bits shall be as follows:

If $t_{Rf} \le n_{Rmax}$:

$$dummy_{Rf} = 0$$

$$dummy_{Ri} = (f_{Ri} \times 126 + n_{Ri} \times 214) - t_{Ri} \times 340$$

If $t_{Rf} > n_{Rmax}$:

$$dummy_{Rf4} = (f_{Rf} \times 4 + n_{Rf} \times 6) - t_{Rf} \times 10$$

$$dummy_{Rf3} = (f_{Rf} \times 3 + n_{Rf} \times 7) - t_{Rf} \times 10$$

$$dummy_{Ri} = (f_{Ri4} \times 96 + f_{Ri3} \times 30) - t_{Ri} \times 340$$

If the fast data buffer uses single latency only, additional dummy bits are inserted at the tail of each FEXT symbol in the 4 Bitmap- F_R constructed subframe. The number of additional dummy bits inserted at the tail of each FEXT symbol shall be as follows:

$$dummy_{SRf} = f_{Rf3} - f_{Rf4}$$

The receiver shall determine Bitmap- F_R and Bitmap- N_R so that $dummy_{Ri}$ is less than 126, $dummy_{Rf4}$ is less than 4 and $dummy_{Rf3}$ is less than 3 in the initialization sequence. At the receiver, the inserted dummy bits shall be removed.

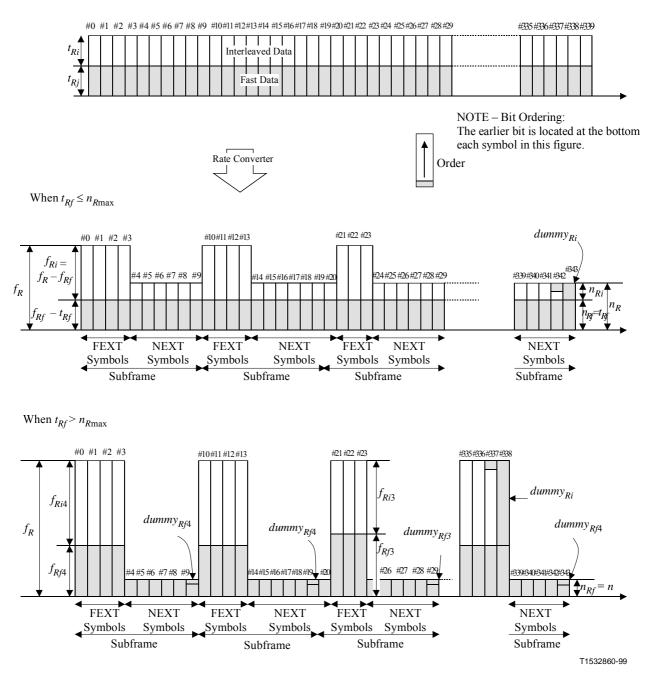


Figure I.12/G.992.1 – Bit distribution for Rate Converter under Dual latency and Dual Bitmap mode

I.4.5 FEXT Bitmapping (replaces 7.16)

The FEXT Bitmapping mode uses the Dual Bitmapping technique (I.4.4) to transmit data only during FEXT. The ATU-C shall transmit only the pilot tone during the $NEXT_R$ symbol. The ATU-R disables Bitmap-N_C and shall not transmit any signal during the $NEXT_C$ symbol (see Figures I.10 and I.16).

The Dual versus FEXT bitmapping mode is selected during G.994.1 using bit "DBM" (see 10.2 and 10.3).

I.4.6 Tone Ordering (replacement for 7.7)

A DMT time-domain signal has a high peak-to-average ratio (its amplitude distribution is almost Gaussian), and large values may be clipped by the digital-to-analogue converter. The error signal caused by clipping can be considered as an additive negative impulse for the time sample that was clipped. The clipping error power is almost equally distributed across all tones in the symbol in which clipping occurs. Clipping is therefore most likely to cause errors on those tones

that, in anticipation of a higher received SNR, have been assigned the largest number of bits (and therefore have the densest constellations). These occasional errors can be reliably corrected by the FEC coding if the tones with the largest number of bits have been assigned to the interleave buffer.

The numbers of bits and the relative gains in two bitmaps to be used for every tone are calculated in ATU-R receiver, and sent back to ATU-C according to a defined protocol (see 10.9.14). The pairs of numbers are typically stored, in ascending order of frequency or tone numbers *i*, in bit and gain tables for Bitmap- F_R and Bitmap- N_R .

For Bitmap- F_R , the "tone-ordered" encoding shall first assign f_{Rf} bits from the rate converter (see I.4.4.2) to the tones with the smallest number of bits assigned to them, and the remaining f_{Ri} bits to the remaining tones. For Bitmap- N_R , it shall first assign n_{Rf} bits from the rate converter to the tones with the smallest number of bits assigned to them, and the remaining n_{Ri} bits to the remaining tones.

All tones shall be encoded with the number of bits assigned to them; one tone in each bitmap may therefore have a mixture of bits from the fast and interleaved buffers.

The ordered bit tables b'_{iF} and b'_{iN} shall be based on the original bit tables b_{iF} and b_{iN} as follows:

For k = 0 to $N_{downmax}$ {

From the bit table, find the set of all *i* with the number of bits per tone $b_i = k$

Assign b_i to the ordered bit allocation table in ascending order of i

```
}
```

Two ordered bit tables for Bitmap- F_R and Bitmap- N_R shall be prepared. A complementary de-ordering procedure should be performed in ATU-R receiver. It is not necessary, however, to send the results of the ordering process to the receiver because the bit tables F_R and N_R were originally generated in ATU-R, and therefore those tables have all the information necessary to perform the de-ordering.

I.4.7 Modulation (pertains to 7.11)

I.4.7.1 Inverse Synchronization Symbol (replaces 7.11.4)

Except for the pilot tone, Inverse Synchronization symbol shall be generated from a tone-by-tone 180 degree phase reversal of Synchronization symbol (i.e. + maps to -, and - maps to +, for each of the 4-QAM signal constellation).

I.4.7.2 Data subcarriers (modifies 7.11.1.1)

The channel analysis signal defined in 10.6.6 allows for a maximum of NSCds-1 carriers (at frequencies $n\Delta f$, n = 1 to NSCds-1) to be used.

I.4.7.3 Nyquist frequency (modifies 7.11.1.3)

The carrier at the Nyquist frequency (#NSCds) shall not be used for user data and shall be real valued; other possible uses are for further study.

I.4.7.4 Modulation by the inverse discrete Fourier transform (replaces 7.11.2)

The modulating transform defines the relationship between the 2*NSCds real values x_n and the Z_i :

$$x_n = \sum_{i=0}^{2^* NSC^{-1}} \exp\left(\frac{j\pi ni}{NSC}\right) Z_i \quad \text{for } n = 0 \text{ to } 2^* NSC^{-1}$$
(7-21)

The value of NSCds shall be 512 for this Annex.

The constellation encoder and gain scaling generate only NSCds-1 complex values of Z_i . In order to generate real values of x_n , the input values (NSCds-1 complex values plus zero at DC and one real value for Nyquist if used) shall be augmented so that the vector Z has Hermitian symmetry. That is,

 $Z_i = \operatorname{conj} \left(Z'_{2*NSCds-i} \right) \quad \text{for } i = \operatorname{NSCds+1} \text{ to } 2*\operatorname{NSCds-1}$ (7-22)

I.4.7.5 Synchronization symbol (modifies 7.11.3)

The synchronization symbol permits recovery of the frame boundary after micro-interruptions that might otherwise force retraining.

The data symbol rate, $f_{symb} = 4$ kHz, the carrier separation, $\Delta f = 4.3125$ kHz, and the IDFT size, N = 2*NSCds, are such that a cyclic prefix of 15.625%*NSCds samples could be used. That is, when NSCds = 256, there are 40 samples in the cyclic prefix.

$$(512+40) \times 4.0 = 512 \times 4.3125 = 2208 \tag{7-23}$$

The cyclic prefix shall, however, be shortened to 12.5%*NSCds samples, and a synchronization symbol (with a nominal length of NSCds*2.125 samples) is inserted after every 68 data symbols. That is,

$$(2 + 0.125)$$
*NSCds × 69 = $(2 + 0.15625)$ *NSCds × 68(7-24)

The data pattern used in the synchronization symbol shall be the pseudo-random sequence PRD, $(d_n, \text{ for } n = 1 \text{ to } 2*\text{NSCds})$ defined by:

$$d_n = 1$$
 for $n = 1$ to 9 (7-25)
 $d_n = d_{n-4} \oplus d_{n-9}$ for $n = 10$ to 2*NSCds (7-26)

The first pair of bits (d_1 and d_2) shall be used for the DC and Nyquist subcarriers (the power assigned to them is zero, so the bits are effectively ignored); the first and second bits of subsequent pairs are then used to define the X_i and Y_i for i = 1 to NSCds-1 as shown in Table 7-13.

The period of the PRD is only 511 bits, so d_{n+511} is equal to d_n . The d_1 - d_9 shall be re-initialized for each synchronization symbol, so each symbol uses the same data.

The two bits that modulate the pilot carrier, shall be overwritten by $\{0,0\}$: generating the $\{+,+\}$ constellation.

The minimum set of subcarriers to be used is the set used for data transmission (i.e. those for which $b_i > 0$); subcarriers for which $b_i = 0$ may be used at a reduced PSD as defined in transmit PSD paragraphs of Annexes A, B and C. The data modulated onto each subcarrier shall be as defined above; it shall not depend on which subcarriers are used.

I.4.7.6 Cyclic prefix (replaces 7.12)

The last 12.5%*NSCds samples of the output of the IDFT (x_n for n = 2*NSCds-0.125*NSCds to 2*NSCds-1) shall be prepended to the block of 2*NSCds samples and read out to the digital-to-analogue converter (DAC) in sequence. For example, when NSCds=256, the subscripts, n, of the DAC samples in sequence are 480 ... 511, 0 ... 511.

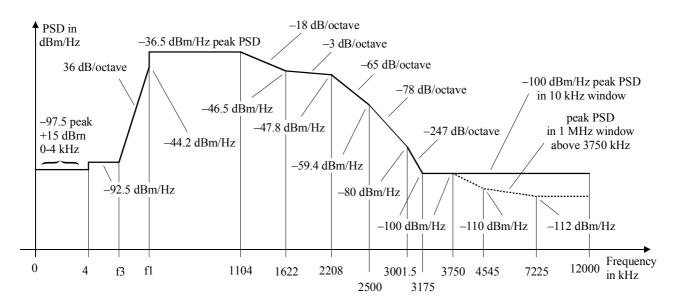
The cyclic prefix shall be used for all symbols beginning with the C-RATES1 segment of the initialization sequence, as defined in 10.6.2.

I.4.8 ATU-C Downstream transmit spectral masks (replaces 7.14)

The downstream spectral masks of Annex I-EU are as specified in this section. When C-MSG1 bit 16 is 0, the PSD mask as specified in § I.4.8.1 shall be used. When C-MSG1 bit 16 is 1, the PSD mask as specified in § I.4.8.2 shall be used.

I.4.8.1 Downstream non-overlapped PSD mask definition

The non-overlapped PSD masks are defined with absolute peak values in Figure I.13. The low frequency stop band is defined for frequencies below f1 kHz (tone n1); the high frequency stop band is defined at frequencies greater than 2208 kHz (tone 512). The in-band region of these PSD masks is the frequency band from f1 kHz to 2208 kHz.



Frequency band f (kHz)	Equation for line (dBm/Hz)
0 < f < 4	-97.5
4 < f < f3	-92.5
f3 < f < f1	$-92.5 + 36 \cdot \log 2(f/f3)$
f1 < f < 1104	-36.5
$1104 \le f \le 1622$	-36.5 - 18.0*log2(f/1104)
1622 < f < 2208	-46.5 - 3.0*log2(f/1622)
2208 < f < 2500	-47.8 - 65*log2(f/2208)
2500 < f < 3001.5	-59.4 - 78*log2(f/2500)
3001.5 < f < 3175	-80 - 247*log2(f/3001.5)
3925 < f < 12000	-100

Frequency (kHz)	PSD level (dBm/Hz)	Measurement BW
0	-97.5	100 Hz
4	-97.5	100 Hz
4	-92.5	100 Hz
f3	-92.5	10 kHz
fl	-44.2	10 kHz
fl	-36.5	10 kHz
1104	-36.5	10 kHz
1622	-46.5	10 kHz
2208	-47.8	10 kHz
2500	-59.4	10 kHz
3001.5	-80	10 kHz
3175	-100	10 kHz
12000	-100	10 kHz

Additionally the PSD masks shall satisfy the following requirements:

Frequency (kHz)	PSD level (dBm/Hz)	Measurement BW
3750	-100	1 MHz
4545	-110	1 MHz
7225	-112	1 MHz
12000	-112	1 MHz

The corner frequencies f1 and f3 depend on the associated upstream PSD mask used, see §I.5.6) and are defined as follows:

Mask designator (DS-mm)	Associated upstream mask	f1 (kHz)	f3 (kHz)
DS-32	EU-32	138	54.45
DS-36	EU-36	155.25	61.26
DS-40	EU-40	172.5	68.06
DS-44	EU-44	189.75	74.87
DS-48	EU-48	207	81.67
DS-52	EU-52	224.25	88.48
DS-56	EU-56	241.5	95.29
DS-60	EU-60	258.75	102.09
DS-64	EU-64	276	108.9

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. The breakpoints in the tables shall be connected by linear straight lines on a dB/log(f) plot.

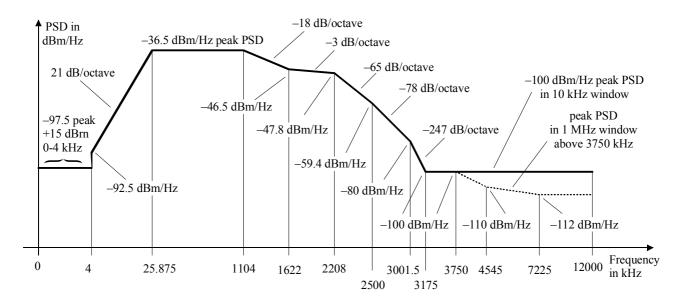
- NOTE 3 MBW specifies the Measurement Bandwidth. The MBW specified for a certain breakpoint with frequency fi is applicable for all frequencies satisfying fi \leq fj, where fj is the frequency of the next specified breakpoint.
- NOTE 4 The power in a 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency i.e. power in the [f, f + 1 MHz] window shall conform to the specification at frequency f.
- 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.

Figure I.13: Non-overlapped Downstream Channel PSD Masks.

Spectral Shaping of the In-Band Region defined in I.4.8.3 and Transmit Signals with Limited Transmit Power defined in I.4.8.4 shall be applied.

I.4.8.2 Downstream Overlapped PSD mask definition

The overlapped PSD mask is defined with absolute peak values in Figure I.14. The low frequency stop band is defined for frequencies below 25.875 kHz (tone 6); the high frequency stop band is defined at frequencies greater than 2208 kHz (tone 512). The in-band region of this PSD mask is the frequency band from 25.875 kHz to 2208 kHz.



Frequency band f (kHz)	Equation for line (dBm/Hz)
0 < f < 4	-97.5
4 < f < 25.875	$-92.5 + 21*\log 2(f/4)$
25.875 < f < 1104	-36.5
1104 < f < 1622	-36.5 - 18.0*log2(f/1104)
1622 < f < 2208	-46.5 - 3.0*log2(f/1622)
2208 < f < 2500	$-47.8 - 65*\log 2(f/2208)$
2500 < f < 3001.5	-59.4 - 78*log2(f/2500)
3001.5 < f < 3175	-80 - 247*log2(f/3001.5)
3925 < f < 12000	-100

Frequency (kHz)	PSD level (dBm/Hz)	Measurement Bandwidth
0	-97.5	100 Hz
4	-97.5	100 Hz
4	-92.5	100 Hz
25.875	-36.5	10 kHz
1104	-36.5	10 kHz
1622	-46.5	10 kHz
2208	-47.8	10 kHz
2500	-59.4	10 kHz
3001.5	-80	10 kHz
3175	-100	10 kHz
12000	-100	10 kHz

Additionally, the PSD mask shall be satisfying following requirements:

Frequency (kHz)	PSD level (dBm/Hz)	Measurement Bandwidth
3750	-100	1 MHz
4545	-110	1 MHz
7225	-112	1 MHz
12000	-112	1 MHz

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. The breakpoints in the tables shall be connected by linear straight lines on a dB/log(f) plot.

NOTE 3 - MBW specifies the Measurement Bandwidth. The MBW specified for a certain breakpoint with

frequency fi is applicable for all frequencies satisfying $fi < f \le fj$, where fj is the frequency of the next specified breakpoint.

- NOTE 4 The power in a 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency i.e. power in the [f, f + 1 MHz] window shall conform to the specification at frequency f.
- 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.

Figure I.14: Non-overlapped Downstream Channel PSD Mask.

I.4.8.3 Spectral Shaping of In-Band Region of PSD Spectrum

In order to shape the ATU-C PSD, frequency dependent gains, called spectral shaping values (ssv_i), shall be applied on each tones during initialisation and showtime. The ssv_i values shall be represented with 1 bit before and 10 bits after the decimal point.

Table I.2 defines the corner points for the nominal PSD shape of the inband region as gain in dB, i.e log_ssv_i . Log_ssv_i on other tones shall be linearly interpolated between corner points on a logarithmic scale for the gain (dB) and a linear scale for the frequency (Hz). Note that the corner points defined in Table I.2 are relative values. Table I.3 defines the similar corner points for the overlapped spectrum.

The spectral shaping values shall be converted from logarithmic scale (log_ssv_i , dB values) to linear ssv_i values according to:

$$ssv_i = \frac{Round\left(1024 \times 10^{\frac{\log_s ssv_i}{20}}\right)}{1024}$$

These points are not passed at initialization for the nominal PSD shape but are provided here for reference. However, for additional spectral shaping (see I.4.8.5), parameters are passed during G.994.1.

The combined accuracy of the process of linear interpolation of the log_ssvi values and the process of conversion to linear ssv_i values shall be strictly less than one half lsb of the 10 bit after the decimal point format of the linear ssvi values. No error shall be introduced when log_ssv_i equals 0dB or is interpolated between log_ssv_i values, which equal 0dB.

- NOTE 1: The above definition ensures that the maximum deviation between ssv_i values used by transmitter and receiver is one lsb.
- NOTE 2: The above needs an accuracy that is strictly < 1/2 lsb. An accuracy of = 1/2 lsb, will lead to inaccurate results.

Tone Index	$Log_ssv_i(dB)$	Comments	
nl	0	fl kHz defines the beginning of the inband region. No shaping is applied in the	
		low stop band.	
256	0	1104 kHz	
376	-10	1622 kHz (-10 = -50 - Nominal_PSD_lowband)	
511	-11.3	2208 kHz (-11.3 = -51.3 - Nominal_PSD_lowband)	

Tone Index	$Log_ssv_i(dB)$	Comments	
6	0	25.875 kHz defines the beginning of the inband region. No shaping is applied	
		in the low stop band.	
256	0	1104 kHz	
376	-10	1622 kHz (-10 = -50 - Nominal_PSD_lowband)	
511	-11.3	2208 kHz (-11.3 = -51.3 - Nominal_PSD_lowband)	

Table I.3: Corner points for the overlapped nominal in-band PSD shape

The absolute values of the transmit PSD are obtained by scaling the relative shaping values with a NOMINAL_PSD_lowband, defined for the lower in-band frequencies. Note that the nominal in-band transmit PSD is frequency dependent. The NOMINAL_PSD_lowband is -40 dBm/Hz (below 1104 kHz) for both the overlapped and non-overlapped spectra.

NOTE 3: In-band PSD spectral shaping is applied prior to the IFFT.

NOTE 4: The value of MAXNOMATPds may be limited by regional regulations.

I.4.8.4 Transmit Signals with Limited Transmit Power

For cases where the transmit signal must be limited to a maximum aggregate transmit power (e.g. $ATP_{dsmax} = +20$ dBm), then

- e) During initialization the PSD transmit level is specified as an offset from the nominal value, i.e. (Nominal_PSD_lowband + ssvi x power cutback) dB, and all values of gi = 1 for the offset value x and power cutback. The same value of offset x is used for both overlapped and non-overlapped cases. The value of x shall be the greater of 0 dB and (21.3 ATPdsmax) dB. For ATPdsmax = 20 dBm, the corresponding value of x shall be 1.3 dB.
- b) If bi>0, then valid range for gi is [-14.5 to +2.5+x] (dB);
 If bi>0, then gi shall be in the [g_{sync} 2.5 to g_{sync} + 2.5] (dB) range;
 If bi=0, then gi shall be equal to 0 (linear) or in the [-14.5 to g_{sync}] (dB) range;
 For G.992.1 annex I-EU, g_{sync} <= x dB

The g_i values shall be constrainted by following relation:

Constraint on g _i values	$\sum_{i=6}^{511} ssv_i^2 * g_i^2 \le \sum_{i=6}^{511} ssv_i^2$
-------------------------------------	---

I.4.8.5 Additional inband spectral shaping

An ATU-R may request additional downstream inband spectral shaping by passing parameters to the ATU-C in a G.994.1 MP, or MS message. The ATU-C may select additional downstream inband spectral shaping by passing parameters to the ATU-R in a G.994.1 MS message. Within the framework of G.994.1, the ATU-C has the ability to make the final decision on the downstream inband PSD shape to be used.

The additional inband spectral shaping parameters are listed in I.7.2.2 and defined in I.7.3. If the Additional inband spectral shaping Spar(2) bit is set to ONE in Table I.7.4, its associated Npar(3) octets in Tables I.7.4.1 to I.7.4.1.5 define the inband spectral shape. If the additional inband spectral shaping Spar(2) bit is set to ZERO, its associated Npar(3) octets are not transmitted and the nominal inband PSD shape defined in I.4.8.3 shall be used. These Npar(3) octets define the downstream PSD levels in the low band (between f1 and 1104 kHz), at 1622 kHz and at 2208 kHz. The PSD levels between 1104 kHz and 1622 kHz, and between 1622 kHz and 2208 kHz are linearly interpolated in log scale. The defined values are the PSD level in dB below the NOMINAL_PSD_lowband of -40dBm/Hz. For example, if all three values are set to 20 dB, the result will be a flat PSD of -60dBm/Hz. If the three values are set to 2 dB, 12 dB and 15.5 dB, the result is the PSD defined in I.4.8.1 reduced by 2dB. In order not to violate the PSD mask defined in I.4.8.1, the second value shall be no less than 10 dB and the third value shall be no less than 11.3 dB.

I.4.8.6 Egress control

G.992.1 Annex I-EU equipment shall be able to reduce the PSD below -80 dBm/Hz for the Amateur radio band between 1.81 MHz and 2.00 MHz. The ATU-C may apply additional spectral shaping as described in I.4.8.5 to help achieve this requirement.

I.4.9 Support of higher downstream bit rates with S = 1/2n (replaces 7.6.4)

With a rate of 4000 data frames per second and a maximum of 255 bytes (maximum RS codeword size) per data frame, the ADSL downstream line rate is limited to approximately 8 Mbit/s per latency path. The line rate limit can be increased beyond this for the interleaved path by mapping 2n RS codewords into one FEC data frame (i.e. by using S = 1/2n in the interleaved path). S = 1/2n shall be used in the downstream direction only over bearer channel AS0.

For a selected value of $n \ge 1$, the K_I data bytes per interleaved mux data frame shall be packed into 2n RS codewords, split into n equal parts, each consisting of 2 consecutive RS codewords. This forces rate adaptation to occur in 32n kbit/s increments. Each of the n parts of the data frame shall begin with a sync byte and shall obey the rules defined in Table I.4 for insertion of dummy bytes. The smallest value of n that can support the K_I data bytes shall be used.

Support of S = 1/2 (i.e., n=1) and S = 1/4 (i.e., n=2) is mandatory.

The resulting data frame structure shall be as shown in Figure I.15.

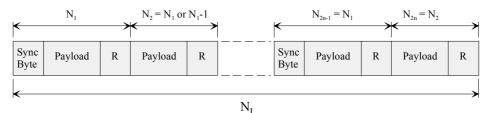


Figure I.15 – Data frame for S = 1/2n mode

When K_I is divisible by 2n, the 2n codewords have the same length $N_{2i-1} = N_{2i} = (K_I/2n + R_I)$ for i = 1 to n, otherwise the odd numbered codewords are equal and are one byte longer than the even numbered codewords, i.e. $N_{2i-1} = (K_I + n)/2n + R_I$ bytes, and $N_{2i} = (K_I - n)/2n + R_I$ bytes for i = 1 to n. For the FEC output data frame, $N_I = \sum_{i=1}^{n} N_i$, with $N_I < 512n - 1$ bytes.

The convolutional interleaver requires all codewords to have the same odd length. To achieve the odd codeword length, insertion of dummy (not transmitted) bytes may be required. For S = 1/2n, the dummy byte addition to the odd numbered and/or even numbered codewords at the input of the interleaver shall be as in Table I.4.

N _{2i-1}	N _{2i}	Dummy Byte Insertion Action	
Odd	Odd	No action	
Even	Even	Add one dummy byte at the beginning of all codewords	
Odd	Even	Add one dummy byte at the beginning of each even numbered codeword	
Even	Odd	Add one dummy byte at the beginning of each odd numbered codeword and two dummy bytes at the beginning of each even numbered codeword [the de-interleaver shall insert one dummy byte into the de-interleaver matrix on the first byte and the $(D + 1)$ th byte of the corresponding codeword to make the addressing work properly]	

I.5 ATU-R Functional Characteristics (pertains to clause 8)

I.5.1 Framing (pertains to 8.4)

I.5.1.1 Superframe structure (replaces 8.4.1.1)

The superframe structure of ATU-R transmitter is identical to that of ATU-C transmitter, as specified in I.4.3.1.

I.5.1.2 Hyperframe structure (replaces 8.4.1.3)

The hyperframe structure of ATU-R transmitter is functionally similar to that of ATU-C transmitter, except that the inverse synch symbol is used in the 1st superframe (SPF#0) (see Figure I.16). The hyperframe is composed of 345 DMT symbols, numbered from 0 to 344. Each symbol is under $FEXT_C$ or $NEXT_C$ duration (see I.5.3), and the following numerical formula gives the information which duration N_{dmt}-th DMT symbol belongs to at ATU-R transmitter (see Figure I.17).

For $N_{dmt} = 0, 1, ..., 344$ $S = 272 \times N_{dmt} \mod 2760$ if { (S > a) and (S + 271 < a + b) } then FEXT_C symbol else then NEXT_C symbol where a = 1315, b = 1293

128 DMT symbols are allocated in the FEXT_{C} duration, and 217 DMT symbols are allocated in the NEXT_{C} duration. The symbols are composed of:

FEXT _C symbol:		
Number of symbol using Bitmap-F _C	= 126	
Number of synch symbol	= 1	
Number of inverse synch symbol	= 1	
NEXT _C symbol:		
Number of symbol using Bitmap-N $_{\rm C}$	= 214	
Number of synch symbol	= 3	

During FEXT Bitmapping mode, the ATU-R shall not transmit any signal.

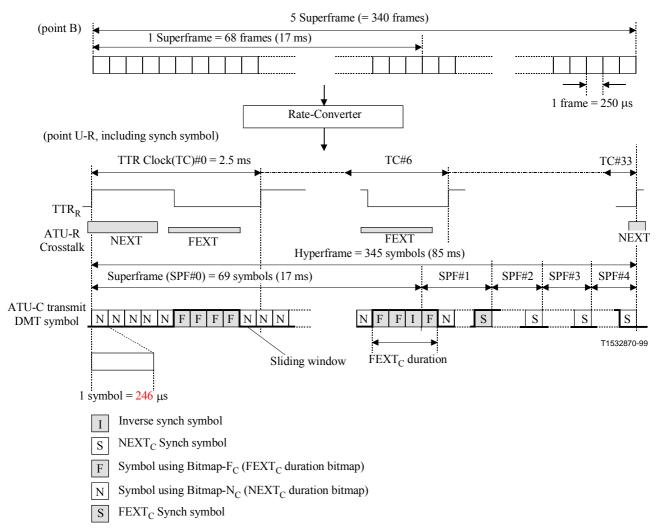


Figure I.16/G.992.1 – Hyperframe structure for upstream

ттр	
TTR _R	
0	0 1 2 3 4 5 6 7 8 9
1	10 11 12 13 14 15 16 17 18 19
2	20 21 22 23 24 25 26 27 28 29
3	30 31 32 33 34 35 36 37 38 39 40
4	41 42 43 44 45 46 47 48 49 50
5	51 52 53 54 55 56 57 58 59 60
6	61 62 63 64 65 66 67 ISS 69 70
7	71 72 73 74 75 76 77 78 79 80
8	81 82 83 84 85 86 87 88 89 90
9	91 92 93 94 95 96 97 98 99 100 101
10	101 102 103 104 105 06 107 108 109 110 111
11	112 113 114 115 1 6 117 118 119 120 21
12	122 123 124 125 126 127 128 129 130 131
13	132 133 134 135 136 SS 138 139 140 141
14	142 143 144 145 146 147 148 149 150 151
15	152 153 154 155 156 157 158 159 160 161
16	162 163 164 165 166 167 168 169 170 171 172
17	173 174 175 176 77 178 179 180 181 82
18	183 184 185 186 187 188 189 190 191 92
19	193 194 195 196 197 198 199 200 201 202
20	203 204 205 SS 207 208 209 210 211 212
21	213 214 215 216 217 218 219 220 221 222
22	223 224 225 226 227 228 229 230 231 232
23	233 234 235 236 237 238 239 240 241 242 243
24	244 245 246 247 248 249 250 251 252 253
25	254 255 256 257 258 259 260 260 262 263
26	264 265 266 267 268 269 270 271 272 273
27	274 SS 276 277 278 279 280 281 282 283
28	284 285 286 287 288 289 290 291 292 293
29	294 295 296 297 298 299 300 301 302 303
30	304 305 306 307 308 309 310 311 312 313 314
31	<u>315</u> <u>316</u> <u>317</u> <u>318</u> <u>319</u> <u>320</u> <u>321</u> <u>322</u> <u>323</u> <u>324</u>
32	325 326 327 328 329 330 331 332 333 334
33	335 336 337 338 339 340 341 342 343 S5
	ISS Inverse synch symbol SS FEXT _R Synch symbol SS NEXT _R synch symbol
	FEXT _R data symbol NEXT _R data symbol T1535340-00

Figure I.17/G.992.1 – Symbol pattern in a hyperframe with cyclic prefix – Upstream

I.5.1.3 Subframe structure (replaces 8.4.1.4)

A subframe is 10 consecutive DMT symbols (except for synch symbols) as shown in Table I.5. The 34 subframes form a hyperframe.

Subframe No.	DMT symbol No.	Note
0	0-9	
1	10-19	
2	20-29	
3	30-39	
4	40-49	
5	50-59	
6	60-70	#68 is Inverse Synch Symbol
7	71-80	
8	81-90	
9	91-100	
10	101-110	
11	111-120	
12	121-130	
13	131-141	#137 is Synch Symbol
14	142-151	
15	152-161	
16	162-171	
17	172-181	
18	182-191	
19	192-201	
20	202-212	#206 is Synch Symbol
21	213-222	
22	223-232	
23	233-242	
24	243-252	
25	253-262	
26	263-272	
27	273-283	#275 is Synch Symbol
28	284-293	
29	294-303	
30	304-313	
31	314-323	
32	324-333	
33	334-344	#344 is Synch Symbol

Table I.5/G.992.1 – Subframe (upstream)

I.5.2 Dual Bitmapping and rate conversion (replaces 8.15)

The function of the rate converter (see I.5.2.2), tone ordering (see I.5.4), constellation encoding, and gain scaling shall use one of two bitmaps stored in the ATU. This method is called the dual bitmap.

I.5.2.1 Dual Bitmap (new)

The Dual Bitmap switching shall be the same as for the downstream data, specified in I.4.4.1. The number of bits and the relative gains to be used for every tone are calculated in the bit loading algorithm during the initialization sequence, and transmitted in C-B&G.

I.5.2.2 Rate Converter (new)

The rate converter buffering changes the data frame boundaries between the reference points B and C according to Bitmap- F_C , Bitmap- N_C and the Sliding Window. Two independent rate converters are prepared for fast data and interleaved data. The amounts of fast and interleaved data in Bitmap- F_C and Bitmap- N_C shall be calculated in the following formulae:

If $t_{Cf} \le n_{Cmax}$:

$$n_{Cf} = t_{Cf}$$
$$n_{Ci} = n_C - n_{Cf}$$
$$f_{Cf} = t_{Cf}$$
$$f_{Ci} = f_C - f_{Cf}$$

If $t_{Cf} > n_{Cmax}$:

$$n_{Cf} = n_{C \max}$$

$$n_{Ci} = 0$$

$$f_{Cf4} = \left[\frac{t_{Cf} \times 10 - n_{Cf} \times 6}{4} \right]$$

$$f_{Cf3} = \left[\frac{t_{Cf} \times 10 - n_{Cf} \times 7}{3} \right]$$

$$f_{Ci} = \begin{cases} f_{Ci4} = f_C - f_{C4} \\ f_{Ci3} = f_C - f_{Cf3} \end{cases}$$

Where:

^t Cf	is the number of allocated bits in one frame for fast bytes at the reference point B.
^t Ci	is the number of allocated bits for interleaved bytes at the reference point B.
f_{Cf} and n_{Cf}	are the numbers of fast bits in Bitmap- F_C and Bitmap- N_C , respectively.
f _{Cf3}	is the number of fast bits in Bitmap-F _C if the subframe (see I.5.1.3) contains 3 Bitmap-F _C except
f _{Cf4}	for synch symbols. is the number of fast bits in Bitmap- F_C if the subframe contains 4 Bitmap- F_C except for synch
f_{Ci} and n_{Ci}	symbols. are the numbers of interleaved bits in Bitmap-F _C and Bitmap-N _C , respectively.
ⁿ C	is the number of total bits in Bitmap-N _C , which is specified in the B&G tables.

During FEXT Bitmap mode, n_{Cf} and n_{Ci} are zero.

To convert the bit rate to be a multiple of 32 kbit/s, the dummy bits for fast data are inserted to the tail of each subframe, and the dummy bits for interleaved data are inserted to the end of the Hyperframe. The number of the dummy bits shall be as follows:

If $t_{Cf} \le n_{Cmax}$:

$$dummy_{Cf} = 0$$
$$dummy_{Ci} = (f_{Ci} \times 126 + n_{Ci} \times 214) - t_{Ci} \times 340$$

If $t_{Cf} > n_{Cmax}$:

$$dummy_{Cf 4} = (f_{Cf} \times 4 + n_{Cf} \times 6) - t_{Cf} \times 10$$

$$dummy_{Cf 3} = (f_{Cf} \times 3 + n_{Cf} \times 7) - t_{Cf} \times 10$$

$$dummy_{Ci} = (f_{Ci4} \times 96 + f_{Ci3} \times 30) - t_{Ci} \times 340$$

,

If the fast data buffer uses single latency only, additional dummy bits are inserted at the tail of each FEXT symbol in the 4 Bitmap-F_C constructed subframe. The number of additional dummy bits inserted at the tail of each FEXT symbol shall be as follows:

$$dummy_{SCf} = f_{Cf3} - f_{Cf4}$$

The receiver shall determine Bitmap-F_C and Bitmap-N_C so that $dummy_{Ci}$ is less than 126, $dummy_{Cf4}$ is less than 4 and $dummy_{Cf3}$ is less than 3 in the initialization sequence. At the receiver, the inserted dummy bits shall be removed.

I.5.3 FEXT Bitmapping (replaces 8.16)

The FEXT Bitmapping mode uses the Dual Bitmapping technique (I.4.4) to transmit data only during FEXT. The ATU-C shall transmit only the pilot tone during the NEXT_R symbol. The ATU-R disables Bitmap-N_C and shall not transmit any signal during the NEXT_C symbol (see Figures I.10 and I.16).

The Dual versus FEXT bitmapping mode is selected during G.994.1 using bit "DBM" (see 10.2 and 10.3).

I.5.4 Tone Ordering (pertains to 8.7)

The tone ordering algorithm shall be the same as for the downstream data, specified in I.4.4.

For Bitmap-F_C, the "tone-ordered" encoding shall first assign f_{Cf} bits from the rate converter (see I.5.2.2) to the tones with the smallest number of bits assigned to them, and the remaining f_{Ci} bits to the remaining tones. For Bitmap-N_C, it shall first assign n_{Cf} bits from the rate converter to the tones with the smallest number of bits assigned to them, and the remaining n_{Ci} bits to the remaining tones. Two ordered bit tables for Bitmap-F_C and Bitmap-N_C shall be prepared.

I.5.5 Modulation (pertains to 8.11)

I.5.5.1 Inverse synchronization symbol (replaces 8.11.4)

Inverse Synchronization symbol shall be generated from a tone-by-tone 180 degree phase reversal of Synchronization symbol (i.e. + maps to -, and - maps to +, for each of the 4-QAM signal constellation).

I.5.5.2 Gain scaling in synchronization symbol (new)

At initialization time, the sync symbol reference transmit PSD level shall be set at the nominal PSD level +10log(g_{sync}^2) dBm/Hz, with g_{sync}^2 defined as the average g_i^2 value over the used (i.e. $b_i > 0$) subcarriers in the NEXT or FEXT bitmap, whichever results in the highest average gain. The sync symbol reference transmit PSD shall not be updated with used subcarrier gain changes during SHOWTIME.

I.5.5.3 Nyquist frequency (supplements 8.11.1.2)

The upstream Nyquist frequency for Annex I-EU shall be at subcarrier NSCus (f = 4.3125*NSCus kHz)..

I.5.5.4 Modulation by the inverse discrete Fourier transform (supplements 8.11.2)

For Annex I-EU, see A.2.1.

I.5.5.5 Synchronization symbol (supplements 8.11.3)

For Annex I-EU, see A.2.2.

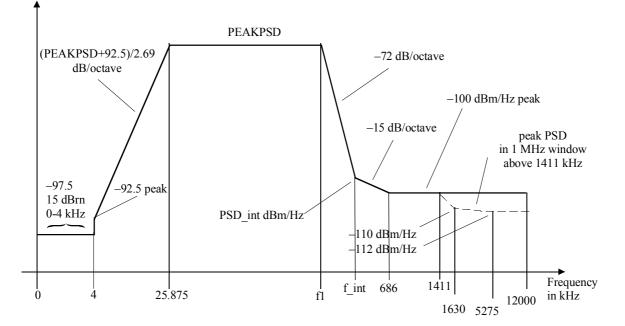
I.5.6 ATU-R Upstream Transmit Spectral Mask (replaces 8.14)

The upstream PSD masks of Annex I-EU are defined with absolute peak values in Figure I.18. The low frequency stop band is defined for frequencies below 25.875 kHz; the high frequency stop band is defined at frequencies greater than f1 kHz (tone n1). The in-band region of these PSD masks is the frequency band from 25.875 kHz to f1 kHz.

and the ATU-R may optionally support upstream masks EU-36 to EU-64. specified in Figure I.18

NOTE: The value of MAXNOMATPus may be limited by regional regulations.





Frequency band f (kHz)	Equation for line (dBm/Hz)
0 < f < 4	-97.5
4 < f < 25.875	-92.5+(PEAKPSD+92.5)* log ₂ (f/4)/log ₂ (25.875/4)
25.875 < f < f1	PEAKPSD
f1< f< f_int	$PEAKPSD-72*log_2(f/f1)$
f_int < f < 686	PSD_int-15*log2(f/f_int)
f > 686	-100

Frequency (kHz)	PSD level (dBm/Hz)	Measurement BW
0	-97.5	100 Hz
4	-97.5	100 Hz
4	-92.5	100 Hz
25.875	PEAKPSD	10 kHz
f1	PEAKPSD	10 kHz
f_int	PSD_int	10 kHz
686 - 12000	-100	10 kHz

Additionally the PSD masks shall satisfy the following requirements:

Frequency (kHz)	PSD level (dBm/Hz)	Measurement BW
1411	-100	1 MHz
1630	-110	1 MHz
5275	-112	1 MHz
12000	-112	1 MHz

NSCus is a function of the upstream mask parameters, which are defined as follows:

Parameters in	FEXT bitman	for mode 1	both bitman	s for mode 2 (see 8	173)	·
1 drameters m	1 LZX1 Ununup	101 mode 1	, oour onunap	5 101 mode 2	Sec 3	1.7.57	•

Designator (EU-nn)	NSCus	Template Nominal PSD P ₀ (dBm/Hz)	Template Maximum Aggregate Transmit Power (dBm)	PEAKPSD (dBm/Hz)	Frequency f1 (kHz)	Intercept Frequency f_int (kHz)	Intercept PSD Level PSD_int (dBm/Hz)
EU-32	32	-38.0	12.5	-34.5	138.00	242.92	-93.2
EU-36	64	-38.5	12.5	-35.0	155.25	274.03	-94.0
EU-40	64	-39.0	12.5	-35.5	172.50	305.06	-94.7
EU-44	64	-39.4	12.5	-35.9	189.75	336.33	-95.4
EU-48	64	-39.8	12.5	-36.3	207.00	367.54	-95.9
EU-52	64	-40.1	12.5	-36.6	224.25	399.07	-96.5
EU-56	64	-40.4	12.5	-36.9	241.50	430.58	-97.0
EU-60	64	-40.7	12.5	-37.2	258.75	462.04	-97.4
EU-64	64	-41.0	12.5	-37.5	276.00	493.45	-97.9

Parameters in NEXT bitmap for mode 1 (see §I.7.3):

Designator (EU-nn)	NSCus	Template Nominal PSD P ₀ (dBm/Hz)	Template Maximum Aggregate Transmit Power (dBm)	PEAKPSD (dBm/Hz)	Frequency f1 (kHz)	Intercept Frequency f_int (kHz)	Intercept PSD Level PSD_int (dBm/Hz)
EU-32	32	-38.0	12.5	-34.5	138.00	242.92	-93.2
EU-36	64	-38.7	12.5	-35.2	155.25	273.47	-94.0
EU-40	64	-39.9	12.5	-36.4	172.50	302.26	-94.7
EU-44	64	-40.7	12.5	-37.2	189.75	331.87	-95.3
EU-48	64	-41.4	12.5	-37.9	207.00	361.55	-95.8
EU-52	64	-41.8	12.5	-38.3	224.25	392.16	-96.4
EU-56	64	-42.1	12.5	-38.6	241.50	423.12	-96.9
EU-60	64	-42.3	12.5	-38.8	258.75	454.51	-97.3
EU-64	64	-42.3	12.5	-38.8	276.00	486.91	-97.8

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. The breakpoints in the tables shall be connected by linear straight lines on a dB/log(f) plot.

NOTE 3 – MBW specifies the Measurement Bandwidth. The MBW specified for a certain breakpoint with frequency fi is applicable for all frequencies satisfying fi< $f \le fj$, where fj is the frequency of the next specified breakpoint.

NOTE 4 – The power in a 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency i.e. power in the [f, f + 1 MHz] window shall conform to the specification at frequency f.

NOTE 5 – The step in the PSD mask at 4 kHz is to protect V.90 performance. Originally, the PSD mask continued the 21.5 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-R interface (see Figures I.3 & I.4).

Figure I.18: Upstream Channel PSD Masks

I.5.7 Forward error correction (supplements 8.6)

The minimum FEC coding capabilities (Table 8-3) for an ATU-R shall include the following interleave depths for the interleaved buffer:

D = 1, 2, 4, 8, and 16

I.5.8 Cyclic prefix (supplements 8.12)

For Annex I-EU, see A.2.3.

I.6 EOC Operation and Maintenance (pertains to clause 9)

I.6.1 ADSL line related primitives (supplements 9.3.1)

I.6.1.1 ADSL line related near-end defects (supplements 9.3.1.3)

Two near-end defects are further defined:

- *Loss-of-signal (LOS)*: The ADSL power shall be measured only in the FEXT_C duration at ATU-C, or only in the FEXT_R duration at ATU-R.
- Severely errored frame (SEF): A SEF defect occurs when the content of two consecutively received ADSL synchronization symbols in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-R, does not correlate with the expected content over a subset of the tones. An SEF defect terminates when the content of two consecutively received ADSL synchronization symbols in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-C, or in the FEXT_R duration at ATU-R, does not consecutively received ADSL synchronization symbols in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-R, correlate with the expected contents over the same subset. The correlation method, the selected subset of tones, and the threshold for declaring these defect conditions are implementation discretionary.

I.6.1.2 ADSL line related far-end defects (supplements 9.3.1.4)

Loss-of-signal is further defined:

• *Loss-of-signal (LOS)*: The ADSL power shall be measured only in the FEXT_C duration at ATU-C, or only in the FEXT_R duration at ATU-R.

I.6.2 Test Parameters (supplements 9.5)

I.6.2.1 Near-end test parameters (supplements 9.5.1)

The near-end primitives are further defined:

- *Attenuation (ATN)*: The received signal power shall be measured only in the FEXT_C duration at ATU-C, or only in the FEXT_R duration at ATU-R.
- Signal-to-Noise ratio (SNR) margin: During FEXT Bitmap mode, this primitive represents the snr margin in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-R.

I.6.2.2 Far-end test parameters (supplements 9.5.2)

The far-end primitives are further defined:

- *Attenuation (ATN)*: The received signal power shall be measured only in the FEXT_C duration at ATU-C, or only in the FEXT_R duration at ATU-R.
- Signal-to-Noise ratio SNR margin: During FEXT Bitmap mode, this primitive represents the snr margin in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-R.

I.6.3 Data registers in the ATU-R (supplements 9.2.4)

For the S=1/2n framing mode (see §I.4.9), the downstream RS₁ shall be the number of parity bytes per sync byte, i.e., $RS_1 = R_1/(n^*S)$.

I.7 Initialization (pertains to clause 10)

I.7.1 Initialization with Hyperframe (replaces 10.1.5)

The exchange of messages between ATU-C and ATU-R should be performed in FEXT_{C} and FEXT_{R} . The DMT symbol has two symbol rates: one is 4.3125 kbaud for the symbol without a cyclic prefix, and the other is 4 x 69/68 kbaud for the symbol with a cyclic prefix. 32 times of the TTR has the same period as 345 times of the 4.3125 kbaud, and 34 times of the TTR is the same as 345 times of 4 x 69/68 kHz.

During FEXT Bitmap mode, the ATU-R shall not transmit any signal during the NEXT_C symbols duration and the ATU-C shall transmit only the pilot tone as the NEXT_R signal except:

- C-PILOT1 (C-PILOT1A) which is accompanied by a signal to allow the ATU-C to indicate the phase of TTR_C to the ATU-R (see I.7.4.1);
- C-QUIETn where no signal is transmitted.

The ATU-C begins transmitting C-PILOT1 at the beginning of the hyperframe without cyclic prefix. The ATU-C informs the phase of the TTR_C to ATU-R during C-PILOT1. The ATU-R begins transmitting R-REVERB1 at the beginning of the hyperframe without cyclic prefix. The ATU-R performs the training of any receiver equalizer using this phase information of the TTR_R generated from received TTR_C .

From C-PILOT1 to C-SEGUE1, the following numerical formula gives the information which duration N_{dmt}-th DMT symbol belongs to at ATU-R (see Figure I.19).

For $N_{dmt} = 0, 1, \dots 344$ $S = 256 \times N_{dmt} \mod 2760$ if { (S + 255 < a) or (S > a + b) } then FEXT_R symbols else then NEXT_R symbols where a = 1243, b = 1461

In order to enter C-RATES1 at the beginning of the hyperframe with cyclic prefix, the number of symbols from C-PILOT1 to C-SEGUE1 shall be a multiple of 345 DMT symbols.

From R-REVERB1 to R-SEGUE1, the following numerical formula gives the information which duration N_{dmt}-th symbol belongs to at ATU-C (see Figure I.20).

For $N_{dmt} = 0, 1, ..., 344$, $S = 256 \times N_{dmt} \mod 2760$ if { (S > a) and (S + 255 < a + b) } then FEXT_C symbols else then NEXT_C symbols where a = 1315, b = 1293

From C-RATES1 to C-SEGUE3, the number of symbols is a multiple of 345 DMT symbols. The following numerical formula gives the information which duration N_{dmt} -th DMT symbol belongs to. ATU-C transmits the message data in FEXT_R symbols (see Figure I.11).

For $N_{dmt} = 0, 1,, 344$	
$S = 272 \times N_{dmt} \mod 2760$	
if $\{ (S + 271 \ge a) \text{ and } (S \le a + b) \}$	then NEXT _R symbols
else	then $FEXT_{\mathbf{R}}$ symbols
where a = 1243, b = 1461	

The ATU-R enters R-REVERB3 at the beginning of the hyperframe with cyclic prefix, which is extracted from received signal. From R-REVERB3 to R-SEGUE5, the number of symbols is a multiple of 345 DMT symbols. The following numerical formula gives the information which duration N_{dmt} -th DMT symbol belongs to. ATU-R transmits the message data in FEXT_C symbols (see Figure I.17).

For N_{dmt} = 0, 1, ..., 344

```
S = 272 \ x \ N_{dmt} \ mod \ 2760 if { (S > a) and (S + 271 < a + b) } else where a = 1315, b = 1293
```

then $FEXT_C$ symbols then $NEXT_C$ symbols

		-
TTR _C		
0		6 7 8 9 10
1		17 18 19 20 21
2	2 22 23 24 25 26 27	28 29 30 31
3	3 32 33 34 35 36 37 38	39 40 41 42
4	4 43 44 45 46 47 48 49	9 50 51 52 53
5		60 61 62 63 64
6		71 72 73 74
7		82 83 84 85
8		
9		03 104 105 106 107
10		114 115 116 117 118 125 126 127 128 1
11 12		125 126 127 128 136 137 138 139
12		
13		$\begin{array}{c ccccccccccccccccccccccccccccccccccc$
14		168 169 170 171 172
16		179 180 181 182
17		╶┙┯───┤┯───┤┯───┤┯
18	<u>8 194 195 196 197 198 199 20</u>	00 201 202 203 204
19	205 206 207 208 209 210	211 212 213 214 215
20	216 217 218 219 220 221	222 223 224 225
21	226 227 228 229 230 231 232	233 234 235 236
22	2 237 238 239 240 241 242 243	
23		254 255 256 257 258
24		265 266 267 268 269
25		276 277 278 279
26		╶──────────────────────────────────────
27 28		97 298 299 300 301 308 309 310 311 312
28 29		308 309 310 311 312 319 320 321 322
29 30		319 320 321 322 330 331 332 333
31		
51		
	FEXT _R symbol	T1535350-00
	NEXT _R symbol	
	L NEATR Symbol	

Figure I.19/G.992.1 – Symbol pattern in a hyperframe without cyclic prefix – Downstream

_	-	-	
Ľ	Ľ	υ.	
1	1.	IV.	D
-	•	••	к

[
<u>، _</u>																
0	0	1	2	3		4		5	6		7		8	(9	10
1	11	12	13		14	15		16		17	1		19		20	21
2	22	23		4	25		26	27		28		29	30		31	
3	32 33 34 35 36 37 38 39 40 41										42					
4	43 44		45	46		47	48		49		50	5		52		53
5		55	56		7	58		59	6	50	61		62			64
6	65	66	67		68	6	9	70		71		72	73		74	
7	75 76	77		78	79		80	8		82		83		4	85	
8	86 87		8	89	9	-	91		92		93	94		95		6
9	97 9		99	100		101	10		103		104		05	10		07
10		109	110		11 122	112	23	113 12		14	11		116			118
12	119 129 130	120	12	132	122	_	23 134		4 35	125		126 137	12	/ 38	128	
3	129 130 140 141		42	132		<u>, 44</u>	134	_	33 146		147	137		38 149		50
4		52	153	145		155	14		140		158		159	-		161
5	162	163	155		165	135	_ <u> - i</u>	167		,, 168	_	59	170		171	17
6	173	174		75	105		177	107		100		180	1/0	21	182	<u>. </u>
7	183 184	18		186	18		188		189	_	90	191	_	192		3
8	194 19		196	197		198	100	_	200	_	201	_	02	20		04
9		206	207	<u> </u>	08	209		210	_	11	212		213	_		215
0	216	217	21	8	219		20	221		222	_	23	224		225	
21	226 227	228	3	229	230		231	2	32	23	3	234	2	35	23	6
2	239 238	2	39	240	2	41	242	2	243	2	244	24	5	246	2	47
3	248 24	49	250	25	1	252	2	53	25	54	255	12	256	2:	57	258
.4	259	260	261		262	26	3	264		265	26	6	267		268	269
25	270	271	2	72	273	2	274	27	5	276		277	27	8	279	ĪT
26	280 281	28	32	283	28	4	285		286	28	37	288	3	289	29	0
27	291 29	2 2	293	294	- 2	295	29	6	297	7	298	29	99	30	0 3	01
28	302 3	303	304		05	306		307		08	309)	310	3		312
9	313	314	31	5	316	31	17	318		319	3	20	321		322	
0	323 324	325		326	327		328	3	29	330)	331	3	32	333	
31	334 335	3	36	337	3	38	339)	340	3	41	34	2	343	3	44
		CT _C syn XT _C syn					-								T153	5360-(

Figure I.20/G.992.1 – Symbol pattern in a hyperframe without cyclic prefix – Upstream

I.7.2 Handshake – Non-standard information block (new)

This section defines the format of the G.994.1 non-standard information block to support Annex I-EU, and tabulates the parameters used by Annex I-EU. The use of these parameters is described in §1.7.3 and §1.7.4.

I.7.2.1 Non-standard information block format (new)

Figure I.21 defines the format of the non-standard information block.

8	7	6	5	4	3	2	1				
	Non-standard information length = $M + 6$ (1 octet)										
	T.35 country code (2 octets – see Note 1)										
	Provider code (vendor identification) (4 octets – see Note 2)										
	Vendor-specific information (M octets – Note 3)										

NOTE 1 – The value of this field shall be B5 00, the country code for USA

NOTE 2 – The value of this field shall be 43 45 4E 54, ASCII "CENT" for Centillium Communications

NOTE 3 – These octets are defined in \$1.7.2.2. Formatting of these octets shall comply with the parsing rules defined in G.994.1 \$9.2.1 to \$9.2.3

Figure I.21 – Non-standard information block format

I.7.2.2 Non-standard information block parameters (new)

The G.994.1 non-standard parameters for Annex I-EU are listed in Tables I.6 to I.7.4.2 below.

In order to minimize message length, the parameters for additional inband spectral shaping (Spar(2) octet and its related Npar(3) octets) shall only be included in MP or MS messages, and shall not be included in CLR or CL messages. All Annex I-EU modems shall support additional inband spectral shaping.

Note - This deviates from the rules specified in G.994.1 for standard information fields, where it is stated in §9.6:

"Once a Transaction C (see 10.1) has been completed, any subsequent MS message within the same G.994.1 session shall only contain those octets of the identification (I) and standard information (S) fields, and those blocks of non-standard information (NS) that were contained in both the CLR and CL messages of the previous Transaction C".

Bits								
8	7	6	5	4	3	2	1	NPar(1)s
x	х	х	х	х	х	х	1	Reserved for future use
х	х	Х	х	х	х	1	х	Reserved for future use
х	х	х	х	х	1	х	х	Reserved for future use
х	х	х	х	1	х	х	х	Reserved for future use
х	х	Х	1	х	х	Х	х	Reserved for future use
х	х	1	х	х	х	Х	х	Reserved for future use
х	1	х	х	х	х	х	х	Reserved for future use
х	0	0	0	0	0	0	0	No parameters in this octet

Table I.6 – Non-standard information field – NPar(1) coding

Bits								
8	7	6	5	4	3	2	1	SPar(1)s
х	Х	х	х	х	х	х	1	G.992.1 Annex Q (and Annex Q-EU)
х	х	х	х	х	х	1	х	G.992.1 Annex I-EU
х	х	х	х	х	1	х	х	G.992.1 Annex C-EU
х	х	х	х	1	х	х	х	Reserved for future use
х	х	х	1	х	х	х	х	Reserved for future use
х	х	1	х	х	х	х	х	Reserved for future use
х	1	х	х	х	х	х	х	Reserved for future use
х	0	0	0	0	0	0	0	No parameters in this octet

Table I.7 – Non-standard information field – SPar(1) coding

Table I.7.3 – Non-standard information field – G.992.1 Annex I-EU NPar(2) coding – Octet 1

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex I-EU NPar(2)s
x	Х	х	х	х	х	х	1	$n_{\text{C-PILOT1}} = 64$
х	х	х	х	х	х	1	х	$n_{\text{C-PILOT1}} = 128$
х	х	х	х	х	1	х	х	$n_{\text{C-PILOT1}} = 256$
х	х	х	х	1	х	х	х	Amateur radio notch - 1.8 MHz band
х	х	х	1	х	х	х	х	Reserved for future use
х	х	1	х	х	х	х	х	$n_{\text{C-PILOT1}} = 96$
х	х	0	0	0	0	0	0	No parameters in this octet
Since A4	48 is th	e only]	TTR in	dication	n signal	specif	ied for	Annex I-EU, there is no need to include it in G.994.1.

Table I.7.3.1 – Non-standard information field – G.992.1 Annex I-EU NPar(2) coding – Octet 2

Bits									
8	7	6	5	4	3	2	1	G.992.1 Annex I-EU NPar(2)s – Octet 2	
х	х	х	Х	Х	х	х	1	R-ACK1	
х	х	х	Х	Х	х	1	х	R-ACK2	
х	х	x	х	х	1	х	х	DBM	
х	х	х	х	1	х	х	х	Reserved for future use	
х	х	х	1	х	х	х	х	Reserved for future use	
х	х	1	х	х	х	х	х	G.997.1 – Clear EOC OAM	
х	х	0	0	0	0	0	0	No parameters in this octet	
ince Ar	nce Annex I-EU only supports ATM transport, STM and ATM parameters are not specified.								

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex I-EU SPar(2)s
X	Х	х	х	х	х	х	1	Additional inband spectral shaping
х	х	х	х	х	х	1	х	Extended upstream
х	х	х	х	х	1	х	х	Reserved for future use
х	х	х	х	1	х	х	Х	Reserved for future use
х	х	х	1	х	х	х	х	Reserved for future use
х	х	1	х	х	х	х	х	Reserved for future use
x	Х	0	0	0	0	0	0	No parameters in this octet

Table I.7.4 – Non-standard information field – G.992.1 Annex I-EU SPar(2) coding

Table I.7.4.1 – Non-standard information field – G.992.1 Annex I-EU Additional inband spectral shaping Npar(3) coding Octet 1

Bits								G.992.1 Annex I-EU Additional inband spectral
8	7	6	5	4	3	2	1	shaping Npar(3)s Octet 1
х	х					х	х	NOMINAL_PSD_lowband (bits 8 & 7)
х	x	х	х	х	х			Reserved for future use

Table I.7.4.1.1 – Non-standard information field – G.992.1 Annex I-EU Additional inband spectral shaping Npar(3) coding Octet 2

_									
	Bits								G.992.1 Annex I-EU Additional inband spectral
	8	7	6	5	4	3	2	1	shaping Npar(3)s Octet 2
	Х	х	х	Х	Х	Х	Х	х	NOMINAL_PSD_lowband (bits 6 to 1)

Table I.7.4.1.2 – Non-standard information field – G.992.1 Annex I-EU Additional inband spectral shaping Npar(3) coding Octet 3

Bits								G.992.1 Annex I-EU Additional inband spectral
8	7	6	5	4	3	2	1	shaping Npar(3)s Octet 3
x	х					х	х	PSD level at 1622 kHz (bits 8 & 7)
x	Х	х	Х	Х	х			Reserved for future use

Table I.7.4.1.3 – Non-standard information field – G.992.1 Annex I-EU Additional inband spectral shaping Npar(3) coding Octet 4

Bits								G.992.1 Annex I-EU Additional inband spectral
8	7	6	5	4	3	2	1	shaping Npar(3)s Octet 4
х	х	Х	х	Х	Х	х	х	PSD level at 1622 kHz (bits 6 to 1)

Table I.7.4.1.4 – Non-standard information field – G.992.1 Annex I-EU Additional inband spectral shaping Npar(3) coding Octet 5

Bits								G.992.1 Annex I-EU Additional inband spectral
8	7	6	5	4	3	2	1	shaping Npar(3)s Octet 5
х	Х					х	Х	PSD level at 2208 kHz (bits 8 & 7)
х	х	х	х	х	х			Reserved for future use

Table I.7.4.1.5 – Non-standard information field – G.992.1 Annex I-EU Additional inband spectral shaping Npar(3) coding Octet 6

	Bits								G.992.1 Annex I-EU Additional inband spectral
	8	7	6	5	4	3	2	1	shaping Npar(3)s Octet 6
-	х	х	х	Х	Х	х	х	х	PSD level at 2208 kHz (bits 6 to 1)

Table I.7.4.2 – Non-standard information field – G.992.1 Annex I-EU Extended upstream NPar(3) coding Octet 1

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex I-EU Extended upstream NPar(3)s Octet 1
х	х	х	х	х	Х	х	1	Mode 1 upstream mask
х	х	х	х	х	Х	1	х	Mode 2 upstream mask
х	х	х	х	х	1	х	х	Optional upstream masks for non-overlapped spectrum
х	х	х	х	1	Х	х	х	EU-64
х	х	х	1	х	Х	х	х	EU-32
х	х	1	х	х	х	х	х	EU-36
Х	х	0	0	0	0	0	0	No parameters in this octet

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex I-EU Extended upstream NPar(3)s Octet 2
x	Х	х	Х	Х	Х	х	1	EU-40
х	х	х	х	х	х	1	х	EU-44
х	х	х	х	х	1	х	х	EU-48
х	х	х	х	1	х	х	х	EU-52
х	х	х	1	х	х	х	х	EU-56
х	Х	1	х	Х	х	х	х	EU-60
х	Х	0	0	0	0	0	0	No parameters in this octet

Table I.7.4.2.1 – Non-standard information field – G.992.1 Annex I-EU Extended upstream NPar(3) coding Octet 2

I.7.3 Handshake – Parameter definitions (supplements 10.2)

- I.7.3.1 Handshake ATU-C (supplements 10.2)
- I.7.3.1.1 CL messages (supplements 10.2.1)

See Table I.8.

NSF parameter	Definition
DBM	If set to ZERO, this bit shall indicate Bitmap-N _R and Bitmap-N _C are enabled (Dual Bitmap
	mode) and are used to transmit data. If set to ONE, this bit shall indicate Bitmap-NR and
	Bitmap-N _C are disabled (FEXT Bitmap mode), i.e. only Bitmap-F _R and Bitmap-F _C are
	used to transmit data by ATU-C and ATU-R respectively. This mode selection shall be only performed by the ATU-C. If it is set to ONE in a CL message, it must be set to ONE in subsequent MS messages from either the ATU-C or ATU-R.
G.992.1 Annex I-EU	If set to ONE, this Spar(1) bit indicates that the ATU-C is configured to support G.992.1 Annex I-EU.
ⁿ C-PILOT1 ⁼⁶⁴	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 64.
ⁿ C-PILOT1 ⁼⁹⁶	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 96.
ⁿ C-PILOT1 ⁼¹²⁸	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 128.
ⁿ C-PILOT1 ⁼²⁵⁶	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 256.
Amateur radio notch – 1.8 MHz band	If set to ONE, this Npar(2) bit indicates that the ATU-C is configured to reduce its transmit power between 1.81 and 2.0 MHz to ≤ -80 dBm.
Extended upstream	If set to ONE, this Spar(2) bit indicates that the ATU-C is configured to support extended upstream.
EU-xx	If the Extended upstream Spar(2) bit is set to ONE, these Npar(3) bits indicate the extended upstream masks that the ATU-C supports. For non-overlapped spectrum, extended upstream masks are associated with downstream masks according to Figure I.13. For overlapped spectrum, any EU-xx may be used with the overlapped downstream spectrum specified in §I.4.8.2.
Mode 1 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-C is configured to support upstream mask mode 1 (different masks during FEXT and NEXT periods).
Mode 2 upstream	If set to ONE, this NPar(3) bit indicates that the ATU-C is configured to support upstream
mask	mask mode 2 (same mask during FEXT and NEXT periods).
Optional upstream masks for non- overlapped spectrum	If set to ONE, this NPar(3) bit indicates that the ATU-C is configured to support the optional upstream masks when using non-overlapped spectrum downstream.

Table I.8/G.992.1 – ATU-C CL message NPar(2) bit definitions for Annex I-EU

I.7.3.1.2 MS messages (supplements 10.2.2)

See Table I.9.

Table I.9/G.992.1 – ATU-C MS message NPar(2) bit definitions for Annex I-EU

NSF parameter	Definition
DBM	If set to ZERO, this bit shall indicate Bitmap- N_R and Bitmap- N_C are enabled (Dual
	Bitmap mode) and are used to transmit data. If set to ONE, this bit shall indicate
	Bitmap-N _R and Bitmap-N _C are disabled (FEXT Bitmap mode), i.e. only Bitmap-F _R and
	Bitmap-F _C are used to transmit data by ATU-C and ATU-R respectively. This mode
	selection shall be only performed by ATU-C. This bit shall be set to ONE if it was set to
	ONE in a previous CL message.
G.992.1 Annex I-EU	If set to ONE, this Spar(1) bit indicates that the ATU-C is selecting G.992.1 Annex I-EU.
ⁿ C-PILOT1 ⁼⁶⁴	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 64 (Note 1).
ⁿ C-PILOT1 ⁼⁹⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on
	subcarrier 96 (Note 1).
ⁿ C-PILOT1 ⁼¹²⁸	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 128 (Note 1).
ⁿ C-PILOT1 ⁼²⁵⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on
C-IILOII	subcarrier 256 (Note 1).
Amateur radio notch -	If set to ONE, this Npar(2) bit indicates that the ATU-C shall reduce its transmit power
1.8 MHz band	between 1.81 and 2.0 MHz to ≤ -80 dBm.
Additional inband	If set to ONE, this Spar(2) bit indicates that the ATU-C shall apply additional downstream
spectral shaping	inband spectral shaping as defined by the values of REDUCED_PSD_lowband, PSD level
	at 1622 kHz, and PSD level at 2208 kHz
REDUCED_PSD_low	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-C
band	shall apply in the passband below 1104 kHz. It is coded in steps of 0.125dB relative to
	NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz.
PSD level at 1622 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-C
1 SD level at 1022 KHZ	shall apply at 1622 kHz. It is coded in steps of 0.125dB relative to
	NOMINAL PSD lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz;
	00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs
	between the REDUCED_PSD_lowband level at 1104 kHz and the PSD level at 1622 kHz.
PSD level at 2208 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-C
	shall apply at 2208 kHz. It is coded in steps of 0.125dB relative to
	NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz;
	00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs
T , 1 1 ,	between the PSD level at 1622 kHz and the PSD level at 2208 kHz.
Extended upstream	If set to ONE, this Spar(2) bit indicates that the ATU-C is selecting extended upstream
EU-xx	operation. If set to ONE, this Npar(3) bit indicates that the ATU-C is selecting upstream PSD mask
EU-XX	US-xx. For non-overlapped spectrum, extended upstream masks are associated with
	downstream masks according to Figure I.13. For overlapped spectrum, any EU-xx may be
	used with the overlapped downstream spectrum specified in §I.4.8.2.
Mode 1 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-C is selecting upstream mask mode 1
	(different masks during FEXT and NEXT periods). (Note 2)
Mode 2 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-C is selecting upstream mask mode 2
1	(same mask during FEXT and NEXT periods). (Note 2)
Optional upstream	If set to ONE, this NPar(3) bit indicates that the ATU-C is selecting one of the optional
masks for non-	upstream masks when using non-overlapped spectrum downstream.
overlapped spectrum	
	e pilot tone bit shall be set in an MS message.
Note 2: One and only or	e upstream mask mode bit shall be set in an MS message.

I.7.3.2 Handshake – ATU-R (supplements 10.3)

I.7.3.2.1 CLR messages (supplements 10.3.1)

See Table I.10.

NSF parameter	Definition
DBM	This bit shall be set to ONE.
G.992.1 Annex I-EU	If set to ONE, this Spar(1) bit indicates that the ATU-R is configured to support G.992.1 Annex I-EU.
ⁿ C-PILOT1 ⁼⁶⁴	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 64.
ⁿ C-PILOT1 ⁼⁹⁶	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 96.
ⁿ C-PILOT1 ⁼¹²⁸	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 128.
ⁿ C-PILOT1 ⁼²⁵⁶	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 256.
Amateur radio notch – 1.8 MHz band	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports the 1.8 MHz Amateur radio band notch.
Extended upstream	If set to ONE, this Spar(2) bit indicates that the ATU-R is configured to support extended upstream.
EU-xx	If the Extended upstream Spar(2) bit is set to ONE, these Npar(3) bits indicate the extended upstream masks that the ATU-R supports. For non-overlapped spectrum, extended upstream masks are associated with downstream masks according to Figure I.13. For overlapped spectrum, any EU-xx may be used with the overlapped downstream spectrum specified in §1.4.8.2.
Mode 1 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-R is configured to support upstream mask mode 1 (different masks during FEXT and NEXT periods).
Mode 2 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-R is configured to support upstream mask mode 2 (same mask during FEXT and NEXT periods).
Optional upstream masks for non- overlapped spectrum	If set to ONE, this NPar(3) bit indicates that the ATU-R is configured to support the optional upstream masks when using non-overlapped spectrum downstream.

Table I.10/G.992.1 – ATU-R CLR message NPar(2) bit definitions for Annex I-EU

I.7.3.2.2 MS messages (supplements 10.3.2)

Table I.11.

NSF parameter	Definition
DBM	If set to ZERO, this bit shall indicate Bitmap- N_R and Bitmap- N_C are enabled (Dual
	Bitmap mode) and are used to transmit data. If set to ONE, this bit shall indicate Bitmap-N _R and Bitmap-N _C are disabled (FEXT Bitmap mode), i.e. only Bitmap-F _R and
	Bitmap-F _C are used to transmit data by ATU-C and ATU-R respectively. This mode
	selection shall be only performed by ATU-C. This bit shall be set to ONE if it was set to ONE in a previous CL message.
G.992.1 Annex I-EU	If set to ONE, this Spar(1) bit indicates that the ATU-R is selecting G.992.1 Annex I-EU.
ⁿ C-PILOT1 ⁼⁶⁴	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is selecting the pilot tone on
	subcarrier 64 (Note 1).
ⁿ C-PILOT1 ⁼⁹⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is selecting the pilot tone on subcarrier 96 (Note 1).

n _{C-PILOT1} =128	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is selecting the pilot tone on
-C-FILOTT	subcarrier 128 (Note 1).
n _{C-PILOT1} =256	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is selecting the pilot tone on
	subcarrier 256 (Note 1).
Amateur radio notch	This selection shall only be performed by the ATU-C. Therefore, this Npar(2) bit shall
– 1.8 MHz band	either be set to the same value as in a previous CL message or set to ONE.
Additional inband	If set to ONE, this Spar(2) bit indicates that the ATU-R is selecting additional
spectral shaping	downstream inband spectral shaping as defined by the values of
	REDUCED_PSD_lowband, PSD level at 1622 kHz, and PSD level at 2208 kHz
REDUCED_PSD_lo	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-
wband	R wishes to have applied in the passband below 1104 kHz. It is coded in steps of
	0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000
PSD level at 1622	means –40 dBm/Hz; 00001101 means -41.625 dBm/Hz. This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-
kHz	R wishes to have applied at 1622 kHz. It is coded in steps of 0.125dB relative to
КПZ	NOMINAL PSD lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz;
	00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs
	between the REDUCED PSD lowband level at 1104 kHz and the PSD level at 1622
	kHz.
PSD level at 2208	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-
kHz	R wishes to have applied at 2208 kHz. It is coded in steps of 0.125dB relative to
	NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz;
	00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs
	between the PSD level at 1622 kHz and the PSD level at 2208 kHz.
Extended upstream	If set to ONE, this Spar(2) bit indicates that the ATU-R is selecting extended upstream
	operation.
EU-xx	If set to ONE, this Npar(3) bit indicates that the ATU-R is selecting upstream PSD mask
	US-xx. For non-overlapped spectrum, extended upstream masks are associated used with
	downstream masks according to Figure I.13. For overlapped spectrum, any EU-xx may
	be used with the overlapped downstream spectrum specified in §I.4.8.2.
Mode 1 upstream	If set to ONE, this NPar(3) bit indicates that the ATU-R is selecting upstream mask mode
mask Mada 2 matrix and	1 (different masks during FEXT and NEXT periods). (Note 2)
Mode 2 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-R is selecting upstream mask mode 2 (same mask during FEXT and NEXT periods). (Note 2)
Optional upstream	If set to ONE, this NPar(3) bit indicates that the ATU-R is selecting one of the optional
masks for non-	upstream masks when using non-overlapped spectrum downstream.
overlapped spectrum	upsteam masks when using non-overtapped spectrum downsteam.
	one pilot tone bit shall be set in an MS message.
	one upstream mask mode bit shall be set in an MS message.
i i i i i i i i i i i i i i i i i i i	

I.7.3.2.3 MP messages (new)

Table I.12.

NSF parameter	Definition
R-ACK1	Proposes that the ATU-C send C-PILOT1A, C-QUIET3A, C-PILOT2 and C-QUIET5 during
	transceiver training.
R-ACK2	Proposes that the ATU-C send C-PILOT1, C-PILOT2 and C-PILOT3 during transceiver
	training.
G.992.1 Annex I-EU	If set to ONE, this Spar(1) bit indicates that the ATU-R is proposing G.992.1 Annex I-EU.
$^{n}C-PILOT1^{=64}$	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the pilot tone on
C TILOTT	subcarrier 64 (Note 1).
$^{n}C-PILOT1^{=96}$	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is proposing the pilot tone on
	subcarrier 96 (Note 1).

ⁿ C-PILOT1 ⁼¹²⁸	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the pilot tone on
C-HLOH	subcarrier 128 (Note 1).
ⁿ C-PILOT1 ⁼²⁵⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the pilot tone on
	subcarrier 256 (Note 1).
Amateur radio notch	This selection shall only be performed by the ATU-C. Therefore, this Npar(2) bit shall either
- 1.8 MHz band	be set to the same value as in a previous CL message or set to ONE.
Additional inband	If set to ONE, this Spar(2) bit indicates that the ATU-R is proposing additional downstream
spectral shaping	inband spectral shaping as defined by the values of REDUCED_PSD_lowband, PSD level at
	1622 kHz, and PSD level at 2208 kHz
REDUCED_PSD_lo	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R
wband	wishes to have applied in the passband below 1104 kHz. It is coded in steps of 0.125dB
	relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40
	dBm/Hz; 00001101 means -41.625 dBm/Hz.
PSD level at 1622	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R
kHz	wishes to have applied at 1622 kHz. It is coded in steps of 0.125dB relative to
	NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz;
	00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs
	between the REDUCED_PSD_lowband level at 1104 kHz and the PSD level at 1622 kHz.
PSD level at 2208	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R
kHz	wishes to have applied at 2208 kHz. It is coded in steps of 0.125dB relative to
	NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz;
	00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs
	between the PSD level at 1622 kHz and the PSD level at 2208 kHz.
Extended upstream	If set to ONE, this Spar(2) bit indicates that the ATU-R is proposing extended upstream
	operation.
EU-xx	If set to ONE, this Npar(3) bit indicates that the ATU-R is proposing upstream PSD mask
	US-xx. For non-overlapped spectrum, extended upstream masks are associated with
	downstream masks according to Figure I.13. For overlapped spectrum, any EU-xx may be
	used with the overlapped downstream spectrum specified in §I.4.8.2.
Mode 1 upstream	If set to ONE, this NPar(3) bit indicates that the ATU-R is proposing upstream mask mode 1
mask	(different masks during FEXT and NEXT periods).
Mode 2 upstream	If set to ONE, this NPar(3) bit indicates that the ATU-R is proposing upstream mask mode 2
mask	(same mask during FEXT and NEXT periods).
Optional upstream	If set to ONE, this NPar(3) bit indicates that the ATU-R is proposing one of the optional
masks for non-	upstream masks when using non-overlapped spectrum downstream.
overlapped spectrum	
Note 1: More than one	pilot tone bit may be set in an MP message.

I.7.4 Transceiver Training – ATU-C (supplements 10.4)

During transceiver training from C-REVERB1 to C-SEGUE1 except C-PILOTn and C-QUIETn, the ATU-C shall transmit both FEXT_R and NEXT_R symbols when Bitmap-N_R is enabled (Dual Bitmap mode), and shall not transmit the NEXT_R symbols except pilot tone when Bitmap-N_R is disabled (FEXT Bitmap mode). The duration of each state is defined as Figure I.26.

I.7.4.1 C-PILOT1 (supplements 10.4.2)

The ATU-C shall start the N_{SWF} (sliding window frame) counter from 0 immediately after entering C-PILOT1, and increment the N_{SWF} counter modulo 345 after transmission of each DMT symbol. According to the sliding window function and this counter, the ATU-C decides to transmit all of the subsequent symbols in either FEXT_R or NEXT_R symbols (for example, see Figures I.11, I.19 and I.24).

C-PILOT1 has two signals.

The first signal is the pilot tone, a single frequency sinusoid at $f_{C-PILOT1}$ defined as:

$$X_{k} = \begin{cases} 0, & k \neq n_{C-PILOT1}, \ 0 \leq k \leq NSC \\ A_{C-PILOT1}, & k = n_{C-PILOT1} \end{cases}$$

The frequency of the pilot tone shall be selected from one of the following choices during G.994.1 as:

16. *f*C-PILOT1 = 276 kHz (*n*C-PILOT1 = 64).
 17. *f*C-PILOT1 = 414 kHz (*n*C-PILOT1 = 96).
 18. *f*C-PILOT1 = 552 kHz (*n*C-PILOT1 = 128).

19. $f_{C-PILOT1} = 1104 \text{ kHz} (n_{C-PILOT1} = 256).$

Transmitters that support Annex I-EU shall support all of these pilot tones.

The second signal is the TTR indication signal used to transmit $NEXT_R/FEXT_R$ information. The ATU-R can detect the phase information of the TTR_C from this signal. The TTR indication signal shall be selected during G.994.1 as:

A48 signal -the constellation encoding of the 48th carrier with 2-bit constellation as follows:

(+, +) to indicate a FEXT_R symbol;

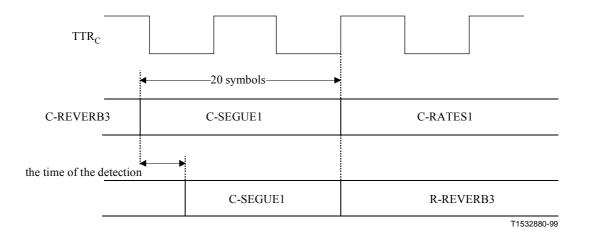
(+, -) to indicate a NEXT_R symbol.

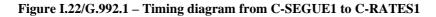
I.7.4.2 C-PILOT1A (supplements 10.4.3)

C-PILOT1A has two signals and it is the same transmitted signal as C-PILOT1 (C.7.4.1).

I.7.4.3 C-REVERB3 (supplements 10.4.11)

In order to synchronize the first symbol of C-RATES1 with the beginning of the hyperframe and to inform the entering timing of C-RATES1 to the ATU-R, the first symbol of C-SEGUE1 shall be transmitted inside of the FEXT_{R} duration as shown in Figure I.22. Therefore, the duration of C-REVERB3 is 3628 DMT symbols.





I.7.4.4 C-REVERB1 (replaces 10.4.5)

C-REVERB1 is a signal that allows the ATU-C and ATU-R receiver to adjust its automatic gain control (AGC) to an appropriate level. The data pattern used in C-REVERB1 shall be the pseudo-random downstream sequence (PRD), d_n for n = 1 to 2*NSCds, defined in I.4.7.5 and repeated here for convenience:

$$d_n = 1 for n = 1 to 9 (10-1)$$

$$d_n = d_{n-4} \oplus d_{n-9} for n = 10 to 2*NSCds$$

The bits shall be used as follows: the first pair of bits $(d_1 \text{ and } d_2)$ is used for the DC and Nyquist subcarriers (the power assigned to them is, of course, zero, so the bits are effectively ignored); then the first and second bits of subsequent pairs are used to define the X_i and Y_i for i = 1 to NSCds-1 as defined in Table 7-13.

The period of PRD is only 511 bits, so d_{n+511} is equal to d_n . The bits d_1 to d_9 shall be re-initialized for each symbol, so each symbol of C-REVERB1 is identical.

The two bits that modulate the pilot carrier shall be overwritten by $\{0,0\}$: generating the $\{+,+\}$ constellation.

The duration of C-REVERB1 is 512 (repeating) symbols without cyclic prefix.

I.7.4.4.1 Power Cut-back (supplements 10.4.5.1)

For Annex I-EU, see A.3.1.

I.7.5 Transceiver Training – ATU-R (supplements 10.5)

During transceiver training from R-REVERB1 to R-SEGUE1 except R-QUIETn, the ATU-R shall transmit both $FEXT_C$ and $NEXT_C$ symbols when Bitmap-N_C is enabled (Dual Bitmap mode) and shall not transmit $NEXT_C$ symbols when Bitmap-N_C is disabled (FEXT Bitmap mode). The duration of each state is defined as Figure I.26.

I.7.5.1 R-QUIET2 (supplements 10.5.1)

The ATU-R enters R-REVERB1 after it completes timing recovery and Hyperframe synchronization from C-PILOT1/C-PILOT1A.

I.7.5.2 R-REVERB1 (supplements 10.5.2)

The data pattern used in R-REVERB1 is the pseudo-random upstream sequence PRU defined in 8.11.3, repeated as necessary for the selected NSCus:

$$\begin{cases} d_n = 1 & \text{for } n = 1 \text{ to } 6 \\ d_n = d_{n-5} & \oplus d_{n-6} & \text{for } n = 7 \text{ to } 64 \end{cases}$$
(C.10-1)

The period of PRU is only 63 bits, so d_{n+63} is equal to d_n .

The ATU-R shall start its N_{SWF} counter immediately after entering R-REVERB1, and then increment the N_{SWF} counter with modulo 345 from 0 when it transmits each DMT symbol. The ATU-C and ATU-R shall have the same value since hyperframe alignment between the ATU-C and ATU-R shall be maintained. According to the sliding window and this counter, the ATU-R decides to transmit all of the subsequent symbols in either the FEXT_C or the NEXT_C symbol.

I.7.5.3 R-QUIET3 (replaces 10.5.3)

The final symbol of R-QUIET3 accommodates the frame alignment of the transmitter to that of the receiver. It may be shortened by any number of samples. The maximum duration of R-QUIET3 is 6145 DMT symbols.

I.7.5.4 R-REVERB2 (supplements 10.5.5)

After ATU-R detects C-SEGUE1, the ATU-R enters R-SEGUE1. The maximum duration of R-REVERB2 is 3643 DMT symbols.

I.7.6 Channel analysis (ATU-C) (supplements 10.6)

ATU-C shall transmit only FEXT_R symbols, and shall not transmit the NEXT_R symbols except the pilot tone from

C-RATES1 to C-CRC2. During C-MEDLEY, the ATU-C shall transmit both FEXT_R and NEXT_R symbols when Bitmap-N_R is enabled (Dual Bitmap mode). The ATU-C shall not transmit NEXT_R symbols except the pilot tone, when Bitmap-N_R is disabled (FEXT Bitmap mode). The duration of each state is defined in Figure I.26.

I.7.6.1 C-SEGUE1 (supplements 10.6.1)

The duration of C-SEGUE1 is 20 symbols in order that the first symbol of C-SEGUE1 shall be inside of the FEXT_R duration.

I.7.6.2 C-MEDLEY (replaces 10.6.6)

C-MEDLEY is a wideband pseudo-random signal used for estimation at the ATU-R of the downstream SNR. The data to be transmitted are derived from the pseudo-random sequence, PRD_m , defined as:

d_n = 1 for n = 1 to 14 and d_n = d_{n-5} \oplus d_{n-11} \oplus d_{n-12} \oplus d_{n-14} for n> 14,

and modulated as defined in 10.4.5. In contrast to C-REVERB1, the cyclic prefix is used and the data sequence continues from one symbol to the next (i.e. d_1 to d_{14} are not re-initialized for each symbol). Because the sequence is of length 2¹⁴-1, and far fewer bits are used for each symbol, the subcarrier vector for C-MEDLEY changes from one symbol period to the next. For non-overlapped spectrum, 2*(512-mm+1) bits are used each symbol, where mm is the minimum subcarrier specified for PSD mask DS-mm in Table I.13. For overlapped spectrum, 2*507 bits are used each symbol. The pilot subcarrier is overwritten by the (+,+) signal constellation. The duration of C-MEDLEY is as shown in Figure I.26. Following C-MEDLEY the ATU-C shall enter the state C-REVERB4.

With the periodical noise of TCM-ISDN, SNR also changes in the same cycle, as shown in Figure I.23. The ATU-C transmits the signal in both of $NEXT_R$ and $FEXT_R$ symbols, and the ATU-R estimates two SNRs from the received $NEXT_R$ and $FEXT_R$ symbols, respectively, as defined in Figure I.24.

The following formula gives the information that received Ndmt-th DMT symbol belongs to:

For $N_{dmt} = 0, 1, ..., 344$ $S = 272 \times N_{dmt} \mod 2760$ if { (S + 271 < a) or (S > d) } then symbol for estimation of FEXT_R SNR if { (S > b) and (S + 271 < c) } then symbol for estimation of NEXT_R SNR where a = 1243, b = 1403, c = 2613, d = 2704

When Bitmap-N_R is disabled (FEXT Bitmap mode), ATU-C shall transmit only the pilot tone as NEXT_R symbol. The number of bits of NEXT_R shall be no more than the number of bits of FEXT_R.

At the transmitter, the PRD_m sequence generator shall continue to be updated during $NEXT_R$ symbols when Bitmap-N_R is disabled (FEXT Bitmap mode).

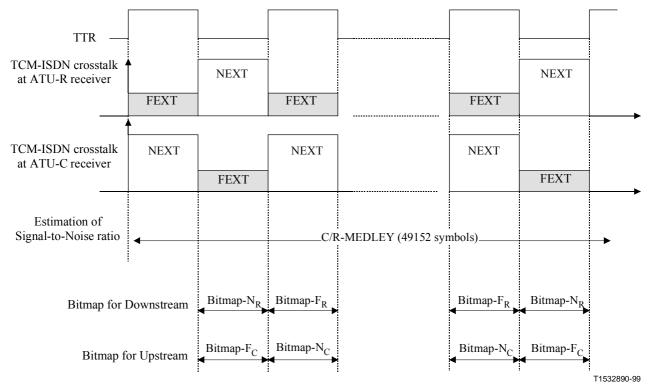


Figure I.23/G.992.1 – Estimation of periodic Signal-to-Noise Ratio

TTR _C	
0	
1	
2	20 21 22 23 24 25 26 27 28 27 28
3	30 31 32 33 34 35 36 36 37 38 39 40
4	41 42 43 44 45 46 47 48 49 50
5	51 52 53 54 55 36 57 59 60
6	61 62 63 64 65 66 67 68 69 70
7	71 72 73 74 75 76 77 8 80
8	81 82 83 84 85 86 87 88 89
9	91 92 93 94 95 96 97 98 99 101
10	101 102 103 104 105 106 107 108 109 111
11	112 113 114 115 116 117 118 129 12
12	122 123 124 125 26 122 128 129 139 131
13	132 133 134 135 136 137 138 138 141
14	142 143 144 145 146 147 148 149 151
15	152 153 154 155 156 1 57 158 169 169
16	162 163 164 165 166 167 168 169 179 179
17	173 174 175 176 177 178 179 189 182
18 19	183 184 185 186 187 188 189 190 193 192 193 194 195 196 197 198 199 200 202 202
20	193 194 193 196 197 198 199 203 204 205 206 207 208 209 233 212
20	203 204 203 206 207 208 207 218 228 222 211 211 213 214 215 216 217 218 228 222 223 223 222 223 223 223 223 223 223 223 223 223 223 223 223 223 223 223 223 223 233
21	213 214 213 216 217 216 777 223 224 225 226 227 228 723
22	233 234 235 236 237 238 239 249 244 242 243
24	244 245 246 247 248 249 259 253
25	
26	264 265 266 267 268 269 273
27	274 275 276 277 278 279 283 283
28	284 285 286 287 288 289 299 299 293
29	294 295 296 297 298 299 300 301 302 303
30	304 305 306 307 308 309 349 342 343 314
31	315 316 317 318 319 320 322 323 324
32	325 326 327 328 329 330 337 332 332 334
33	335 336 337 338 339 340 344 344
	Symbol for estimation of FEXT _R S/N Symbol not used for S/N estimation
	Symbol for estimation of NEXT _R S/N T1535370-00

Figure I.24/G.992.1 – Symbol pattern in a hyperframe for S/N estimation – Downstream

I.7.6.3 C-RATES1 (supplements 10.6.2)

In order to support data rates greater than 16 Mbit/s, the B_I field has 10 bits. The RRSI fields shall use the same extended syntax as defined in I.7.9.4 for C-RATES-RA.

For the S=1/2n framing mode (see §I.4.9), the downstream RS_I shall be the number of parity bytes per sync byte, i.e.,

 $RS_I = R_I / (n*S).$

Suffix(ces) of m_i (Note 1)	Parameter (Note 3)
47-44	Minimum required downstream SNR margin at initialization (Note 2)
43-18	Reserved for future use
17	Trellis coding option
16	Overlapped spectrum option (Note 4)
15	Unused (shall be set to "1")
14-12	Reserved for future use
11	NTR
10-9	Framing mode
8-6	Transmit PSD during initialization
5	Reserved
4-0	Maximum numbers of bits per subcarrier supported
OTE 1 – Within the separate fields	s the least significant bits have the lowest subscripts.
OTE 2 – A positive number of dB;	; binary coded 0-15 dB.
TOTE 2 All	

64014 6G MGG1

I.7.6.4 C-MSG1 (supplements 10.6.4)

NOTE 3 – All reserved bits shall be set to "0".

NOTE 4 – The initialization sequence allows for interworking of overlapped and non-overlapped spectrum implementations. Therefore, this indication is for information only.

I.7.6.4.1 Maximum numbers of bits per subcarrier supported – Bits 4-0 (replaces 10.6.4.8)

The N_{downmax} (transmit) capability shall be binary encoded onto $\{m_4, ..., m_0\}$ (e.g. $10001_2 = 17$). The maximum

number of bits for the upstream data, N_{upmax} , that the ATU-C receiver can support need not be signalled to the ATU-R; it will be implicit in the bits and gains message, C-B&G, which is transmitted after channel analysis.

I.7.7 Channel analysis (ATU-R) (supplements 10.7)

From R-RATES1 to R-CRC2, the ATU-R shall transmit only the FEXT_{C} symbols and shall not transmit the NEXT_{C} symbols. In R-SEGUE2 and R-MEDLEY, the ATU-R shall transmit both FEXT_{C} and NEXT_{C} symbols when Bitmap-N_C is enabled (Dual Bitmap mode) and shall not transmit NEXT_{C} symbols when Bitmap-N_C is disabled (FEXT Bitmap mode). The duration of each state is defined in Figure I.26.

I.7.8 R-SEGUE1 (supplements 10.7.1)

The maximum duration of R-SEGUE1 is 14 symbols (see Figure I.22).

I.7.8.1 R-REVERB3 (supplements 10.7.2)

The ATU-R shall start R-REVERB3 aligned with the beginning of a Hyperframe.

I.7.8.2 R-SEGUE2 (supplements 10.7.3)

The duration of R-SEGUE2 is 13 symbols.

I.7.8.3 R-MEDLEY (replaces 10.7.8)

R-MEDLEY is a wideband pseudo-random signal used for estimation of the upstream SNR at the ATU-C. The data to be transmitted are derived from the pseudo-random sequence PRU_m defined as:

d $_{n}$ = 1 for n = 1 to 23 and d $_{n}$ = d $_{n-18} \oplus$ d $_{n-23}$ for n> 23.

In contrast to R-REVERB1, the cyclic prefix is used and the data sequence continues from one symbol to the next (i.e. d_1 to d_{23} are not re-initialized for each symbol). Because the sequence is of length 2^{23} -1, and $2^*(nn-5)$ bits are used for

each symbol (where nn is the maximum subcarrier specified for PSD mask EU-nn in Table I.18), the subcarrier vector for R-MEDLEY changes from one symbol period to the next. Following R-MEDLEY the ATU-R enters signalling state R-REVERB4. The duration of R-MEDLEY is as shown in Figure I.26.

With the periodical noise of TCM-ISDN, SNR also changes in the same cycle, as shown in Figure I.23. ATU-R shall transmit the signal in both of $NEXT_C$ and $FEXT_C$ symbols, and ATU-C shall estimate two SNRs from the received $NEXT_C$ and $FEXT_C$ symbols, respectively, as defined in Figure I.25.

The following numerical formula gives the information that received N_{dmt}-th DMT symbol belongs to:

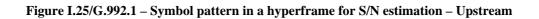
For $N_{dmt} = 0, 1, ..., 344$ $S = 272 \times N_{dmt} \mod 2760$ if { (S > b) and (S + 271 < c) } then symbol for estimation of FEXT_C SNR if { (S + 271 < a) } then symbol for estimation of NEXT_C SNR where a = 1148, b = 1315, c = 2608

When Bitmap-N_C is disabled (FEXT Bitmap mode), the ATU-R shall not transmit NEXT_C symbol. The number of bits of NEXT_C shall be no more than the number of bits of FEXT_C.

At the transmitter, the PRU_m sequence generator shall continue to be updated during $NEXT_C$ symbols when Bitmap-N_C is disabled (FEXT Bitmap mode).

TTR _R	
0	
1	
2	20 25 26 27 28 29
3	30 34 35 36 37 38 39 40
4	4 3 4 4 4 5 4 6 4 7 4 8 4 9 5 0
5	54 55 56 57 58 59 6 0
6	63 64 65 66 67 68 69 70
7	71 75 76 77 78 79 80
8	81 83 84 85 86 87 88 89 90
9	91 93 94 95 96 97 98 99 100 101
10	101 103 104 105 06 107 108 109 110 111
11	115 1 6 117 118 119 120 21
12	125 126 127 128 129 130 131
13	136 137 138 139 140 14
14	142 143 144 144 145 150 151 152 152 152 152 150 151
15	152 354 355 156 157 158 159 160 161
16	162 163 166 167 168 169 170 171 172
17	173 176 77 178 179 180 181 82 183 184 185 186 187 188 189 190 191 92
18 19	183 184 185 186 187 188 189 190 191 92 193 194 195 196 197 198 199 200 201 292
20	203 204 205 206 207 208 209 210 211 212
20	213 234 235 210 211 211 213 234 235 218 219 220 221 222
22	213 224 225 227 228 229 230 231 232
23	233 234 235 236 231 238 239 240 241 242 243
24	244 245 247 248 249 250 251 252 253
25	254 257 258 259 260 260 262 263
26	264 265 268 269 270 271 272 2 3
27	274 275 278 279 280 281 282 283
28	284 285 286 287 2 88 289 290 291 292 293
29	294 298 299 300 301 302 303
30	304 303 306 307 308 309 310 311 312 313 314
31	318 319 320 321 322 323 324
	325 326 327 328 329 330 331 332 333 3 4
32	
32 33	339 340 341 342 343 344
	335 336 337 338 340 341 342 343 344 T1535290-00

Symbol for estimation of NEXT_C S/N



I.7.8.4 R-MSG1 (supplements 10.7.6)

Suffix(ces) of m_i (Note 1)	Parameter (Note 2)
47-18	Reserved for future use
17	Trellis coding option
16	Overlapped spectrum option (Note 3)
15	Unused (shall be set to "1")
14	Support of $S = 1/2$ mode (see I.4.9) (Note 4)
13	Support of dual latency downstream
12	Support of dual latency upstream
11	Network Timing Reference
10, 9	Framing mode
8-5	Reserved for future use
4-0	Maximum numbers of bits per subcarrier supported
NOTE 1 – Within the separate fields t	the least significant bits have the lowest subscripts.
NOTE 2 - All reserved bits shall be set	et to "0".
	allows for interworking of overlapped and non-overlapped spectrum
implementations. Therefore, this indic	cation is for information only.
NOTE 4 – Since the $S=1/2$ mode is m	andatory for Annex I-EU, a modem supporting Annex I-EU shall set this bit to

Table I.14/G.992.1 – Assignment of 48 bits of R-MSG1

NOTE 4 – Since the S=1/2 mode is mandatory for Annex I-EU, a modem supporting Annex I-EU shall set this bit to binary ONE.

I.7.8.4.1 Maximum numbers of bits per subcarrier supported – Bits 4-0 (replaces 10.7.6.6)

The N_{upmax} (transmit) capability is encoded onto $\{m_4, ..., m_0\}$ with a conventional binary representation (e.g. $10001_2 = 17$).

I.7.9 Exchange – ATU-C (supplements 10.8)

During C-RATESn, C-MSGn, C-B&G, and C-CRCn, the ATU-C shall transmit the FEXT_R symbol. In the other signals, the ATU-C shall transmit both $FEXT_R$ and $NEXT_R$ symbols when Bitmap-N_R is enabled (Dual Bitmap mode), and shall not transmit the $NEXT_R$ symbols except pilot tone when Bitmap-N_R is disabled (FEXT Bitmap mode). The duration of each state is defined in Figure I.27.

I.7.9.1 C-MSG2 (supplements 10.8.9)

Replace Table 10-13 with Table I.15.

Suffix(ces) of <i>m_i</i> (Note 1)	Parameter (Note 2)	
31-26	Estimated average loop attenuation	
25-21	Reserved for future use	
20-16	Performance margin with selected rate option	
15-11	Reserved for future use	
10-0	Total number of bits supported	
NOTE 1 – Within the separate fields the least significant bits have the lowest subscripts.		
NOTE 2 – All reserved bits shall be set to "0".		

Table I.15/G.992.1 – Assignment of 32 bits of C-MSG2

For NSCus=32,

 $n_{1C-MSG2} = 43$ $n_{2C-MSG2} = 91$ Otherwise,

 $n_{1C-MSG2} = 139$ $n_{2C-MSG2} = 187$

I.7.9.1.1 Total number of bits per symbol supported (replaces 10.8.9.3)

The ATU-C receiver shall also calculate the maximum number of bits per symbol that the upstream channel can support with the performance margin defined in C-MSG-RA at an error rate of 10^{-7} .

The maximum number of bits per symbol is defined at the reference point B, that is calculated from the FEXT_C and NEXT_C downstream channel performance [e.g. if the maximum numbers of bits that can be supported in FEXT_C and NEXT_C symbols are 111 and 88 {Total number of bits per symbol supported} = $(111 \times 126 + 88 \times 214)/340 = 96$]. This number is encoded into bits 10-0 using a conventional binary representation [e.g. if the maximum number of bits that can be supported is 96 (data rate = 384 kbit/s), { m_{10} , ..., m_0 } = 000011111112].

NOTE – The number of symbols per hyperframe is 340. The number of FEXT symbols is 126. The number of NEXT symbols is 214.

I.7.9.1.2 Estimated average upstream loop attenuation (supplements 10.8.9.1)

For Annex I-EU, see A.3.2.

I.7.9.2 C-B&G (replaces 10.8.13)

C-B&G shall be used to transmit to the ATU-R the bits and gains information, Bitmap-FC { b_1 , g_1 , b_2 , g_2 , ... $b_{NSCus-1}$, $g_{NSCus-1}$ }, and Bitmap-N_C { $b_{NSCus+1}$, $g_{NSCus+1}$, $b_{NSCus+2}$, $g_{NSCus+2}$, ..., $b_{2*NSCus-1}$, $g_{2*NSCus-1}$ }, that are to be used on the upstream carriers. b_i of Bitmap-F_C indicates the number of bits to be coded by ATU-R transmitter onto the *i* th upstream carrier in FEXT_C symbols; g_i of Bitmap-F_C indicates the scale factor, relative to the gain that was used for that carrier during the transmission of R-MEDLEY, that shall be applied to the *i* th upstream carrier in FEXT_C symbols. Similarly, b_i of Bitmap-N_C indicates the number of bits onto the (*i* – NSCus) th upstream carrier in NEXT_C symbols; g_i of Bitmap-N_C indicates the scale factor that shall be applied to the (*i* – NSCus) th upstream carrier in NEXT_C symbols.

Because no bits or energy will be transmitted at DC or one-half the sampling rate, b_0 , g_0 , b_{NSCus} , g_{NSCus} , $b_{2*NSCus}$, and $g_{2*NSCus}$ are all presumed to be zero and shall not be transmitted.

Each b_i shall be represented as an unsigned 5-bit integer, with valid b_i s lying in the range of zero to N_{upmax} , the maximum number of bits that the ATU-R is prepared to modulate onto any subcarrier, which is communicated in R-MSG1.

Each g_i shall be represented as an unsigned 11-bit fixed-point quantity, with the binary point assumed just to the right of

the third most significant bit. For example, a g_i with binary representation (most significant bit listed first)

 001.01000000_2 would instruct the ATU-R to scale the constellation for carrier *i*, by a gain factor of 1.25, so that the power in that carrier shall be 1.94 dB higher than it was during R-MEDLEY.

For subcarriers on which no data are to be transmitted, and the receiver will never allocate bits (e.g. out-of-band subcarriers) both b_i and g_i shall be set to zero (00000₂ and 00000000 000₂, respectively). For subcarriers on which no data are to be currently transmitted, but the receiver may allocate bits later (e.g. as a result of an SNR improvement), the b_i shall be set to zero and the g_i to a value in the 0.19 to 1.33 range (000.00110000₂ to 001.0101010₁).

Let NSCu=128, except when EU-32 is used where NSCu=32. The C-B&G information shall be mapped in a 32*(NSCu-1)-bit (4*(NSCu-1) byte) message *m* defined by:

 $m = \{m_{32*}(NSCu-1)-1, m_{32*}(NSCu-1)-2, ..., m_1, m_0\} = \{g_{2*}NSCu-1, b_{2*}NSCu-1, ..., g_{NSCu+1}, b_{NSCu+1}, g_{NSCu-1}, ..., g_{1}, b_1\},$ (C.10-2)

with the MSB of b_i and g_i in the higher *m* index and m_0 being transmitted first. The message *m* shall be transmitted in 4*(NSCu-1) FEXT_R symbols. When NSCu=32, including C_CRC5, the total length is 336 symbols while for NSCu=128, the total length is 336+3*345=1371 symbols, using the transmission method as described in 10.8.9.

When Bitmap-N_C is disabled (FEXT Bitmap mode), b_i and g_i of Bitmap-N_C shall be set to zero. For index between NSCus+1 and 127, the m values are set to 0.

I.7.9.3 C-SEGUE3 (replaces 10.8.16)

The duration of C-SEGUE3 is 18 symbols. Following C-SEGUE3, the ATU-C completes the initialization and enters C-SHOWTIME. In C-SHOWTIME, ATU-C shall transmit the signal using Bitmap- F_R and Bitmap- N_R with the sliding window.

When Bitmap-N_R is disabled (FEXT Bitmap mode), ATU-C shall transmit only the pilot tone as NEXT_R symbols.

I.7.9.4 C-RATES-RA (supplements 10.8.3)

	← bits →										
fields	7	6	5	4	3	2	1	0			
RS _F	0	0		value of RS _F							
			MS	MSB LSB							
RSI	$B_8(AS0)$	$B_9(AS0)$		value of RS _I							
			MSB LSB								
S	I9	I_8		value of S							
			MS	MSB LSB							
Ι	I ₇	I ₆	$I_5 \qquad I_4 \qquad I_3 \qquad I_2 \qquad I_1 \qquad I_0$								
FS(LS2)	value of FS(LS2) <i>set to</i> {0000000 ₂ }										

Table I.16/G.992.1 – RRSI fields of C-RATES-RA

The RS_I field has been extended to include the most significant bit B_9 of B_1 (AS0), the number of payload bytes in the AS0 bearer channel in the downstream interleave buffer, in bit 6. This is to support the higher data rates for the optional S=1/4 and S=1/3 modes.

The S field shall be coded $\{100100_2\}$ to indicate S=1/4.

For the S=1/2n framing mode (see §I.4.9), the downstream RS_I shall be the number of parity bytes per sync byte, i.e., $RS_I = R_I/(n^*S)$.

I.7.10 Exchange – ATU-R (supplements 10.9)

ATU-R shall transmit only the FEXT_{C} symbols in R-MSGn, R-RATESn, R-B&G, R-CRCn. In other signals, the ATU-R shall transmit both FEXT_{C} and NEXT_{C} symbols when Bitmap-N_C is enabled (Dual Bitmap mode) and shall not transmit NEXT_{C} symbols when Bitmap-N_C is disabled (FEXT Bitmap mode). The duration of each state is defined in Figure I.27.

I.7.10.1 R-MSG-RA (supplements 10.9.2)

Replace Table 10-15 with Table I.17.

Suffix(ces) of m _i	Parameter				
(Note)	All reserved bits shall be set to 0				
79-71	Reserved for ITU-T				
70	Extension to number of RS payload bytes, K				
69, 68	Extension to number of tones carrying data (ncloaded)				
67-56	B _{fast-max}				
55-49	Number of RS overhead bytes, (R)				
48-40	Number of RS payload bytes, K				
39-32	Number of tones carrying data (ncloaded)				
31-25 Estimated average loop attenuation					
24-21	Coding gain				
20-16	Performance margin with selected rate option				
15	Reserved for ITU-T				
14	Extension to total number of bits per DMT symbol, Bmax				
13-12	Maximum Interleave Depth downstream				
11-0	Total number of bits per DMT symbol, B _{max}				
OTE – Within the sep	arate fields the least significant bits have the lowest subscripts.				

Table I.17/G.992.1 – Assignment of 80 bits of R-MSG-RA (Annex I-EU)

I.7.10.1.1 Total number of bits supported (B_{max}) (replaces 10.9.2.8)

This parameter shall be defined as in R-MSG2, see I.7.9.1.

I.7.10.1.2 B_{fast-max} (new)

 $B_{fast-max}$ is the maximum number of bits of the fast buffer for fast data transmitted on the condition that the bits of the fast data can be equally assigned to all FEXT-symbols and NEXT-symbols.

Fast Buffered Data B_{fast-max} is t_f.

I.7.10.2 R-MSG2 (supplements 10.9.8)

Suffix(ces) of m _i (Note 1)	Parameter (Note 2)				
31-25	Estimated average loop attenuation				
24-21	Reserved for future use				
20-16 Performance margin with selected rate option					
15	Reserved for future use				
14	Extension to total number of bits per DMT symbol, B _{max}				
13-12	Reserved for future use				
11-0	Total number of bits per DMT symbol, Bmax				
OTE 1 – Within the separate fi	elds the least significant bits have the lowest subscripts.				

Table I.18/G.992.1 – Assignment of 32 bits of R-MSG2

 $N_{1R-MSG2} = 10$ $N_{2R-MSG2} = 20$

I.7.10.2.1 Total number of bits per symbol supported (supplements 10.9.8.3)

The maximum number of bits per symbol that the downstream channel can support is encoded into bits 14 and 11 - 0.

The maximum number of bits per symbol is defined at the reference point B, that is calculated from the FEXT_R and NEXT_R downstream channel performance. For example, if the maximum numbers of bits that can be supported in FEXT_R and NEXT_R symbols are 111 and 88, the total number of bits per symbol supported is $(111 \times 126 + 88 \times 214)/340 = 96$.

NOTE – The number of symbols per hyperframe is 340, the number of FEXT symbols is 126, and the number of NEXT symbols is 214.

I.7.10.2.2 Estimated average downstream loop attenuation (supplements 10.9.8.1)

For Annex I-EU, see A.3.3.

I.7.10.3 R-REVERB5 (supplement of 10.9.12)

The duration of R-REVERB5 is 345n-40, 3<=n<=19, when NSCu=128, or 3<=n<=16 when NSCu=32.

I.7.10.4 R-B&G (replaces 10.9.14)

The purpose of R-B&G is to transmit to ATU-C the bits and gains information, Bitmap-F_R { b_1 , g_1 , b_2 , g_2 , ..., $b_{NSCds-1}$, $g_{NSCds-1}$ }, and Bitmap-N_R { $b_{NSCds+1}$, $g_{NSCds+1}$, $b_{NSCds+2}$, $g_{NSCds+2}$, ..., $b_{2*NSCds-1}$, $g_{2*NSCds-1}$ }, to be used on the downstream subcarriers. b_i of Bitmap-F_R indicates the number of bits to be coded by ATU-C transmitter onto the *i* th downstream subcarrier in FEXT_R symbols; g_i of Bitmap-F_R indicates the scale factor that shall be applied to the *i* th downstream subcarrier in FEXT_R symbols, relative to the gain that was used for that carrier during the transmission of C-MEDLEY. Similarly, b_i of Bitmap-N_R indicates the number of bits onto the (*i* – NSCds) th downstream carrier in NEXT_R symbols; g_i of Bitmap-N_R indicates the scale factor that shall be applied to the (*i* – NSCds) th downstream carrier in NEXT_R symbols. Because no bits or energy will be transmitted at DC or one-half the sampling rate, b_0 , g_0 , b_{NSCds} , g_{NSCds} , $b_{2*NSCds}$, and $g_{2*NSCds}$ are all presumed to be zero, and are not transmitted. When subcarrier 64 is reserved as the pilot tone, b_{64} and $b_{NSCds+64}$, shall be set to 0, g_{64} and $g_{NSCds+128}$ shall be set to g_{sync} . When subcarrier 128 is reserved as the pilot tone, b_{128} and $b_{NSCds+128}$, shall be set to 0, g_{256} and $g_{NSCds+256}$ shall be set to g_{sync} . The value g_{sync} represents the gain scaling applied to the sync symbol.

Each b_i is represented as an unsigned 5-bit integer, with valid b_i lying in the range of zero to N_{downmax} , the maximum

number of bits that the ATU-C is prepared to modulate onto any subcarrier, which is communicated in C-MSG1.

Each g_i is represented as an unsigned 11-bit fixed-point quantity, with the binary point assumed just to the right of the

third most significant bit. For example, a g_i with binary representation (most significant bit listed first) 001.010000002 would instruct the ATU-C to scale the constellation for carrier *i* by a gain factor of 1.25, so that the power in that carrier shall be 1.94 dB higher than it was during C-MEDLEY.

For subcarriers on which no data are to be transmitted, and the receiver will never allocate bits (e.g. out-of-band subcarriers) both b_i and g_i shall be set to zero (00000₂ and 00000000 000₂, respectively). For subcarriers on which no data are to be currently transmitted, but the receiver may allocate bits later (e.g. as a result of an SNR improvement), the b_i shall be set to zero and the g_i to a value in the 0.19 to 1.33 range (000.00110000₂ to 001.0101010₁).

The R-B&G information shall be mapped in a (2*NSCds-2)*16-bit ((2*NSCds-2)*2 byte) message *m* defined by:

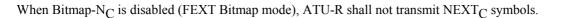
 $m = \{m_{(2*NSCds-2)*16-1}, m_{(2*NSCds-2)*16-2}, ..., m_1, m_0\} = \{g_{2*NSCds-1}, b_{2*NSCds-1}, ..., g_{NSCds+1}, b_{NSCds+1}, b_{NSCds+1}, b_{NSCds-1}, ..., g_{1}, b_{1}\},$ (I.10-3)

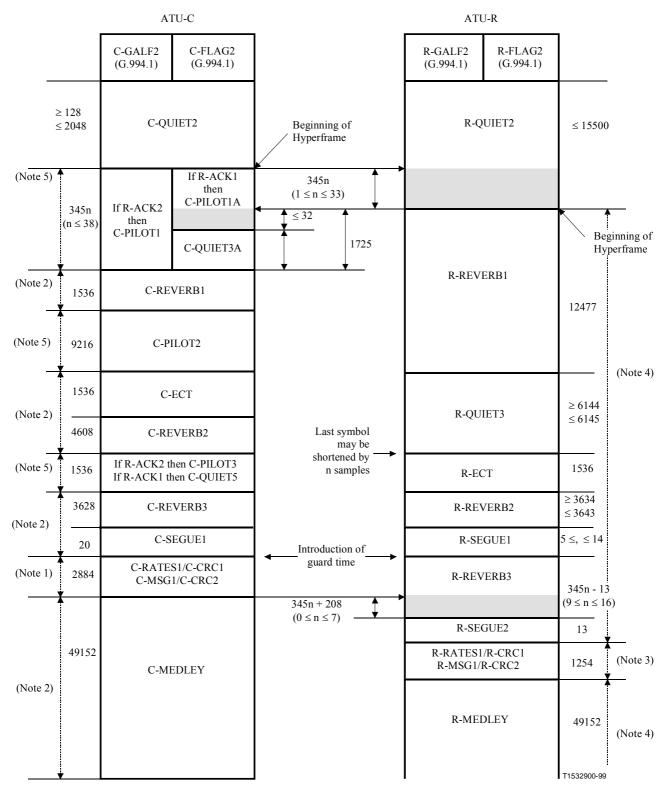
with the MSB of b_i and g_i in the higher *m* index and m_0 being transmitted first. The message *m* shall be transmitted in (2*NSCds-2)*2 symbols, using the transmission method as described in 10.9.8.

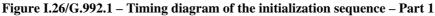
When Bitmap-N_R is disabled (FEXT Bitmap mode), b_i and g_i of Bitmap-N_R shall be set to zero.

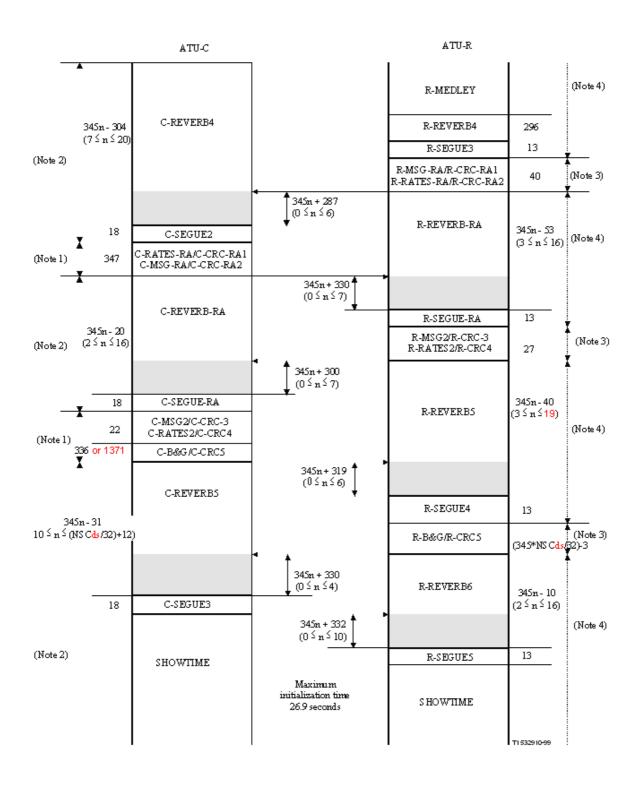
I.7.10.5 R-SEGUE5 (replaces 10.9.17)

The duration of R-SEGUE5 is 13 symbols. Following R-SEGUE-5, ATU-R completes the initialization and enters R-SHOWTIME. In R-SHOWTIME, ATU-R shall transmit the signal using Bitmap- F_C and Bitmap- N_C with the sliding window.









- NOTE 1 The ATU-C shall transmit the FEXTR symbols, and shall not transmit as NEXTR symbols except the pilot tone.
- NOTE 2 The ATU-C shall transmit both FEXTR and NEXTR symbols, when Bitmap-NR is enabled (Dual Bitmap mode). ATU-C shall not transmit the NEXTR symbols except pilot tone, when Bitmap-NR is disabled (FEXT Bitmap mode).
- NOTE 3 The ATU-R shall transmit the FEXTC symbols, and shall not transmit the NEXTC symbols.
- NOTE 4 The ATU-R shall transmit both FEXTC symbols, when Bitmap-NC is enabled (Dual Bitmap mode). ATU-R shall not transmit NEXTC symbols, when Bitmap-NC is disabled (FEXT Bitmap mode).

NOTE 5 – The ATU-C shall transmit both FEXTR and NEXTR symbols.

Figure I.27/G.992.1 – Timing diagram of the initialization sequence – Part 2

[Editor's note: Need to update Figure I.27 to parameterize the length of C-B&G and the maximum length of R-REVERB5.]

I.8 AOC On-line adaptation and reconfiguration (pertains to clause 11)

I.8.1.1 Bit swap request (replaces 11.2.3)

The receiver shall initiate a bit swap by sending a bit swap request to the transmitter via the AOC channel. This request tells the transmitter which subcarriers are to be modified. The format of the request is shown in Table I.19.

Message header		Message field 1-4				
{111111112}	Bitmap index	Subchannel	Command	Subchannel		
(8 bits)	(1 bit)	index – bits 10	(5 bits)	index – bits 8		
(0 010)		& 9		to 1		
		(2 bits)	1 1 1	(8 bits)		

Table I.19/G.992.1 – Format of the bit swap request message

The request shall comprise nine bytes as follows:

- an AOC message header consisting of 8 binary ones;
- message fields 1-4, each of which consists of a one-bit bitmap index, subchannel index bits 10 & 9, and a five-bit command followed by bits 8 to 1 of the subchannel index. One-bit bitmap index, subchannel index bits 10 & 9, and valid five-bit commands for the bit swap message shall be as shown in Table I.20. In Table I.20, the MSB for the bit swap request command represents the Bitmap index. For downstream data, Bitmap index equals 0 indicates Bitmap-F_R, and Bitmap index equals 1 indicates Bitmap-N_R. Similarly for upstream data, Bitmap index equals 0 0 indicates Bitmap-F_C, and 1 indicates Bitmap-N_C. The next 2 bits are subchannel index bits 10 & 9. The ten-bit subchannel index is counted from low to high frequencies with the lowest frequency subcarrier having the number zero. The subcarrier index zero shall not be used;
- the bit swap between $FEXT_{C/R}$ symbols and $NEXT_{C/R}$ symbols is not allowed.

Value (8 bit)	F					
yzz000002	Do nothing					
yzz000012	Increase the number of allocated bits by one					
yzz000102	Decrease the number of allocated bits by one					
yzz000112	Vzz000112 Increase the transmitted power by 1 dB					
yzz001002	D ₂ Increase the transmitted power by 2 dB					
yzz001012	Jzz00101 ₂ Increase the transmitted power by 3 dB					
yzz00110 ₂ Reduce the transmitted power by 1 dB						
yzz001112	Reduce the transmitted power by 2 dB					
yzz01xxx ₂	yzz01xxx ₂ Reserved for vendor discretionary commands					
NOTE – y is "0" for FEXT _{C/R} symbols, and "1" for NEXT _{C/R} symbols of the Sliding Window.						
NOTE – subchannel index = zz_2 *256 + subchannel index value from lower 8 bit field						

Table I.20/G.992.1 - Bit swap request command

The bit swap request message (i.e. header and message fields) shall be transmitted five consecutive times.

To avoid g_i divergence between ATU-C and ATU-R after several bit swaps, for a g_i update of Δ dB the new g_i value should be given by:

$$g_i' = (1/256) \times round(256 \times g_i \times 10 \exp(\Delta/20))$$
 (I.11-1)

I.8.1.2 Extended bit swap request (supplements 11.2.4)

The format of the extended bit swap request is shown in Table I.21.

Message header	Message field 1-6				
{11111100 ₂ }	Bitmap index	Subchannel	Command	Subchannel	
(8 bits)	(1 bit)	index – bits 10	(5 bits)	index – bits 8	
(0 010)		& 9		to 1	
		(2 bits)		(8 bits)	

In the same manner as the bit swap request, each of the message fields of the extended bit swap request consists of one-bit bitmap index, a five-bit command followed by a related ten-bit subchannel index.

I.8.1.3 Bit swap acknowledge (supplements 11.2.5)

The bit swap superframe counter number shall only indicate the last superframe (SPF#4) of a hyperframe.

The new bit and/or transmit power table(s) shall then take effect starting from the first frame (frame 0) of SPF#0 of a hyperframe.

If the bit swap superframe counter number contained in the received bit swap acknowledge message does not indicate SPF#4, then the new table(s) shall take effect starting from frame 0 of SPF#0 of the next hyperframe.

I.9 POTS splitter

For operation according to G.992.1 Annex I-EU, the Annex E.4/G.992.3 requirements applying over a frequency band up to 1104 kHz, shall be met over a frequency band up to 2208 kHz.

付属資料6

G.992.1 ANNEX I-EU (REVISION 2.0) PROPRIETARY EXTENSION TO G.992.1 ANNEX I

This document defines G.992.1 Annex I-EU (Double spectrum downstream with extended upstream spectrum), a proprietary extension to G.992.1 Annex I to extend the data rate beyond 24Mbit/s upstream by way of:

- Increase upstream bandwidth \rightarrow increased number of subcarriers, NSCus=96
- Increased bit loading, beyond 15 bits/bin

Due to the increase in upstream data rates, the upstream maximum interleave depth has been increased to 16. Support of this is mandatory.

The attached text is the approved text for Annex I, marked up with revision control to show the changes necessary to support the additional functionality.

Revision 2 text is based on G.992.1 Annex I-EU Revision 1.1, and supports the following features:

- extended upstream to subcarrier 96. Added EU-S68 to EU-S96.
- •
- •
- •
- •

ANNEX I-EU

Specific requirements for an ADSL system to support upstream data rates greater than 4 Mbit/s with improved performance on short loops operating in the same cable as ISDN as defined in ITU-T Recommendation G.961 Appendix III

I.1 Scope

This annex describes those specifications that are unique to an ADSL system coexisting in the same binder as TCM-ISDN as defined Recommendation G.961 Appendix III. The subclauses in this annex provide supplementary and replacement material to the clauses in the main body. The nature of the material is parenthetically indicated in the subclause heading. The modifications described in this annex allow a performance improvement from the ADSL system specified in Annex C for short loops in an environment coexisting with TCM-ISDN in the same cable. Specifically, this Annex specifies extensions to upstream bandwidth and maximum bit loading to support upstream data rates greater than 2 Mbit/s. This annex also defines those parameters of this ADSL system that have been left undefined in the main body of this Recommendation. An ADSL system implementing Annex I-EU shall support Annex I. It is recommended that an ADSL system implementing Annex C.

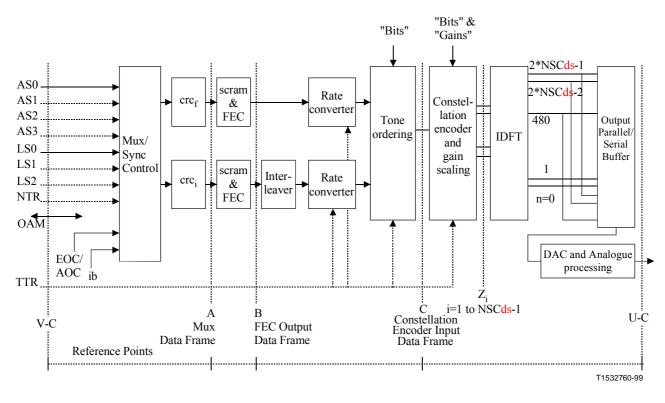
I.2 Definitions

Bitmap-F _C	ATU-R transmitter bitmap under TCM-ISDN FEXT noise generated at ATU-C
Bitmap-F _R	ATU-C transmitter bitmap under TCM-ISDN FEXT noise generated at ATU-R
Bitmap-N _C	ATU-R transmitter bitmap under TCM-ISDN NEXT noise generated at ATU-C
Bitmap-N _R	ATU-C transmitter bitmap under TCM-ISDN NEXT noise generated at ATU-R
Dual Bitmap FEXT Bitmap	The Dual Bitmap method has dual bit rates under the FEXT and NEXT noise from TCM-ISDN Similar to the Dual Bitmap method however transmission only occurs during FEXT noise from TCM-ISDN
FEXT _C duration	TCM-ISDN FEXT duration at ATU-C estimated by the ATU-R
FEXT _C symbol	DMT symbol transmitted by ATU-R during TCM-ISDN FEXT
FEXT _R duration	TCM-ISDN FEXT duration at ATU-R estimated by the ATU-C
FEXT _R symbol	DMT symbol transmitted by ATU-C during TCM-ISDN FEXT
Hyperframe NEXT _C duration	5 Superframes structure which synchronized TTR TCM-ISDN NEXT duration at ATU-C estimated by the ATU-R
NEXT _C symbol	DMT symbol transmitted by ATU-R during TCM-ISDN NEXT
NEXT _R duration	TCM-ISDN NEXT duration at ATU-R estimated by the ATU-C
NEXT _R symbol	DMT symbol transmitted by ATU-C during TCM-ISDN NEXT
NSCds	The highest subcarrier index that can be used for downstream transmission (i.e., the subcarrier index corresponding to the Nyquist frequency) For example, $NSCds = 256$ for a downstream channel using the frequency band up to 1.104MHz; $NSCds = 512$ for a downstream channel using the frequency band up to 2.208MHz.
NSCus	The highest subcarrier index that can be used for upstream transmission (i.e., the subcarrier index corresponding to the Nyquist frequency) For example, $NSCus = 64$ for an upstream channel using the frequency band up to 276 kHz.
N _{SWF}	Sliding Window frame counter
Subframe	10 consecutive DMT symbols (except for sync symbols) according to TTR timing
TTR TTR _C	TCM-ISDN Timing Reference Timing reference used in ATU-C
TTRR	Timing reference used in ATU-R
UI	Unit Interval

I.3 Reference Models

I.3.1 ATU-C transmitter reference model (replaces figures in 5.1)

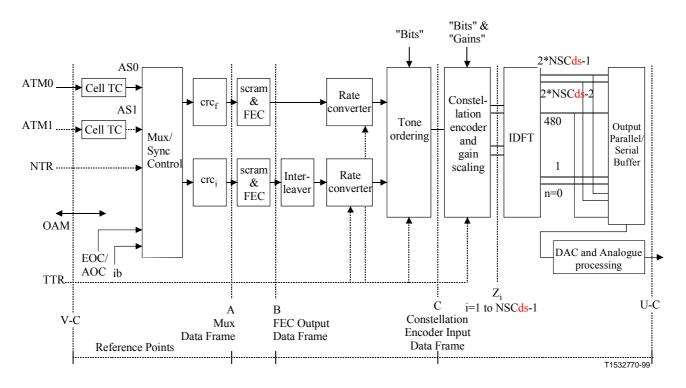
See Figure I.1 and Figure I.2.



NOTE - The TTR may be generated in ATU-C without being provided from the TCM-ISDN clock.



Annex I-EU does not currently support STM transport. It only supports ATM transport.

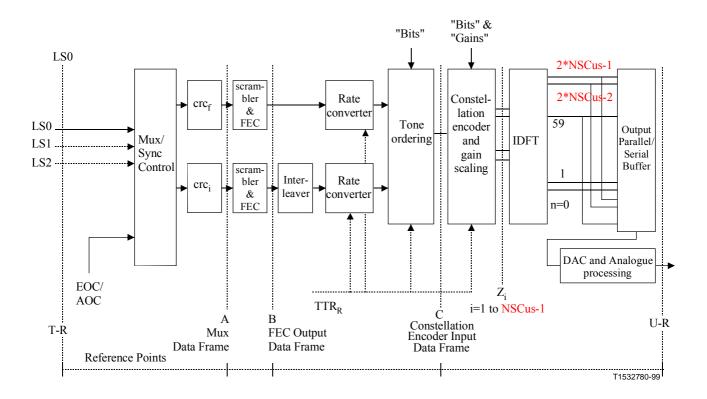


NOTE - The TTR may be generated in ATU-C without being provided from the TCM-ISDN clock.

Figure I.2/G.992.1 – ATU-C transmitter reference model for ATM transport

I.3.2 ATU-R transmitter reference model (replaces figures in 5.2)

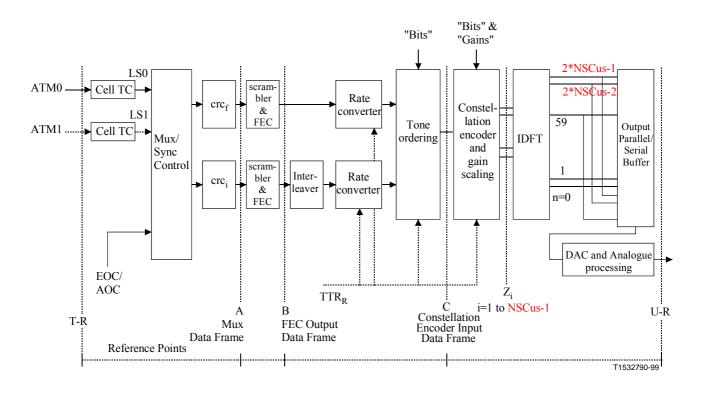
See Figure I.3 and Figure I.4.



NOTE – The TTR_R shall be generated in ATU-R from the received TTR_C signal, and it is locked to 690 periods of upstream sampling clock (1.104 MHz).

Figure I.3/G.992.1 – ATU-R transmitter reference model for STM transport

Annex I-EU does not currently support STM transport. It only supports ATM transport.



NOTE – The TTR_R shall be generated in ATU-R from the received TTR_C signal, and it is locked to 690 periods of upstream sampling clock (1.104 MHz).

Figure I.4/G.992.1 – ATU-R transmitter reference model for ATM transport

I.3.3 ATU-C/R transmitter timing model (replacement for 5.3)

I.3.3.1 TCM-ISDN crosstalk timing model (new)

Figure I.5 shows the timing chart of the crosstalk from TCM-ISDN.

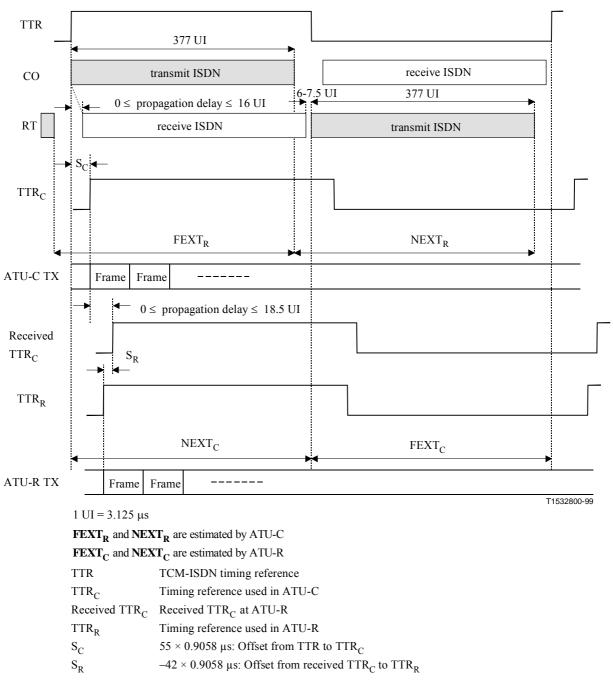


Figure I.5/G.992.1 – Timing chart of the TCM-ISDN crosstalk

The data stream of TCM-ISDN is transmitted in TTR period. CO transmits the stream in the first half of the TTR period and RT transmits in the second half of the TTR period. ATU-C receives NEXT noise from the ISDN in the first half of the TTR period and FEXT noise from the ISDN in the second half of the TCM-ISDN period. On the other hand, ATU-R receives FEXT noise from the ISDN in the first half of the TTR period and NEXT noise from the ISDN in the second half of the TTR period.

As defined in I.7.6.2 and I.7.8.3, the ATU-C shall estimate the FEXT_R and NEXT_R duration at ATU-R, and the ATU-R shall estimate FEXT_C and NEXT_C duration at ATU-C taking propagation delay on the subscribe line into consideration.

The ATU-C shall transmit any symbols by synchronizing with the TTR_C . The ATU-R shall transmit any symbols synchronizing with the TTR_R generated from received TTR_C .

I.3.3.2 Sliding window (new)

Figure I.6 shows the timing chart of the transmission for the Annex I-EU downstream at ATU-C.

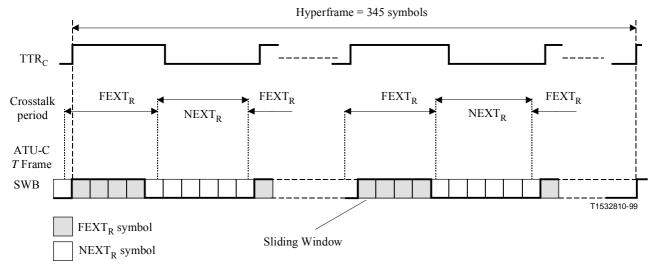


Figure I.6/G.992.1 – Sliding window for downstream symbols

The Sliding Window defines the transmission symbols under the crosstalk noise environment synchronized to the period of TTR. The $\text{FEXT}_{C/R}$ symbol represents the symbol completely inside the $\text{FEXT}_{C/R}$ duration. The $\text{NEXT}_{C/R}$ symbol represents any symbol containing the $\text{NEXT}_{C/R}$ duration. Thus, there are more $\text{NEXT}_{C/R}$ symbols than $\text{FEXT}_{C/R}$ symbols.

The ATU-C decides which transmission symbol is FEXT_R or NEXT_R symbol according to the sliding window and transmits it with the corresponding bit table. Similarly, the ATU-R decides the transmission symbol is a FEXT_C or NEXT_C and transmits it with the corresponding bit table. Although the phase of the sliding window is asynchronous with $\text{TTR}_{C/R}$, the pattern is fixed to the 345 frames of the hyperframe.

I.3.3.3 ATU-C Symbol Synchronization to TTR (new)

345 symbols are 34 cycles with cyclic prefix of TTR_C (or 32 cycles of TTR_C without cyclic prefix). This implies a PLL lock at the ATU-R.

I.3.3.4 Dual Bitmap switching (new)

The ATU-C transmits FEXT_R symbols using Bitmap-F_R (in FEXT_R duration), and transmits NEXT_R symbols using Bitmap-N_R (in NEXT_R duration) according to the result of initialization. The ATU-R transmits FEXT_C symbols using Bitmap-F_C (in FEXT_C duration), and transmits NEXT_C symbols using Bitmap-F_C (in NEXT_C duration), and transmits NEXT_C symbols using Bitmap-N_C (in NEXT_C duration) in the same manner.

The ATU-C shall have the capability to disable Bitmap-N_C and Bitmap-N_R (see I.4.5 and I.5.3).

I.3.3.5 Loop timing at ATU-R (new)

The phase relation between received symbol and transmitted symbol of ATU-R at the reference point U-R shall meet the phase tolerances as shown in Figure I.7.

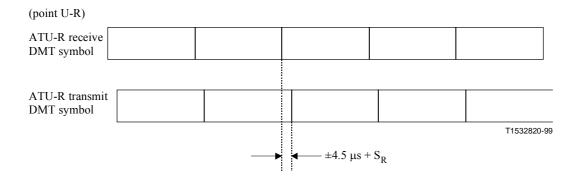


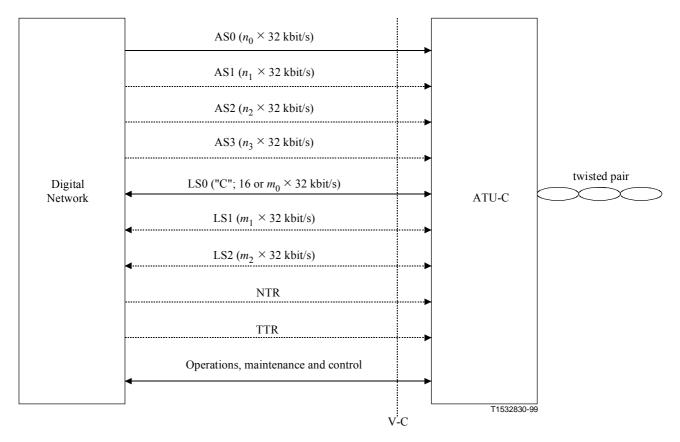
Figure I.7/G.992.1 – Loop timing for ATU-R

I.4 ATU-C functional characteristics (pertains to clause 7)

I.4.1 STM transmission protocols specific functionality (pertains to 7.1)

I.4.1.1 ATU-C input and output V interface for STM transport (replaces figure in 7.1.1)

See Figure I.8.



NOTE 1 – Optional bearer channels (both duplex and simplex) and features are shown with dotted lines. NOTE 2 – TTR may be generated in the ATU-C without being provided from the V-C reference point.

Figure I.8/G.992.1 – ATU-C functional interfaces for STM transport at the V-C reference point

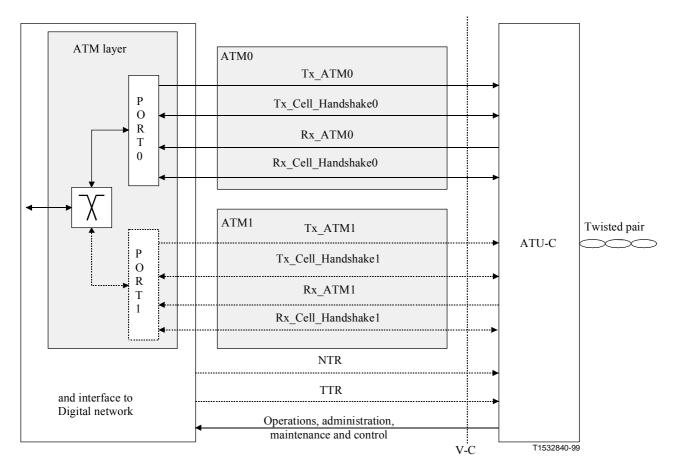
I.4.1.2 Payload transfer delay (supplements 7.1.4)

Since Annex I-EU uses a rate converter, the maximum payload transfer delay is longer than specified values in 7.1.4. The additional one-way transfer delay due to the rate converters shall be less than 1.7 ms for fast data and 13 ms for interleaved data.

I.4.2 ATM transmission protocols specific functionalities (pertains to 7.2)

I.4.2.1 ATU-C Input and Output V interface for ATM transport (replaces figure in 7.2.1)

See Figure I.9.



NOTE - TTR can be generated in the ATU-C without being provided from the V-C reference point.

Figure I.9/G.992.1 – ATU-C functional interfaces to the ATM layer at the V-C reference point

I.4.2.2 Payload transfer delay (supplements 7.2.2)

Since Annex I-EU uses a rate converter, the maximum payload transfer delay is longer than specified values in 7.2.2. The additional one-way transfer delay due to the rate converters shall be less than 1.7 ms for fast data and 13 ms for interleaved data.

I.4.3 Framing (pertains to 7.4)

I.4.3.1 Superframe structure (supplements 7.4.1.1)

Since the rate converter reorders the user data and overhead bit-level data to create hyperframes, the input data frames to the constellation encoder are different than those defined in 7.4.1.1.

I.4.3.2 Hyperframe structure (replaces 7.4.1.3)

Annex I-EU uses the hyperframe structure shown in Figure I.10. Figure I.10 shows the phase relationship between the TTR_C and the hyperframe at the point U-C. Each hyperframe is composed of 5 superframes, which are numbered from 0 to 4. In order to indicate the boundary of the hyperframe, the inverse synch symbol is used for the 4th superframe (SPF#3), which is generated from a tone-by-tone 180-degree phase reversal of the synchronization symbol (see I.4.7.1) except for the pilot tone.

The bit-level data stream from the rate-converter is extracted according to the size of Bitmap- F_R and Bitmap- N_R using the Sliding Window (see I.3.3.2).

In order to make the bit rate to be a multiple of 32 kbit/s, the dummy bits are inserted at the end of hyperframe by the rate converter (see I.4.4.2). The hyperframe is composed of 345 DMT symbols, numbered from 0 to 344. Each symbol is assigned as $FEXT_R$ or $NEXT_R$ symbol in a $FEXT_R$ or $NEXT_R$ duration (see I.2), and the following numerical formula gives the information which duration N_{dmt}-th DMT symbol belongs to at ATU-C transmitter (see Figure I.11).

For N _{dmt} = 0, 1,, 344	
$S = 272 \times N_{dmt} \mod 2760$	
if $\{ (S + 271 < a) \text{ or } (S > a + b) \}$	then FEXT _R symbol
else	then NEXT _R symbol
where a = 1243, b = 1461	

Thus, 128 DMT symbols are allocated in the FEXT_R duration, and 217 DMT symbols are allocated in the NEXT_R duration. The symbols are composed of:

FEXT _R symbol:							
Number of symbol using Bitmap- F_R	= 126						
Number of synch symbol	= 1						
Number of inverse synch symbol	= 1						
NEXT _R symbol:							
Number of symbol using Bitmap-N _R	= 214						
Number of synch symbol	= 3						

During FEXT Bitmap mode, the ATU-C shall transmit only the pilot tone in NEXT_R symbols.

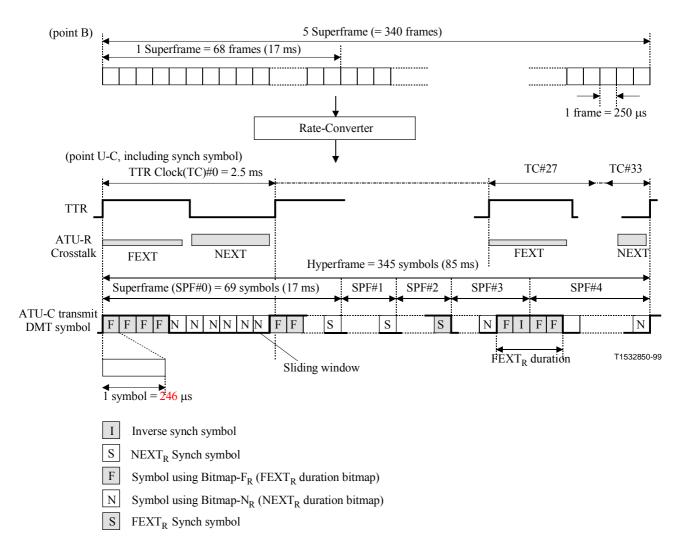


Figure I.10/G.992.1 – Hyperframe structure for downstream

2									
0	0 1 2	3	4	5		6	7	8	9
1	10 11 12	13	14	15	16	5 17	7 18	3 1	9
2	20 21 22	23	24	25	26	27	28	29	
3	30 31 32	33 3	34	35	36	37	38	39	40
4	41 42	43 44	4	45	46	47	48	49	50
5	51 52 5	3 54		55	56	57	58	59	60
6	61 62 63	64	6	5 6	6	67	SS	69	70
7	71 72 73	74	75	76	7	7 7	8 7	9 8	30
8	81 82 83	84	85	86	87	88	89) 9()
9	91 92 93	94	95	96	97	98	99	100	101
10	101 102 103	104 10	05	106	107	108	109	110	111
11		14 11:		116	117	118	119	120	121
12	122 123 12				127	128	129	130	131
13	132 133 134	135	13						141
14	142 143 144	145	146						51
15	152 153 154	155	156		158				
16	162 163 164		166	167	168	169	170	171	172
17			76	177	178	179	180	181	182
18	183 184 1 193 194 19	85 180 5 196		187 97 1	188 98	189 199	190 200	191 201	192
19 20	203 204 205	5 196 SS	20		· · ·		· · ·		202
20	203 204 203 213 214 215	216	217	· · · · ·		<u> </u>			212 22
21	213 214 213 223 224 225	226	227		229	·			
22	233 234 235		227	238	239	240	241	242	243
23		246 24		248	249	250	251	252	253
25		56 257		258	259	260	260	262	263
26	264 265 26					270	271	272	273
27	274 ISS 276	277	27		9 2	80 2	81 2	82 2	283
28	284 285 286	287	288	289	29	0 29	1 29	2 29)3
29	294 295 296	297	298	299	300	301	302	303	;
30	304 305 306	307 3	08	309	310	311	312	313	314
31	315 316 3	317 31	8	319	320	321	322	323	324
32	325 326 32	27 328	3	329	330	331	332	333	334
33	335 336 337	7 338	3	39 3	40	341	342	343	SS
	ISS Inverse synch sym	ibol S	SS F	EXT _r Sy	/nch syn	nbol SS	NEXT	Г _R synch	symbol
	FEXT _R data symbol	ol 🗌	N	IEXT _R da	ata symb	ol		T1	535330-00

Figure I.11/G.992.1 – Symbol pattern in a hyperframe with cyclic prefix – Downstream

I.4.3.3 Subframe Structure (replaces 7.4.1.4)

A subframe is 10 consecutive DMT symbols (except for synch symbols) as shown in Table I.1. The 34 subframes form a hyperframe.

Subframe No.	DMT symbol No.	Note
0	0-9	
1	10-19	
2	20-29	
3	30-39	
4	40-49	
5	50-59	
6	60-70	#68 is Synch Symbol
7	71-80	
8	81-90	
9	91-100	
10	101-110	
11	111-120	
12	121-130	
13	131-141	#137 is Synch Symbol
14	142-151	
15	152-161	
16	162-171	
17	172-181	
18	182-191	
19	192-201	
20	202-212	#206 is Synch Symbol
21	213-222	
22	223-232	
23	233-242	
24	243-252	
25	253-262	
26	263-272	
27	273-283	#275 is Inverse Synch Symbol
28	284-293	
29	294-303	
30	304-313	
31	314-323	
32	324-333	
33	334-344	#344 is Synch Symbol

Table I.1/G.992.1 – Subframe (downstream)

I.4.3.4 Reduced overhead framing with merged fast and sync bytes (modifies 7.4.3.2)

In S=1/2n framing mode (see §I.4.9), there are n Sync bytes per symbol time. The contents of the Sync bytes is the same as in regular framing except that it repeats at n times the rate causing the superframe to be 68/n symbols in length. The contents of the sync bytes are shown in Table 7-6/G.992.1. In S=1/2n framing mode, "Frame Number" in column 1 in Table 7-6/G.992.1 is replaced by "Sync Byte Index Number".

As a result of the increase in superframe rate, the superframe contents is carried more frequently. For the case when N=2, the EOC and AOC bandwidth doubles, thereby transferring actual messages at twice the rate. The CRC byte is carried twice as frequently and therefore the maximum error rate rises from just over 58 per second to 117 per second. Where the duration of an error condition is measured, this needs to be taken into consideration. The indicator bits are also sent twice as often, which needs to be taken into consideration for statistics collection.

I.4.4 Dual Bitmapping and Rate Conversion (replaces 7.15)

The functions of the rate converter (see I.4.4.2), tone ordering (see I.4.6), constellation encoding, and gain scaling shall use one of two bitmaps stored in the ATU. This method is called the dual bitmap.

I.4.4.1 Dual Bitmap (new)

The Dual Bitmap method has individual bit rates under the FEXT and NEXT noise, and this needs an additional bit and gain table, $\{b_i, g_i\}$, and ordered bit table, b'_i , for the tone ordering. The dual bitmaps are switched synchronized with the sliding window pattern of NEXT/FEXT symbols. The number of bits and the relative gains to be used for every tone are calculated in the bit loading algorithm during the initialization sequence, and transmitted in R-B&G.

I.4.4.2 Rate Converter (new)

The rate converter buffering changes the data frame boundaries between the reference points B and C according to Bitmap- F_R , Bitmap- N_R and the Sliding Window. Two independent rate converters are prepared for fast data and interleaved data. The amount of fast and interleaved data in Bitmap- F_R and Bitmap- N_R shall be calculated with the following formulae and illustrated in Figure I.12:

If $t_{Rf} \le n_{Rmax}$:

$$n_{Rf} = t_{Rf}$$

$$n_{Ri} = n_R - n_{Rf}$$

$$f_{Rf} = t_{Rf}$$

$$f_{Ri} = f_R - f_{Rf}$$

If $t_{Rf} > n_{Rmax}$:

$$n_{Rf} = n_{R \max}$$

$$n_{Ri} = 0$$

$$f_{Rf} = \begin{cases} f_{Rf4} = \left\lceil \frac{t_{Rf} \times 10 - n_{Rf} \times 6}{4} \right\rceil$$

$$f_{Rf3} = \left\lceil \frac{t_{Rf} \times 10 - n_{Rf} \times 7}{3} \right\rceil$$

$$f_{Ri} = \begin{cases} f_{Ri4} = f_R = f_{Rf4} \\ f_{Ri3} = f_R - f_{Rf3} \end{cases}$$

Where:

^t Rf	is the number of allocated bits in one frame for fast bytes at the reference point B.
t _{Ri}	is the number of allocated bits for interleaved bytes at the reference point B.
f_{Rf} and n_{Rf}	are the numbers of fast bits in Bitmap- F_R and Bitmap- N_R , respectively.
f _{Rf3}	is the number of fast bits in Bitmap-F _R if the subframe (see I.4.3.3) contains 3 Bitmap-F _R except for
f _{Rf4}	synch symbols. is the number of fast bits in Bitmap- F_R if the subframe contains 4 Bitmap- F_R except for synch
f _{Ri} and n _{Ri} n _R	symbols. are the numbers of interleaved bits in Bitmap- F_R and Bitmap- N_R , respectively. is the number of total bits in Bitmap- N_R , which is specified in the B&G tables.

During FEXT Bitmap mode, n_{Rf} and n_{Ri} are zero.

To convert the bit rate to be a multiple of 32 kbit/s, the dummy bits for fast data are inserted to the tail of each subframe, and the dummy bits for interleaved data are inserted to the end of the Hyperframe. The number of the dummy bits shall be as follows:

If $t_{Rf} \le n_{Rmax}$:

$$dummy_{Rf} = 0$$

$$dummy_{Ri} = (f_{Ri} \times 126 + n_{Ri} \times 214) - t_{Ri} \times 340$$

If $t_{Rf} > n_{Rmax}$:

$$dummy_{Rf4} = (f_{Rf} \times 4 + n_{Rf} \times 6) - t_{Rf} \times 10$$

$$dummy_{Rf3} = (f_{Rf} \times 3 + n_{Rf} \times 7) - t_{Rf} \times 10$$

$$dummy_{Ri} = (f_{Ri4} \times 96 + f_{Ri3} \times 30) - t_{Ri} \times 340$$

If the fast data buffer uses single latency only, additional dummy bits are inserted at the tail of each FEXT symbol in the 4 Bitmap- F_R constructed subframe. The number of additional dummy bits inserted at the tail of each FEXT symbol shall be as follows:

$$dummy_{SRf} = f_{Rf3} - f_{Rf4}$$

The receiver shall determine Bitmap- F_R and Bitmap- N_R so that $dummy_{Ri}$ is less than 126, $dummy_{Rf4}$ is less than 4 and $dummy_{Rf3}$ is less than 3 in the initialization sequence. At the receiver, the inserted dummy bits shall be removed.

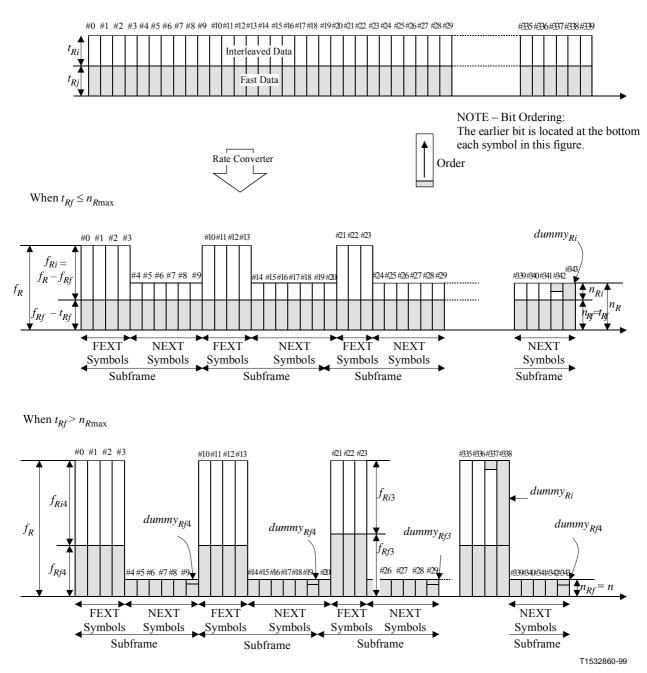


Figure I.12/G.992.1 – Bit distribution for Rate Converter under Dual latency and Dual Bitmap mode

I.4.5 FEXT Bitmapping (replaces 7.16)

The FEXT Bitmapping mode uses the Dual Bitmapping technique (I.4.4) to transmit data only during FEXT. The ATU-C shall transmit only the pilot tone during the $NEXT_R$ symbol. The ATU-R disables Bitmap-N_C and shall not transmit any signal during the $NEXT_C$ symbol (see Figures I.10 and I.16).

The Dual versus FEXT bitmapping mode is selected during G.994.1 using bit "DBM" (see 10.2 and 10.3).

I.4.6 Tone Ordering (replacement for 7.7)

A DMT time-domain signal has a high peak-to-average ratio (its amplitude distribution is almost Gaussian), and large values may be clipped by the digital-to-analogue converter. The error signal caused by clipping can be considered as an additive negative impulse for the time sample that was clipped. The clipping error power is almost equally distributed across all tones in the symbol in which clipping occurs. Clipping is therefore most likely to cause errors on those tones

that, in anticipation of a higher received SNR, have been assigned the largest number of bits (and therefore have the densest constellations). These occasional errors can be reliably corrected by the FEC coding if the tones with the largest number of bits have been assigned to the interleave buffer.

The numbers of bits and the relative gains in two bitmaps to be used for every tone are calculated in ATU-R receiver, and sent back to ATU-C according to a defined protocol (see 10.9.14). The pairs of numbers are typically stored, in ascending order of frequency or tone numbers *i*, in bit and gain tables for Bitmap- F_R and Bitmap- N_R .

For Bitmap- F_R , the "tone-ordered" encoding shall first assign f_{Rf} bits from the rate converter (see I.4.4.2) to the tones with the smallest number of bits assigned to them, and the remaining f_{Ri} bits to the remaining tones. For Bitmap- N_R , it shall first assign n_{Rf} bits from the rate converter to the tones with the smallest number of bits assigned to them, and the remaining n_{Ri} bits to the remaining tones.

All tones shall be encoded with the number of bits assigned to them; one tone in each bitmap may therefore have a mixture of bits from the fast and interleaved buffers.

The ordered bit tables b'_{iF} and b'_{iN} shall be based on the original bit tables b_{iF} and b_{iN} as follows:

For k = 0 to N_{downmax} {

From the bit table, find the set of all *i* with the number of bits per tone $b_i = k$

Assign b_i to the ordered bit allocation table in ascending order of i

```
}
```

Two ordered bit tables for Bitmap- F_R and Bitmap- N_R shall be prepared. A complementary de-ordering procedure should be performed in ATU-R receiver. It is not necessary, however, to send the results of the ordering process to the receiver because the bit tables F_R and N_R were originally generated in ATU-R, and therefore those tables have all the information necessary to perform the de-ordering.

I.4.7 Modulation (pertains to 7.11)

I.4.7.1 Inverse Synchronization Symbol (replaces 7.11.4)

Except for the pilot tone, Inverse Synchronization symbol shall be generated from a tone-by-tone 180 degree phase reversal of Synchronization symbol (i.e. + maps to -, and - maps to +, for each of the 4-QAM signal constellation).

I.4.7.2 Data subcarriers (modifies 7.11.1.1)

The channel analysis signal defined in 10.6.6 allows for a maximum of NSCds-1 carriers (at frequencies $n\Delta f$, n = 1 to NSCds-1) to be used.

I.4.7.3 Nyquist frequency (modifies 7.11.1.3)

The carrier at the Nyquist frequency (#NSCds) shall not be used for user data and shall be real valued; other possible uses are for further study.

I.4.7.4 Modulation by the inverse discrete Fourier transform (replaces 7.11.2)

The modulating transform defines the relationship between the 2*NSCds real values x_n and the Z_i :

$$x_n = \sum_{i=0}^{2^* NSC^{-1}} \exp\left(\frac{j\pi ni}{NSC}\right) Z_i \quad \text{for } n = 0 \text{ to } 2^* NSC^{-1}$$
(7-21)

The value of NSCds shall be 512 for this Annex.

The constellation encoder and gain scaling generate only NSCds-1 complex values of Z_i . In order to generate real values of x_n , the input values (NSCds-1 complex values plus zero at DC and one real value for Nyquist if used) shall be augmented so that the vector Z has Hermitian symmetry. That is,

 $Z_i = \operatorname{conj} \left(Z'_{2*NSCds-i} \right) \quad \text{for } i = \operatorname{NSCds+1} \text{ to } 2*\operatorname{NSCds-1}$ (7-22)

I.4.7.5 Synchronization symbol (modifies 7.11.3)

The synchronization symbol permits recovery of the frame boundary after micro-interruptions that might otherwise force retraining.

The data symbol rate, $f_{symb} = 4$ kHz, the carrier separation, $\Delta f = 4.3125$ kHz, and the IDFT size, N = 2*NSCds, are such that a cyclic prefix of 15.625%*NSCds samples could be used. That is, when NSCds = 256, there are 40 samples in the cyclic prefix.

$$(512+40) \times 4.0 = 512 \times 4.3125 = 2208 \tag{7-23}$$

The cyclic prefix shall, however, be shortened to 12.5%*NSCds samples, and a synchronization symbol (with a nominal length of NSCds*2.125 samples) is inserted after every 68 data symbols. That is,

$$(2 + 0.125)$$
*NSCds × 69 = $(2 + 0.15625)$ *NSCds × 68(7-24)

The data pattern used in the synchronization symbol shall be the pseudo-random sequence PRD, $(d_n, \text{ for } n = 1 \text{ to } 2*\text{NSCds})$ defined by:

$$d_n = 1$$
 for $n = 1$ to 9 (7-25)
 $d_n = d_{n-4} \oplus d_{n-9}$ for $n = 10$ to 2*NSCds (7-26)

The first pair of bits (d_1 and d_2) shall be used for the DC and Nyquist subcarriers (the power assigned to them is zero, so the bits are effectively ignored); the first and second bits of subsequent pairs are then used to define the X_i and Y_i for i = 1 to NSCds-1 as shown in Table 7-13.

The period of the PRD is only 511 bits, so d_{n+511} is equal to d_n . The d_1 - d_9 shall be re-initialized for each synchronization symbol, so each symbol uses the same data.

The two bits that modulate the pilot carrier, shall be overwritten by $\{0,0\}$: generating the $\{+,+\}$ constellation.

The minimum set of subcarriers to be used is the set used for data transmission (i.e. those for which $b_i > 0$); subcarriers for which $b_i = 0$ may be used at a reduced PSD as defined in transmit PSD paragraphs of Annexes A, B and C. The data modulated onto each subcarrier shall be as defined above; it shall not depend on which subcarriers are used.

I.4.7.6 Cyclic prefix (replaces 7.12)

The last 12.5%*NSCds samples of the output of the IDFT (x_n for n = 2*NSCds-0.125*NSCds to 2*NSCds-1) shall be prepended to the block of 2*NSCds samples and read out to the digital-to-analogue converter (DAC) in sequence. For example, when NSCds=256, the subscripts, n, of the DAC samples in sequence are 480 ... 511, 0 ... 511.

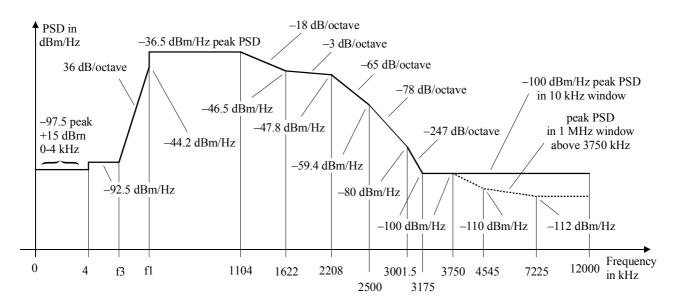
The cyclic prefix shall be used for all symbols beginning with the C-RATES1 segment of the initialization sequence, as defined in 10.6.2.

I.4.8 ATU-C Downstream transmit spectral masks (replaces 7.14)

The downstream spectral masks of Annex I-EU are as specified in this section. When C-MSG1 bit 16 is 0, the PSD mask as specified in § I.4.8.1 shall be used. When C-MSG1 bit 16 is 1, the PSD mask as specified in § I.4.8.2 shall be used.

I.4.8.1 Downstream non-overlapped PSD mask definition

The non-overlapped PSD masks are defined with absolute peak values in Figure I.13. The low frequency stop band is defined for frequencies below f1 kHz (tone n1); the high frequency stop band is defined at frequencies greater than 2208 kHz (tone 512). The in-band region of these PSD masks is the frequency band from f1 kHz to 2208 kHz.



Frequency band f (kHz)	Equation for line (dBm/Hz)
0 < f < 4	-97.5
4 < f < f3	-92.5
f3 < f < f1	$-92.5 + 36 \cdot \log 2(f/f3)$
f1 < f < 1104	-36.5
$1104 \le f \le 1622$	-36.5 - 18.0*log2(f/1104)
1622 < f < 2208	-46.5 - 3.0*log2(f/1622)
2208 < f < 2500	-47.8 - 65*log2(f/2208)
2500 < f < 3001.5	-59.4 - 78*log2(f/2500)
3001.5 < f < 3175	-80 - 247*log2(f/3001.5)
3925 < f < 12000	-100

Frequency (kHz)	PSD level (dBm/Hz)	Measurement BW
0	-97.5	100 Hz
4	-97.5	100 Hz
4	-92.5	100 Hz
f3	-92.5	10 kHz
fl	-44.2	10 kHz
fl	-36.5	10 kHz
1104	-36.5	10 kHz
1622	-46.5	10 kHz
2208	-47.8	10 kHz
2500	-59.4	10 kHz
3001.5	-80	10 kHz
3175	-100	10 kHz
12000	-100	10 kHz

Additionally the PSD masks shall satisfy the following requirements:

Frequency (kHz)	PSD level (dBm/Hz)	Measurement BW
3750	-100	1 MHz
4545	-110	1 MHz
7225	-112	1 MHz
12000	-112	1 MHz

The corner frequencies f1 and f3 depend on the associated upstream PSD mask used, see §I.5.6) and are defined as follows:

Mask designator	Associated	f1 (kHz)	f3 (kHz)
(DS-mm)	upstream mask		
DS-32	EU-32	138	54.45
DS-36	EU-36	155.25	61.26
DS-40	EU-40	172.5	68.06
DS-44	EU-44	189.75	74.87
DS-48	EU-48	207	81.67
DS-52	EU-52	224.25	88.48
DS-56	EU-56	241.5	95.29
DS-60	EU-60	258.75	102.09
DS-64	EU-64	276	108.9
DS-68	EU-S68	293.25	115.71
DS-72	EU-S72	310.5	122.51
DS-76	EU-S76	327.75	129.32
DS-80	EU-S80	345	136.12
DS-84	EU-S84	362.25	142.93
DS-88	EU-S88	379.5	149.74
DS-92	EU-S92	396.75	156.54
DS-96	EU-S96	414	163.35

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. The breakpoints in the tables shall be connected by linear straight lines on a dB/log(f) plot.

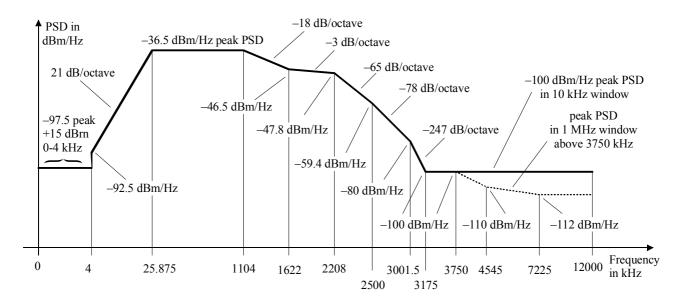
- NOTE 3 MBW specifies the Measurement Bandwidth. The MBW specified for a certain breakpoint with frequency fi is applicable for all frequencies satisfying fi $< f \le fj$, where fj is the frequency of the next specified breakpoint.
- NOTE 4 The power in a 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency i.e. power in the [f, f + 1 MHz] window shall conform to the specification at frequency f.
- 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.

Figure I.13: Non-overlapped Downstream Channel PSD Masks.

Spectral Shaping of the In-Band Region defined in I.4.8.3 and Transmit Signals with Limited Transmit Power defined in I.4.8.4 shall be applied.

I.4.8.2 Downstream Overlapped PSD mask definition

The overlapped PSD mask is defined with absolute peak values in Figure I.14. The low frequency stop band is defined for frequencies below 25.875 kHz (tone 6); the high frequency stop band is defined at frequencies greater than 2208 kHz (tone 512). The in-band region of this PSD mask is the frequency band from 25.875 kHz to 2208 kHz.



Frequency band f (kHz)	Equation for line (dBm/Hz)
0 < f < 4	-97.5
4 < f < 25.875	$-92.5 + 21*\log 2(f/4)$
25.875 < f < 1104	-36.5
1104 < f < 1622	-36.5 - 18.0*log2(f/1104)
1622 < f < 2208	-46.5 - 3.0*log2(f/1622)
2208 < f < 2500	$-47.8 - 65*\log 2(f/2208)$
2500 < f < 3001.5	-59.4 - 78*log2(f/2500)
3001.5 < f < 3175	-80 - 247*log2(f/3001.5)
3925 < f < 12000	-100

Frequency (kHz)	PSD level (dBm/Hz)	Measurement Bandwidth
0	-97.5	100 Hz
4	-97.5	100 Hz
4	-92.5	100 Hz
25.875	-36.5	10 kHz
1104	-36.5	10 kHz
1622	-46.5	10 kHz
2208	-47.8	10 kHz
2500	-59.4	10 kHz
3001.5	-80	10 kHz
3175	-100	10 kHz
12000	-100	10 kHz

Additionally, the PSD mask shall be satisfying following requirements:

Frequency (kHz)	PSD level (dBm/Hz)	Measurement Bandwidth
3750	-100	1 MHz
4545	-110	1 MHz
7225	-112	1 MHz
12000	-112	1 MHz

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. The breakpoints in the tables shall be connected by linear straight lines on a dB/log(f) plot.

NOTE 3 - MBW specifies the Measurement Bandwidth. The MBW specified for a certain breakpoint with

frequency fi is applicable for all frequencies satisfying $fi < f \le fj$, where fj is the frequency of the next specified breakpoint.

- NOTE 4 The power in a 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency i.e. power in the [f, f + 1 MHz] window shall conform to the specification at frequency f.
- 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.

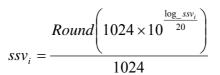
Figure I.14: Non-overlapped Downstream Channel PSD Mask.

I.4.8.3 Spectral Shaping of In-Band Region of PSD Spectrum

In order to shape the ATU-C PSD, frequency dependent gains, called spectral shaping values (ssv_i), shall be applied on each tones during initialisation and showtime. The ssv_i values shall be represented with 1 bit before and 10 bits after the decimal point.

Table I.2 defines the corner points for the nominal PSD shape of the inband region as gain in dB, i.e log_ssv_i . Log_ssv_i on other tones shall be linearly interpolated between corner points on a logarithmic scale for the gain (dB) and a linear scale for the frequency (Hz). Note that the corner points defined in Table I.2 are relative values. Table I.3 defines the similar corner points for the overlapped spectrum.

The spectral shaping values shall be converted from logarithmic scale (log_ssv_i , dB values) to linear ssv_i values according to:



These points are not passed at initialization for the nominal PSD shape but are provided here for reference. However, for additional spectral shaping (see I.4.8.5), parameters are passed during G.994.1.

The combined accuracy of the process of linear interpolation of the log_ssvi values and the process of conversion to linear ssv_i values shall be strictly less than one half lsb of the 10 bit after the decimal point format of the linear ssvi values. No error shall be introduced when log_ssv_i equals 0dB or is interpolated between log_ssv_i values, which equal 0dB.

- NOTE 1: The above definition ensures that the maximum deviation between ssv_i values used by transmitter and receiver is one lsb.
- NOTE 2: The above needs an accuracy that is strictly < 1/2 lsb. An accuracy of = 1/2 lsb, will lead to inaccurate results.

Tone Index	$Log_ssv_i(dB)$	Comments
nl	0	f1 kHz defines the beginning of the inband region. No shaping is applied in the
		low stop band.
256	0	1104 kHz
376	-10	1622 kHz (-10 = -50 - Nominal PSD lowband)
511	-11.3	2208 kHz (-11.3 = -51.3 - Nominal_PSD_lowband)

Table I.2: Corner	points for the non-	overlapped nominal	in-band PSD shape.

Tone Index	$Log_ssv_i(dB)$	Comments
6	0	25.875 kHz defines the beginning of the inband region. No shaping is applied
		in the low stop band.
256	0	1104 kHz
376	-10	$1622 \text{ kHz} (-10 = -50 \text{ - Nominal_PSD_lowband})$
511	-11.3	2208 kHz (-11.3 = -51.3 - Nominal_PSD_lowband)

Table I.3: Corner points for the overlapped nominal in-band PSD shape

The absolute values of the transmit PSD are obtained by scaling the relative shaping values with a NOMINAL_PSD_lowband, defined for the lower in-band frequencies. Note that the nominal in-band transmit PSD is frequency dependent. The NOMINAL_PSD_lowband is -40 dBm/Hz (below 1104 kHz) for both the overlapped and non-overlapped spectra.

NOTE 3: In-band PSD spectral shaping is applied prior to the IFFT.

NOTE 4: The value of MAXNOMATPds may be limited by regional regulations.

I.4.8.4 Transmit Signals with Limited Transmit Power

For cases where the transmit signal must be limited to a maximum aggregate transmit power (e.g. $ATP_{dsmax} = +20$ dBm), then

- f) During initialization the PSD transmit level is specified as an offset from the nominal value, i.e. (Nominal_PSD_lowband + ssvi x power cutback) dB, and all values of gi = 1 for the offset value x and power cutback. The same value of offset x is used for both overlapped and non-overlapped cases. The value of x shall be the greater of 0 dB and (21.3 ATPdsmax) dB. For ATPdsmax = 20 dBm, the corresponding value of x shall be 1.3 dB.
- b) If bi>0, then valid range for gi is [-14.5 to +2.5+x] (dB);
 If bi>0, then gi shall be in the [g_{sync} 2.5 to g_{sync} + 2.5] (dB) range;
 If bi=0, then gi shall be equal to 0 (linear) or in the [-14.5 to g_{sync}] (dB) range;
 For G.992.1 annex I-EU, g_{sync} <= x dB

The g_i values shall be constrainted by following relation:

Constraint on g _i values	$\sum_{i=6}^{511} ssv_i^2 * g_i^2 \le \sum_{i=6}^{511} ssv_i^2$
-------------------------------------	---

I.4.8.5 Additional inband spectral shaping

An ATU-R may request additional downstream inband spectral shaping by passing parameters to the ATU-C in a G.994.1 MP, or MS message. The ATU-C may select additional downstream inband spectral shaping by passing parameters to the ATU-R in a G.994.1 MS message. Within the framework of G.994.1, the ATU-C has the ability to make the final decision on the downstream inband PSD shape to be used.

The additional inband spectral shaping parameters are listed in I.7.2.2 and defined in I.7.3. If the Additional inband spectral shaping Spar(2) bit is set to ONE in Table I.7.4, its associated Npar(3) octets in Tables I.7.4.1 to I.7.4.1.5 define the inband spectral shape. If the additional inband spectral shaping Spar(2) bit is set to ZERO, its associated Npar(3) octets are not transmitted and the nominal inband PSD shape defined in I.4.8.3 shall be used. These Npar(3) octets define the downstream PSD levels in the low band (between f1 and 1104 kHz), at 1622 kHz and at 2208 kHz. The PSD levels between 1104 kHz and 1622 kHz, and between 1622 kHz and 2208 kHz are linearly interpolated in log scale. The defined values are the PSD level in dB below the NOMINAL_PSD_lowband of -40dBm/Hz. For example, if all three values are set to 20 dB, the result will be a flat PSD of -60dBm/Hz. If the three values are set to 2 dB, 12 dB and 15.5 dB, the result is the PSD defined in I.4.8.1 reduced by 2dB. In order not to violate the PSD mask defined in I.4.8.1, the second value shall be no less than 10 dB and the third value shall be no less than 11.3 dB.

I.4.8.6 Egress control

G.992.1 Annex I-EU equipment shall be able to reduce the PSD below -80 dBm/Hz for the Amateur radio band between 1.81 MHz and 2.00 MHz. The ATU-C may apply additional spectral shaping as described in I.4.8.5 to help achieve this requirement.

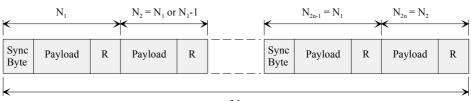
I.4.9 Support of higher downstream bit rates with S = 1/2n (replaces 7.6.4)

With a rate of 4000 data frames per second and a maximum of 255 bytes (maximum RS codeword size) per data frame, the ADSL downstream line rate is limited to approximately 8 Mbit/s per latency path. The line rate limit can be increased beyond this for the interleaved path by mapping 2n RS codewords into one FEC data frame (i.e. by using S = 1/2n in the interleaved path). S = 1/2n shall be used in the downstream direction only over bearer channel AS0.

For a selected value of $n \ge 1$, the K_I data bytes per interleaved mux data frame shall be packed into 2n RS codewords, split into n equal parts, each consisting of 2 consecutive RS codewords. This forces rate adaptation to occur in 32n kbit/s increments. Each of the n parts of the data frame shall begin with a sync byte and shall obey the rules defined in Table I.4 for insertion of dummy bytes. The smallest value of n that can support the K_I data bytes shall be used.

Support of S = 1/2 (i.e., n=1) and S = 1/4 (i.e., n=2) is mandatory.

The resulting data frame structure shall be as shown in Figure I.15.



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Figure I.15 – Data frame for S = 1/2n mode

When K_I is divisible by 2n, the 2n codewords have the same length $N_{2i-1} = N_{2i} = (K_I/2n + R_I)$ for i = 1 to n, otherwise the odd numbered codewords are equal and are one byte longer than the even numbered codewords, i.e. $N_{2i-1} = (K_I + n)/2n + R_I$ bytes, and $N_{2i} = (K_I - n)/2n + R_I$ bytes for i = 1 to n. For the FEC output data frame, $N_I = \sum_{i=1}^{n} N_i$, with $N_I < 512n - 1$ bytes.

The convolutional interleaver requires all codewords to have the same odd length. To achieve the odd codeword length, insertion of dummy (not transmitted) bytes may be required. For S = 1/2n, the dummy byte addition to the odd numbered and/or even numbered codewords at the input of the interleaver shall be as in Table I.4.

Table I.4/G.992.1 –Dumm	y byte insertion	at interleaver input for $S = 1/2r$	1
-------------------------	------------------	-------------------------------------	---

N _{2i-1}	N _{2i}	Dummy Byte Insertion Action
Odd	Odd	No action
Even	Even	Add one dummy byte at the beginning of all codewords
Odd	Even	Add one dummy byte at the beginning of each even numbered codeword
Even	Odd	Add one dummy byte at the beginning of each odd numbered codeword and two dummy bytes at the beginning of each even numbered codeword [the de-interleaver shall insert one dummy byte into the de-interleaver matrix on the first byte and the $(D + 1)$ th byte of the corresponding codeword to make the addressing work properly]

I.5 ATU-R Functional Characteristics (pertains to clause 8)

I.5.1 Framing (pertains to 8.4)

I.5.1.1 Superframe structure (replaces 8.4.1.1)

The superframe structure of ATU-R transmitter is identical to that of ATU-C transmitter, as specified in I.4.3.1.

I.5.1.2 Hyperframe structure (replaces 8.4.1.3)

The hyperframe structure of ATU-R transmitter is functionally similar to that of ATU-C transmitter, except that the inverse synch symbol is used in the 1st superframe (SPF#0) (see Figure I.16). The hyperframe is composed of 345 DMT symbols, numbered from 0 to 344. Each symbol is under $FEXT_C$ or $NEXT_C$ duration (see I.5.3), and the following numerical formula gives the information which duration N_{dmt}-th DMT symbol belongs to at ATU-R transmitter (see Figure I.17).

For $N_{dmt} = 0, 1, ..., 344$ $S = 272 \times N_{dmt} \mod 2760$ if { (S > a) and (S + 271 < a + b) } then FEXT_C symbol else then NEXT_C symbol where a = 1315, b = 1293

128 DMT symbols are allocated in the FEXT_{C} duration, and 217 DMT symbols are allocated in the NEXT_{C} duration. The symbols are composed of:

FEXT _C symbol:	
Number of symbol using Bitmap- F_{C}	= 126
Number of synch symbol	= 1
Number of inverse synch symbol	= 1
NEXT _C symbol:	
Number of symbol using Bitmap-N _C	= 214
Number of synch symbol	= 3

During FEXT Bitmapping mode, the ATU-R shall not transmit any signal.

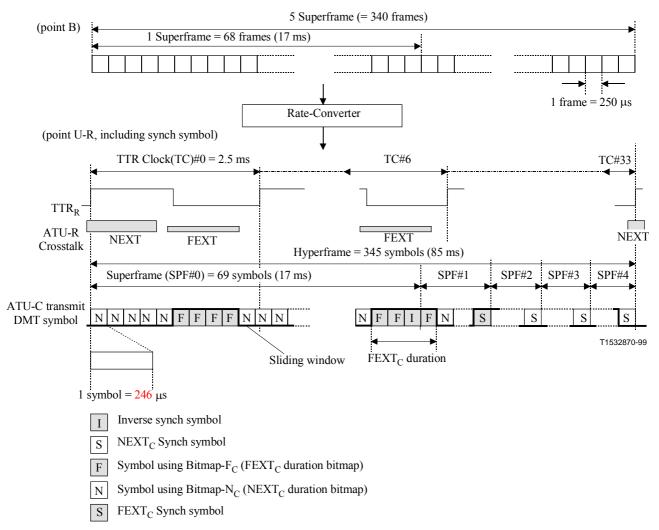


Figure I.16/G.992.1 – Hyperframe structure for upstream

ттр	
TTR _R	
0	0 1 2 3 4 5 6 7 8 9
1	10 11 12 13 14 15 16 17 18 19
2	20 21 22 23 24 25 26 27 28 29
3	30 31 32 33 34 35 36 37 38 39 40
4	41 42 43 44 45 46 47 48 49 50
5	51 52 53 54 55 56 57 58 59 60
6	61 62 63 64 65 66 67 ISS 69 70
7	71 72 73 74 75 76 77 78 79 80
8	81 82 83 84 85 86 87 88 89 90
9	91 92 93 94 95 96 97 98 99 100 101
10	101 102 103 104 105 06 107 108 109 110 111
11	112 113 114 115 1 6 117 118 119 120 21
12	122 123 124 125 126 127 128 129 130 131
13	132 133 134 135 136 SS 138 139 140 141
14	142 143 144 145 146 147 148 149 150 151
15	152 153 154 155 156 157 158 159 160 161
16	162 163 164 165 166 167 168 169 170 171 172
17	173 174 175 176 77 178 179 180 181 82
18	183 184 185 186 187 188 189 190 191 92
19	193 194 195 196 197 198 199 200 201 202
20	203 204 205 SS 207 208 209 210 211 212
21	213 214 215 216 217 218 219 220 221 222
22	223 224 225 226 227 228 229 230 231 232
23	233 234 235 236 237 238 239 240 241 242 243
24	244 245 246 247 248 249 250 251 252 253
25	254 255 256 257 2 5 8 259 260 260 262 2 63
26	264 265 266 267 268 269 270 271 272 273
27	274 SS 276 277 278 279 280 281 282 283
28	284 285 286 287 288 289 290 291 292 293
29	294 295 296 297 298 299 300 301 302 303
30	<u>304</u> 305 306 307 308 <u>309</u> 310 311 312 313 <u>3</u> 14
31	315 316 317 318 319 320 321 322 323 324
32	325 326 327 328 329 330 331 332 333 334
33	335 336 337 338 339 340 341 342 343 S5
	ISS Inverse synch symbol SS FEXT _R Synch symbol SS NEXT _R synch symbol
	FEXT _R data symbol NEXT _R data symbol T1535340-00

Figure I.17/G.992.1 – Symbol pattern in a hyperframe with cyclic prefix – Upstream

I.5.1.3 Subframe structure (replaces 8.4.1.4)

A subframe is 10 consecutive DMT symbols (except for synch symbols) as shown in Table I.5. The 34 subframes form a hyperframe.

Subframe No.	DMT symbol No.	Note
0	0-9	
1	10-19	
2	20-29	
3	30-39	
4	40-49	
5	50-59	
6	60-70	#68 is Inverse Synch Symbol
7	71-80	
8	81-90	
9	91-100	
10	101-110	
11	111-120	
12	121-130	
13	131-141	#137 is Synch Symbol
14	142-151	
15	152-161	
16	162-171	
17	172-181	
18	182-191	
19	192-201	
20	202-212	#206 is Synch Symbol
21	213-222	
22	223-232	
23	233-242	
24	243-252	
25	253-262	
26	263-272	
27	273-283	#275 is Synch Symbol
28	284-293	
29	294-303	
30	304-313	
31	314-323	
32	324-333	
33	334-344	#344 is Synch Symbol

Table I.5/G.992.1 – Subframe (upstream)

I.5.2 Dual Bitmapping and rate conversion (replaces 8.15)

The function of the rate converter (see I.5.2.2), tone ordering (see I.5.4), constellation encoding, and gain scaling shall use one of two bitmaps stored in the ATU. This method is called the dual bitmap.

I.5.2.1 Dual Bitmap (new)

The Dual Bitmap switching shall be the same as for the downstream data, specified in I.4.4.1. The number of bits and the relative gains to be used for every tone are calculated in the bit loading algorithm during the initialization sequence, and transmitted in C-B&G.

I.5.2.2 Rate Converter (new)

The rate converter buffering changes the data frame boundaries between the reference points B and C according to Bitmap- F_C , Bitmap- N_C and the Sliding Window. Two independent rate converters are prepared for fast data and interleaved data. The amounts of fast and interleaved data in Bitmap- F_C and Bitmap- N_C shall be calculated in the following formulae:

If $t_{Cf} \le n_{Cmax}$:

$$n_{Cf} = t_{Cf}$$
$$n_{Ci} = n_C - n_{Cf}$$
$$f_{Cf} = t_{Cf}$$
$$f_{Ci} = f_C - f_{Cf}$$

If $t_{Cf} > n_{Cmax}$:

$$n_{Cf} = n_{C \max}$$

$$n_{Ci} = 0$$

$$f_{Cf4} = \left[\frac{t_{Cf} \times 10 - n_{Cf} \times 6}{4}\right]$$

$$f_{Cf3} = \left[\frac{t_{Cf} \times 10 - n_{Cf} \times 7}{3}\right]$$

$$f_{Ci} = \begin{cases} f_{Ci4} = f_C - f_{C4} \\ f_{Ci3} = f_C - f_{Cf3} \end{cases}$$

Where:

^t Cf	is the number of allocated bits in one frame for fast bytes at the reference point B.
^t Ci	is the number of allocated bits for interleaved bytes at the reference point B.
f_{Cf} and n_{Cf}	are the numbers of fast bits in Bitmap- F_C and Bitmap- N_C , respectively.
fCf3	is the number of fast bits in Bitmap- F_C if the subframe (see I.5.1.3) contains 3 Bitmap- F_C except
f _{Cf4}	for synch symbols. is the number of fast bits in Bitmap- F_C if the subframe contains 4 Bitmap- F_C except for synch
f_{Ci} and n_{Ci}	symbols. are the numbers of interleaved bits in Bitmap-F _C and Bitmap-N _C , respectively.
nC	is the number of total bits in Bitmap-N _{C} , which is specified in the B&G tables.
· · · · · · · · ·	

During FEXT Bitmap mode, n_{Cf} and n_{Ci} are zero.

To convert the bit rate to be a multiple of 32 kbit/s, the dummy bits for fast data are inserted to the tail of each subframe, and the dummy bits for interleaved data are inserted to the end of the Hyperframe. The number of the dummy bits shall be as follows:

If $t_{Cf} \le n_{Cmax}$:

$$dummy_{Cf} = 0$$
$$dummy_{Ci} = (f_{Ci} \times 126 + n_{Ci} \times 214) - t_{Ci} \times 340$$

If $t_{Cf} > n_{Cmax}$:

$$dummy_{Cf 4} = (f_{Cf} \times 4 + n_{Cf} \times 6) - t_{Cf} \times 10$$

$$dummy_{Cf 3} = (f_{Cf} \times 3 + n_{Cf} \times 7) - t_{Cf} \times 10$$

$$dummy_{Ci} = (f_{Ci4} \times 96 + f_{Ci3} \times 30) - t_{Ci} \times 340$$

,

If the fast data buffer uses single latency only, additional dummy bits are inserted at the tail of each FEXT symbol in the 4 Bitmap-F_C constructed subframe. The number of additional dummy bits inserted at the tail of each FEXT symbol shall be as follows:

$$dummy_{SCf} = f_{Cf3} - f_{Cf4}$$

The receiver shall determine Bitmap-F_C and Bitmap-N_C so that $dummy_{Ci}$ is less than 126, $dummy_{Cf4}$ is less than 4 and $dummy_{Cf3}$ is less than 3 in the initialization sequence. At the receiver, the inserted dummy bits shall be removed.

I.5.3 FEXT Bitmapping (replaces 8.16)

The FEXT Bitmapping mode uses the Dual Bitmapping technique (I.4.4) to transmit data only during FEXT. The ATU-C shall transmit only the pilot tone during the NEXT_R symbol. The ATU-R disables Bitmap-N_C and shall not transmit any signal during the NEXT_C symbol (see Figures I.10 and I.16).

The Dual versus FEXT bitmapping mode is selected during G.994.1 using bit "DBM" (see 10.2 and 10.3).

I.5.4 Tone Ordering (pertains to 8.7)

The tone ordering algorithm shall be the same as for the downstream data, specified in I.4.4.

For Bitmap-F_C, the "tone-ordered" encoding shall first assign f_{Cf} bits from the rate converter (see I.5.2.2) to the tones with the smallest number of bits assigned to them, and the remaining f_{Ci} bits to the remaining tones. For Bitmap-N_C, it shall first assign n_{Cf} bits from the rate converter to the tones with the smallest number of bits assigned to them, and the remaining n_{Ci} bits to the remaining tones. Two ordered bit tables for Bitmap-F_C and Bitmap-N_C shall be prepared.

I.5.5 Modulation (pertains to 8.11)

I.5.5.1 Inverse synchronization symbol (replaces 8.11.4)

Inverse Synchronization symbol shall be generated from a tone-by-tone 180 degree phase reversal of Synchronization symbol (i.e. + maps to -, and - maps to +, for each of the 4-QAM signal constellation).

I.5.5.2 Gain scaling in synchronization symbol (new)

At initialization time, the sync symbol reference transmit PSD level shall be set at the nominal PSD level +10log(g_{sync}^2) dBm/Hz, with g_{sync}^2 defined as the average g_i^2 value over the used (i.e. $b_i > 0$) subcarriers in the NEXT or FEXT bitmap, whichever results in the highest average gain. The sync symbol reference transmit PSD shall not be updated with used subcarrier gain changes during SHOWTIME.

I.5.5.3 Nyquist frequency (supplements 8.11.1.2)

The upstream Nyquist frequency for Annex I-EU shall be at subcarrier NSCus (f = 4.3125*NSCus kHz)..

I.5.5.4 Modulation by the inverse discrete Fourier transform (supplements 8.11.2)

For Annex I-EU, see A.2.1.

I.5.5.5 Synchronization symbol (supplements 8.11.3)

For Annex I-EU, see A.2.2.

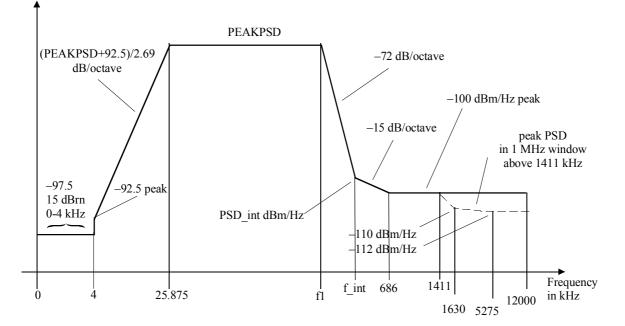
I.5.6 ATU-R Upstream Transmit Spectral Mask (replaces 8.14)

The upstream PSD masks of Annex I-EU are defined with absolute peak values in Figure I.18. The low frequency stop band is defined for frequencies below 25.875 kHz; the high frequency stop band is defined at frequencies greater than f1 kHz (tone n1). The in-band region of these PSD masks is the frequency band from 25.875 kHz to f1 kHz.

and the ATU-R may optionally support upstream masks EU-36 to EU-64. specified in Figure I.18

NOTE: The value of MAXNOMATPus may be limited by regional regulations.





Frequency band f (kHz)	Equation for line (dBm/Hz)
0 < f < 4	-97.5
4 < f < 25.875	-92.5+(PEAKPSD+92.5)* log ₂ (f/4)/log ₂ (25.875/4)
25.875 < f < f1	PEAKPSD
f1< f< f_int	$PEAKPSD-72*log_2(f/f1)$
f_int < f < 686	PSD_int-15*log2(f/f_int)
f > 686	-100

Frequency (kHz)	PSD level (dBm/Hz)	Measurement BW
0	-97.5	100 Hz
4	-97.5	100 Hz
4	-92.5	100 Hz
25.875	PEAKPSD	10 kHz
fl	PEAKPSD	10 kHz
f_int	PSD_int	10 kHz
686 - 12000	-100	10 kHz

Additionally the PSD masks shall satisfy the following requirements:

Frequency (kHz)	PSD level (dBm/Hz)	Measurement BW
1411	-100	1 MHz
1630	-110	1 MHz
5275	-112	1 MHz
12000	-112	1 MHz

NSCus is a function of the upstream mask parameters, which are defined as follows:

Parameters in	EEVT Literate	fammada 1	le atte le iture au	a fam manda)	(aaa et 7 2)	۱.
Parameters in	FEAT Dumar	i for mode i	DOID DIIMAD	s for mode z i	Isee of 7 h	1.
i aranietero m	I DITI Olullap	101 moue 1	, oour orunap	5 IOI IIIOue -	(See ST. 1.5)	<i>.</i>

Designator (EU-nn)	NSCus	Template Nominal PSD P ₀ (dBm/Hz)	Template Maximum Aggregate Transmit Power (dBm)	PEAKPSD (dBm/Hz)	Frequency f1 (kHz)	Intercept Frequency f_int (kHz)	Intercept PSD Level PSD_int (dBm/Hz)
EU-32	32	-38.0	12.5	-34.5	138.00	242.92	-93.2
EU-36	64	-38.5	12.5	-35.0	155.25	274.03	-94.0
EU-40	64	-39.0	12.5	-35.5	172.50	305.06	-94.7
EU-44	64	-39.4	12.5	-35.9	189.75	336.33	-95.4
EU-48	64	-39.8	12.5	-36.3	207.00	367.54	-95.9
EU-52	64	-40.1	12.5	-36.6	224.25	399.07	-96.5
EU-56	64	-40.4	12.5	-36.9	241.50	430.58	-97.0
EU-60	64	-40.7	12.5	-37.2	258.75	462.04	-97.4
EU-64	64	-41.0	12.5	-37.5	276.00	493.45	-97.9

Parameters in NEXT bitmap for mode 1 (see §I.7.3):

Designator (EU-nn)	NSCus	Template Nominal PSD P ₀ (dBm/Hz)	Template Maximum Aggregate Transmit Power (dBm)	PEAKPSD (dBm/Hz)	Frequency f1 (kHz)	Intercept Frequency f_int (kHz)	Intercept PSD Level PSD_int (dBm/Hz)
EU-32	32	-38.0	12.5	-34.5	138.00	242.92	-93.2
EU-36	64	-38.7	12.5	-35.2	155.25	273.47	-94.0
EU-40	64	-39.9	12.5	-36.4	172.50	302.26	-94.7
EU-44	64	-40.7	12.5	-37.2	189.75	331.87	-95.3
EU-48	64	-41.4	12.5	-37.9	207.00	361.55	-95.8
EU-52	64	-41.8	12.5	-38.3	224.25	392.16	-96.4
EU-56	64	-42.1	12.5	-38.6	241.50	423.12	-96.9
EU-60	64	-42.3	12.5	-38.8	258.75	454.51	-97.3
EU-64	64	-42.3	12.5	-38.8	276.00	486.91	-97.8

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. The breakpoints in the tables shall be connected by linear straight lines on a dB/log(f) plot.

NOTE 3 – MBW specifies the Measurement Bandwidth. The MBW specified for a certain breakpoint with frequency fi is applicable for all frequencies satisfying fi< $f \le fj$, where fj is the frequency of the next specified breakpoint.

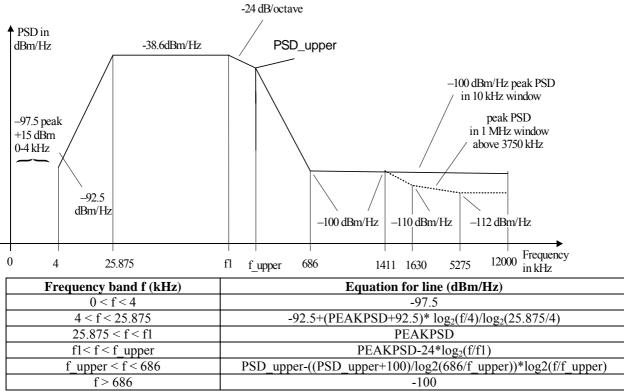
NOTE 4 – The power in a 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency i.e. power in the [f, f + 1 MHz] window shall conform to the specification at frequency f.

NOTE 5 – The step in the PSD mask at 4 kHz is to protect V.90 performance. Originally, the PSD mask continued the 21.5 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-R interface (see Figures I.3 & I.4).

Figure I.18: Upstream Channel PSD Masks

When EU-S68 or beyond is used, only mode 2 shall be used. The PSD masks are defined in Figure I.x1 and Table I.x2. The frequency band from 25.875 kHz to f_upper can be used.



Note: PSD_upper=PEAKPSD-24*log2(f_upper/f1)

Frequency (kHz)	PSD level (dBm/Hz)	Measurement BW
0	-97.5	100 Hz
4	-97.5	100 Hz
4	-92.5	100 Hz
10	interpolated	10 kHz
25.875	-38.6	10 kHz
276	-38.6	10 kHz
f_upper	PSD_upper	10 kHz
686	-100	10 kHz
5275	-100	10 kHz
12000	-100	10 kHz

Figure I.x1: Mask definition for EU-S68 to EU-S96

Designator	Template Maximum Aggregate Transmit Power (dBm)	Upper Frequency <i>f_upper</i> (kHz)	PSD_upper: PSD Level at f_upper (dBm/Hz)
EU-S68	12.5	293.25	-40.70
EU-S72	12.5	310.50	-42.68
EU-S76	12.5	327.75	-44.55
EU-S80	12.5	345.00	-46.33
EU-S84	12.5	362.25	-48.02
EU-S88	12.5	379.50	-49.63
EU-S92	12.5	396.75	-51.17
EU-S96	12.5	414.00	-52.64

Table I.x2: Parameters for EU-S68 to EU-S96

I.5.7 Forward error correction (supplements 8.6)

The minimum FEC coding capabilities (Table 8-3) for an ATU-R shall include the following interleave depths for the interleaved buffer:

D = 1, 2, 4, 8, and 16

I.5.8 Cyclic prefix (supplements 8.12)

For Annex I-EU, see A.2.3.

I.6 EOC Operation and Maintenance (pertains to clause 9)

I.6.1 ADSL line related primitives (supplements 9.3.1)

I.6.1.1 ADSL line related near-end defects (supplements 9.3.1.3)

Two near-end defects are further defined:

- *Loss-of-signal (LOS)*: The ADSL power shall be measured only in the FEXT_C duration at ATU-C, or only in the FEXT_R duration at ATU-R.
- Severely errored frame (SEF): A SEF defect occurs when the content of two consecutively received ADSL synchronization symbols in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-R, does not correlate with the expected content over a subset of the tones. An SEF defect terminates when the content of two consecutively received ADSL synchronization symbols in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-C, or in the FEXT_R duration at ATU-R, does not consecutively received ADSL synchronization symbols in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-R, correlate with the expected contents over the same subset. The correlation method, the selected subset of tones, and the threshold for declaring these defect conditions are implementation discretionary.

I.6.1.2 ADSL line related far-end defects (supplements 9.3.1.4)

Loss-of-signal is further defined:

• Loss-of-signal (LOS): The ADSL power shall be measured only in the FEXT_C duration at ATU-C, or only in the FEXT_R duration at ATU-R.

I.6.2 Test Parameters (supplements 9.5)

I.6.2.1 Near-end test parameters (supplements 9.5.1)

The near-end primitives are further defined:

- *Attenuation (ATN)*: The received signal power shall be measured only in the FEXT_C duration at ATU-C, or only in the FEXT_R duration at ATU-R.
- Signal-to-Noise ratio (SNR) margin: During FEXT Bitmap mode, this primitive represents the snr margin in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-R.

I.6.2.2 Far-end test parameters (supplements 9.5.2)

The far-end primitives are further defined:

• *Attenuation (ATN)*: The received signal power shall be measured only in the FEXT_C duration at ATU-C, or only in the FEXT_R duration at ATU-R.

• *Signal-to-Noise ratio SNR margin*: During FEXT Bitmap mode, this primitive represents the snr margin in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-R.

I.6.3 Data registers in the ATU-R (supplements 9.2.4)

For the S=1/2n framing mode (see §I.4.9), the downstream RS_I shall be the number of parity bytes per sync byte, i.e., $RS_I = R_I/(n^*S)$.

I.7 Initialization (pertains to clause 10)

I.7.1 Initialization with Hyperframe (replaces 10.1.5)

The exchange of messages between ATU-C and ATU-R should be performed in FEXT_{C} and FEXT_{R} . The DMT symbol has two symbol rates: one is 4.3125 kbaud for the symbol without a cyclic prefix, and the other is 4 x 69/68 kbaud for the symbol with a cyclic prefix. 32 times of the TTR has the same period as 345 times of the 4.3125 kbaud, and 34 times of the TTR is the same as 345 times of 4 x 69/68 kHz.

During FEXT Bitmap mode, the ATU-R shall not transmit any signal during the NEXT_C symbols duration and the ATU-C shall transmit only the pilot tone as the NEXT_R signal except:

- C-PILOT1 (C-PILOT1A) which is accompanied by a signal to allow the ATU-C to indicate the phase of TTR_C to the ATU-R (see I.7.4.1);
- C-QUIETn where no signal is transmitted.

The ATU-C begins transmitting C-PILOT1 at the beginning of the hyperframe without cyclic prefix. The ATU-C informs the phase of the TTR_C to ATU-R during C-PILOT1. The ATU-R begins transmitting R-REVERB1 at the beginning of the hyperframe without cyclic prefix. The ATU-R performs the training of any receiver equalizer using this phase information of the TTR_R generated from received TTR_C .

From C-PILOT1 to C-SEGUE1, the following numerical formula gives the information which duration N_{dmt}-th DMT symbol belongs to at ATU-R (see Figure I.19).

For $N_{dmt} = 0, 1, \dots 344$ $S = 256 \times N_{dmt} \mod 2760$ if { (S + 255 < a) or (S > a + b) } then FEXT_R symbols else then NEXT_R symbols where a = 1243, b = 1461

In order to enter C-RATES1 at the beginning of the hyperframe with cyclic prefix, the number of symbols from C-PILOT1 to C-SEGUE1 shall be a multiple of 345 DMT symbols.

From R-REVERB1 to R-SEGUE1, the following numerical formula gives the information which duration N_{dmt}-th symbol belongs to at ATU-C (see Figure I.20).

For $N_{dmt} = 0, 1,, 344$,	
$S = 256 \times N_{dmt} \mod 2760$	
if $\{ (S > a) \text{ and } (S + 255 < a + b) \}$	then $FEXT_C$ symbols
else	then NEXT _C symbols
where a = 1315, b = 1293	-

From C-RATES1 to C-SEGUE3, the number of symbols is a multiple of 345 DMT symbols. The following numerical formula gives the information which duration N_{dmt} -th DMT symbol belongs to. ATU-C transmits the message data in FEXT_R symbols (see Figure I.11).

For $N_{dmt} = 0, 1, ..., 344$ S = 272 x N_{dmt} mod 2760

if { (S + 271 \ge a) and (S \le a + b) }	then NEXT _R symbols
else	then $FEXT_R$ symbols
a = 1242 h $= 1461$	

where a = 1243, b = 1461

The ATU-R enters R-REVERB3 at the beginning of the hyperframe with cyclic prefix, which is extracted from received signal. From R-REVERB3 to R-SEGUE5, the number of symbols is a multiple of 345 DMT symbols. The following numerical formula gives the information which duration N_{dmt} -th DMT symbol belongs to. ATU-R transmits the message data in FEXT_C symbols (see Figure I.17).

For $N_{dmt} = 0, 1, ..., 344$ $S = 272 \times N_{dmt} \mod 2760$ if { (S > a) and (S + 271 < a + b) } then FEXT_C symbols else then NEXT_C symbols where a = 1315, b = 1293

тт	R -
11	IN _C

R _C _				:									_
0	0 1	2	3	4	5	6		7		8	9	10)
1	11 12	13	14	15	16	5	17	18		19	2	0 2	21
2	22 23	24	25	26		27	28	2	.9	30		31	l
3	32 33	34 35	36	6 3	7	38	3	9	40	4	41	42	
4	43 44	45 4	6	47	48	49		50	51		52	53	Ī
5	54 55	56	57	58	59	6	0	61		62	63	64	1
6	65 66	67	68	69	7	0	71	72	2	73		74	-
7	75 76 7		79	80		81	82		83	84		85	L
8	86 87	88 89			91	92		93	94		95	96	1
9	97 98			101	102	103		104	10		106	107	-
10	108 109	110	111	112	113		14	115		116	11		8
11	119 120		122	123		24	125		26	127		128	Ļ
12		31 132	13			135	13		137		38	139	1
13	140 141	142 14			145	146		147	148		149	150	<u>i</u> _
14	151 152		154	155	156	15		158		59	160		÷
15 16	162 163	164	165	166	16		168	16		170		71 17	2
	173 17		176			178	179		101	18	192	182	Ļ
17 18	183 184 194 195	185 186 196 1		37 13 198 1	58 199	189		90 201	191 20		203	193 204	<u></u>
18	205 206	207	208	209	210		, 11	201		213	203		
20	216 217		208	207		21	222	212		224			Ť
21		28 229	23			232	23		234	_	35	236	İ
22	237 238	239 24			242	243	<u> </u>	244	245		246	247	1
23	248 249		251	252	253	25	4	255		56	257	258	
24	259 260	261	262	263	26		265	266		267	26		
25	270 27	1 272	273	274		275	276	2	77	27	8	279	
26	280 281 2	282 283	28	34 2	85	286	28	87	288	2	289	290	η
27	291 292	293 29	94	295	296	297	'	298	29	9	300	301	
28	302 303	304	305	306	307	3	08	309	3	310	31	1 312	2
29	313 314	315	316	317	31	8	319	32	0	321	3	22	Ī
30	323 324 32	25 326	327	7 32	8	329	330) (331	33	32	333	Ι
31	334 335	336 33	7 3	38 3	39	340	3	41	342		343	344	Ī
	$ FEXT_R = $											T1535350)-0(

Figure I.19/G.992.1 – Symbol pattern in a hyperframe without cyclic prefix – Downstream

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-	•	••	к

[
-								-		i L			_	_	_	_				
0	0	<u> </u>	1	\bot	2	╘	3		4		5	(5		7		8		9	10
1	11		12		13		14	_	15	1	16	<u> </u>	17	<u> </u>	18	\downarrow	19		20	21
2		22		3	2		2				27		28	s 39	29		_	30 31		÷
3										37 48	4	38 49		39 5(40 51		41 52		42 53
4 5	43		4 55		, 56		, 57		58	-	59	_	<u> </u>	_	, 61	_	62	_	63	64
6		5	66		67		68		<u> </u>		70	4	71	4	72	<u> </u>	73	1	74	
7	75	76		, 77		78		<u>'</u> 79	8	n l	8	1	-	2		3	8	4		5
8	86	87		88	<u> </u>	89		90		91		92		2 93		94		95		96
9	97	_	98		9	_	00	10)1	10	2	10	3	10)4	10	5	10)6	107
0	108		109		110		111		112	÷	113	_	114		115	_	116	T	117	118
1		19		20	12	1	12		12		12	4	12	5	12		127	7	128	
2	129	130	_	131	L	132	L	133		34	1	35	_	36		37	_	38		39
3	140	14	1	14	2	14	3	144	4	145	: T	146	5	14'	7	148	3	149		150
4	151	1	152	1	53	1	54	1	55	1:	56	1	57	1	58	1	59	1	60	161
5	16	52	163	3	164	T	165	; T	166	1	167	Т	168	╘	169	Τ	170	Т	171	17
6		173	1	74	1	75	1	76	17	7	1'	78	17	79	18	30	18	31	18	2
7	183	184	1	185		186		187		188		189	<u>'</u>	190		191	1	192		193
8	194	1	95	- 19	96	- 19	97	19	8	19	9	20	0	20)1	20	2	20)3	204
9	205	;	206		207		208		209	2	210	2	211		212	2	213		214	215
0	2	16	21	7	21	8	21	9	220		22	1	222	2	223	3	224	ŀ	225	
1	226	227		228	4	229		230	2	31	2	.32	2	33	2	.34	2	35	2	36
2	239	23	8	239)	240)	241		242		243		244	ł	245		246	5	247
3	248		249	2	50	2	51	2	52	2:	53	2:	54	2	55	2:	56	2	57	258
4	25		260		261		262		263		264		265		266		267		268	269
5		270	_	71	27		27	73	27		27		27		27		27		27	<u> </u>
6	280	281		282		283		284	_	285		286		287		288		289		290
7	291		92	29		29		29		290		29		29		29		30		301
8	302		303		304		305		306		07		808		309		310		311	312
9	31		31		315		310		317	÷ –	_		319		320		321		322	
		324		325	_	26		27	32	-		29		30		31	33		33	_
1	334	33	5	336)	337	/	338	5	339		340		341		342		343	,	344
		FE	XT _C	sym	bol														T15	- 35360-0
		-	e																	
] NE	XT _C	sym	bol															

Figure I.20/G.992.1 – Symbol pattern in a hyperframe without cyclic prefix – Upstream

I.7.2 Handshake – Non-standard information block (new)

This section defines the format of the G.994.1 non-standard information block to support Annex I-EU, and tabulates the parameters used by Annex I-EU. The use of these parameters is described in §1.7.3 and §1.7.4.

I.7.2.1 Non-standard information block format (new)

Figure I.21 defines the format of the non-standard information block.

8	7	6	5	4	3	2	1
		Non-star		nation length octet)	n = M + 6		
				ntry code see Note 1)			
		Provid		ndor identifi see Note 2)	cation)		
		Ve		fic informati – Note 3)	on		

NOTE 1 – The value of this field shall be B5 00, the country code for USA

NOTE 2 – The value of this field shall be 43 45 4E 54, ASCII "CENT" for Centillium Communications

NOTE 3 – These octets are defined in \$1.7.2.2. Formatting of these octets shall comply with the parsing rules defined in G.994.1 \$9.2.1 to \$9.2.3

Figure I.21 – Non-standard information block format

I.7.2.2 Non-standard information block parameters (new)

The G.994.1 non-standard parameters for Annex I-EU are listed in Tables I.6 to I.7.4.2 below.

In order to minimize message length, the parameters for additional inband spectral shaping (Spar(2) octet and its related Npar(3) octets) shall only be included in MP or MS messages, and shall not be included in CLR or CL messages. All Annex I-EU modems shall support additional inband spectral shaping.

Note - This deviates from the rules specified in G.994.1 for standard information fields, where it is stated in §9.6:

"Once a Transaction C (see 10.1) has been completed, any subsequent MS message within the same G.994.1 session shall only contain those octets of the identification (I) and standard information (S) fields, and those blocks of non-standard information (NS) that were contained in both the CLR and CL messages of the previous Transaction C".

Bits								
8	7	6	5	4	3	2	1	NPar(1)s
x	х	х	х	х	х	х	1	Reserved for future use
х	х	х	х	Х	х	1	х	Reserved for future use
х	х	х	х	х	1	х	х	Reserved for future use
х	х	х	х	1	х	х	х	Reserved for future use
х	х	х	1	Х	х	Х	х	Reserved for future use
х	х	1	х	Х	х	Х	х	Reserved for future use
х	1	х	х	х	х	х	х	Reserved for future use
х	0	0	0	0	0	0	0	No parameters in this octet

Table I.6 – Non-standard information field – NPar(1) coding

Bits								
8	7	6	5	4	3	2	1	SPar(1)s
х	х	х	х	х	х	х	1	G.992.1 Annex Q (and Annex Q-EU)
х	х	х	х	х	х	1	х	G.992.1 Annex I-EU
х	х	х	х	х	1	х	х	G.992.1 Annex C-EU
х	х	Х	х	1	х	Х	Х	Reserved for future use
х	х	х	1	х	х	х	х	Reserved for future use
х	х	1	х	х	х	х	х	Reserved for future use
х	1	х	х	х	х	х	х	Reserved for future use
x	0	0	0	0	0	0	0	No parameters in this octet

Table I.7 – Non-standard information field – SPar(1) coding

Table I.7.3 – Non-standard information field – G.992.1 Annex I-EU NPar(2) coding – Octet 1

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex I-EU NPar(2)s
X	Х	х	Х	Х	Х	Х	1	$n_{\text{C-PILOT1}} = 64$
х	х	х	х	х	х	1	х	$n_{\text{C-PILOT1}} = 128$
х	х	х	х	х	1	х	х	$n_{\text{C-PILOT1}} = 256$
х	х	х	х	1	х	х	х	Amateur radio notch – 1.8 MHz band
х	Х	х	1	х	х	Х	х	Reserved for future use
Х	Х	1	х	х	х	х	х	$n_{\text{C-PILOT1}} = 96$
Х	Х	0	0	0	0	0	0	No parameters in this octet
Since A4	48 is th	e only	TTR in	dication	n signal	l specifi	ied for	Annex I-EU, there is no need to include it in G.994.1.

Table I.7.3.1 – Non-standard information field – G.992.1 Annex I-EU NPar(2) coding – Octet 2

Bits													
8	7	6	5	4	3	2	1	G.992.1 Annex I-EU NPar(2)s – Octet 2					
Х	Х	х	х	Х	х	х	1	R-ACK1					
х	х	х	х	х	х	1	х	R-ACK2					
х	Х	х	х	Х	1	х	х	DBM					
х	х	х	х	1	х	х	х	Reserved for future use					
х	х	х	1	х	х	х	х	Reserved for future use					
х	Х	1	х	Х	х	х	х	G.997.1 – Clear EOC OAM					
х	х	0	0	0	0	0	0	No parameters in this octet					
	nce Annex I-EU only supports ATM transport, STM and ATM parameters are not specified.												

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex I-EU SPar(2)s
х	Х	х	Х	Х	х	х	1	Additional inband spectral shaping
х	х	х	х	х	х	1	х	Extended upstream
х	х	х	х	Х	1	х	Х	Reserved for future use
х	Х	х	х	1	х	Х	Х	Reserved for future use
х	х	х	1	х	х	х	х	Reserved for future use
х	Х	1	х	Х	Х	Х	Х	Reserved for future use
x	Х	0	0	0	0	0	0	No parameters in this octet

Table I.7.4 – Non-standard information field – G.992.1 Annex I-EU SPar(2) coding

Table I.7.4.1 – Non-standard information field – G.992.1 Annex I-EU Additional inband spectral shaping Npar(3) coding Octet 1

Bits								G.992.1 Annex I-EU Additional inband spectral
8	7	6	5	4	3	2	1	shaping Npar(3)s Octet 1
х	х					х	х	NOMINAL_PSD_lowband (bits 8 & 7)
х	x	х	х	х	х			Reserved for future use

Table I.7.4.1.1 – Non-standard information field – G.992.1 Annex I-EU Additional inband spectral shaping Npar(3) coding Octet 2

_									
	Bits								G.992.1 Annex I-EU Additional inband spectral
	8	7	6	5	4	3	2	1	shaping Npar(3)s Octet 2
	Х	х	х	Х	Х	Х	Х	х	NOMINAL_PSD_lowband (bits 6 to 1)

Table I.7.4.1.2 – Non-standard information field – G.992.1 Annex I-EU Additional inband spectral shaping Npar(3) coding Octet 3

Bits	7		7	4	2	2	1	G.992.1 Annex I-EU Additional inband spectral
8	/	6	3	4	3	2	1	shaping Npar(3)s Octet 3
х	Х					Х	Х	PSD level at 1622 kHz (bits 8 & 7)
Х	Х	х	х	Х	Х			Reserved for future use

Table I.7.4.1.3 – Non-standard information field – G.992.1 Annex I-EU Additional inband spectral shaping Npar(3) coding Octet 4

Bits								G.992.1 Annex I-EU Additional inband spectral
8	7	6	5	4	3	2	1	shaping Npar(3)s Octet 4
х	х	Х	х	Х	Х	х	х	PSD level at 1622 kHz (bits 6 to 1)

Table I.7.4.1.4 – Non-standard information field – G.992.1 Annex I-EU Additional inband spectral shaping Npar(3) coding Octet 5

Bits								G.992.1 Annex I-EU Additional inband spectral
8	7	6	5	4	3	2	1	shaping Npar(3)s Octet 5
х	Х					х	Х	PSD level at 2208 kHz (bits 8 & 7)
х	х	х	х	Х	х			Reserved for future use

Table I.7.4.1.5 – Non-standard information field – G.992.1 Annex I-EU Additional inband spectral shaping Npar(3) coding Octet 6

Bits								G.992.1 Annex I-EU Additional inband spectral
8	7	6	5	4	3	2	1	shaping Npar(3)s Octet 6
х	х	х	х	Х	Х	х	Х	PSD level at 2208 kHz (bits 6 to 1)

Table I.7.4.2 – Non-standard information field – G.992.1 Annex I-EU Extended upstream NPar(3) coding Octet 1

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex I-EU Extended upstream NPar(3)s Octet 1
х	х	х	х	х	Х	х	1	Mode 1 upstream mask
х	х	х	х	х	Х	1	х	Mode 2 upstream mask
х	х	х	х	х	1	х	х	Optional upstream masks for non-overlapped spectrum
х	х	х	х	1	Х	х	х	EU-64
х	х	х	1	х	Х	х	х	EU-32
х	х	1	х	х	х	х	х	EU-36
Х	х	0	0	0	0	0	0	No parameters in this octet

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex I-EU Extended upstream NPar(3)s Octet 2
x	х	х	х	Х	х	х	1	EU-40
х	х	х	х	х	х	1	х	EU-44
х	х	х	х	х	1	х	х	EU-48
х	х	х	х	1	х	х	х	EU-52
х	х	х	1	х	х	х	х	EU-56
х	х	1	х	х	х	х	х	EU-60
x	Х	0	0	0	0	0	0	No parameters in this octet

Table I.7.4.2.1 – Non-standard information field – G.992.1 Annex I-EU Extended upstream NPar(3) coding Octet 2

 Table I.7.4.2.2 – Non-standard information field – G.992.1 Annex I-EU Extended upstream

 NPar(3) coding Octet 3

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex I-EU Extended upstream NPar(3)s Octet 3
x	х	х	х	х	х	х	1	EU-S68
х	х	х	х	х	х	1	х	EU-S72
х	х	х	х	х	1	х	х	EU-S76
х	х	х	х	1	х	х	х	EU-S80
х	х	х	1	х	х	х	х	EU-S84
х	х	1	х	х	х	х	х	EU-S88
Х	х	0	0	0	0	0	0	No parameters in this octet

 Table I.7.4.2.3 – Non-standard information field – G.992.1 Annex I-EU Extended upstream

 NPar(3) coding Octet 4

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex I-EU Extended upstream NPar(3)s Octet 4
x	х	х	х	х	х	х	1	EU-S92
х	х	х	х	х	х	1	Х	EU-S96
х	х	х	х	х	1	х	х	Reserved for future use
х	х	х	х	1	х	Х	Х	Reserved for future use
х	х	х	1	х	х	х	х	Reserved for future use
х	х	1	х	х	х	х	х	Reserved for future use
x	х	0	0	0	0	0	0	No parameters in this octet

I.7.3 Handshake – Parameter definitions (supplements 10.2)

I.7.3.1 Handshake – ATU-C (supplements 10.2)

I.7.3.1.1 CL messages (supplements 10.2.1)

See Table I.8.

NSF parameter	Definition
DBM	If set to ZERO, this bit shall indicate Bitmap-N _R and Bitmap-N _C are enabled (Dual Bitmap
	mode) and are used to transmit data. If set to ONE, this bit shall indicate Bitmap-NR and
	Bitmap-N _C are disabled (FEXT Bitmap mode), i.e. only Bitmap-F _R and Bitmap-F _C are
	used to transmit data by ATU-C and ATU-R respectively. This mode selection shall be only performed by the ATU-C. If it is set to ONE in a CL message, it must be set to ONE in subsequent MS messages from either the ATU-C or ATU-R.
G.992.1 Annex I-EU	If set to ONE, this Spar(1) bit indicates that the ATU-C is configured to support G.992.1 Annex I-EU.
ⁿ C-PILOT1 ⁼⁶⁴	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 64.
ⁿ C-PILOT1 ⁼⁹⁶	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 96.
ⁿ C-PILOT1 ⁼¹²⁸	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 128.
ⁿ C-PILOT1 ⁼²⁵⁶	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 256.
Amateur radio notch – 1.8 MHz band	If set to ONE, this Npar(2) bit indicates that the ATU-C is configured to reduce its transmit power between 1.81 and 2.0 MHz to ≤ -80 dBm.
Extended upstream	If set to ONE, this Spar(2) bit indicates that the ATU-C is configured to support extended upstream.
EU-xx	If the Extended upstream Spar(2) bit is set to ONE, these Npar(3) bits indicate the extended upstream masks that the ATU-C supports. For non-overlapped spectrum, extended upstream masks are associated with downstream masks according to Figure I.13. For overlapped spectrum, any EU-xx may be used with the overlapped downstream spectrum specified in §I.4.8.2.
Mode 1 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-C is configured to support upstream mask mode 1 (different masks during FEXT and NEXT periods).
Mode 2 upstream	If set to ONE, this NPar(3) bit indicates that the ATU-C is configured to support upstream
mask	mask mode 2 (same mask during FEXT and NEXT periods).
Optional upstream masks for non- overlapped spectrum	If set to ONE, this NPar(3) bit indicates that the ATU-C is configured to support the optional upstream masks when using non-overlapped spectrum downstream.

Table I.8/G.992.1 – ATU-C CL message NPar(2) bit definitions for Annex I-EU

I.7.3.1.2 MS messages (supplements 10.2.2)

See Table I.9.

Table I.9/G.992.1 – ATU-C MS message NPar(2) bit definitions for Annex I-EU

NSF parameter	Definition
DBM	If set to ZERO, this bit shall indicate Bitmap-N _R and Bitmap-N _C are enabled (Dual
	Bitmap mode) and are used to transmit data. If set to ONE, this bit shall indicate Bitmap-N _R and Bitmap-N _C are disabled (FEXT Bitmap mode), i.e. only Bitmap-F _R and
	Bitmap-F _C are used to transmit data by ATU-C and ATU-R respectively. This mode
	selection shall be only performed by ATU-C. This bit shall be set to ONE if it was set to ONE in a previous CL message.
G.992.1 Annex I-EU	If set to ONE, this Spar(1) bit indicates that the ATU-C is selecting G.992.1 Annex I-EU.
ⁿ C-PILOT1 ⁼⁶⁴	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 64 (Note 1).
ⁿ C-PILOT1 ⁼⁹⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 96 (Note 1).
ⁿ C-PILOT1 ⁼¹²⁸	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 128 (Note 1).
ⁿ C-PILOT1 ⁼²⁵⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 256 (Note 1).
Amateur radio notch – 1.8 MHz band	If set to ONE, this Npar(2) bit indicates that the ATU-C shall reduce its transmit power between 1.81 and 2.0 MHz to ≤ -80 dBm.
Additional inband	If set to ONE, this Spar(2) bit indicates that the ATU-C shall apply additional downstream
spectral shaping	inband spectral shaping as defined by the values of REDUCED_PSD_lowband, PSD level at 1622 kHz, and PSD level at 2208 kHz
REDUCED_PSD_low	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-C
band	shall apply in the passband below 1104 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz.
PSD level at 1622 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-C
	shall apply at 1622 kHz. It is coded in steps of 0.125dB relative to
	NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz;
	00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs between the REDUCED_PSD_lowband level at 1104 kHz and the PSD level at 1622 kHz.
PSD level at 2208 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-C shall apply at 2208 kHz. It is coded in steps of 0.125dB relative to
	NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz;
	00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs
P 1 1 1	between the PSD level at 1622 kHz and the PSD level at 2208 kHz.
Extended upstream	If set to ONE, this Spar(2) bit indicates that the ATU-C is selecting extended upstream operation.
EU-xx	If set to ONE, this Npar(3) bit indicates that the ATU-C is selecting upstream PSD mask
	US-xx. For non-overlapped spectrum, extended upstream masks are associated with
	downstream masks according to Figure I.13. For overlapped spectrum, any EU-xx may be
	used with the overlapped downstream spectrum specified in §I.4.8.2.
Mode 1 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-C is selecting upstream mask mode 1
	(different masks during FEXT and NEXT periods). (Note 2)
Mode 2 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-C is selecting upstream mask mode 2 (same mask during FEXT and NEXT periods). (Note 2)
Optional upstream	If set to ONE, this NPar(3) bit indicates that the ATU-C is selecting one of the optional
masks for non-	upstream masks when using non-overlapped spectrum downstream.
overlapped spectrum	
	ne pilot tone bit shall be set in an MS message.
Note 2: One and only or	ne upstream mask mode bit shall be set in an MS message.

I.7.3.2 Handshake – ATU-R (supplements 10.3)

I.7.3.2.1 CLR messages (supplements 10.3.1)

See Table I.10.

NSF parameter	Definition
DBM	This bit shall be set to ONE.
G.992.1 Annex I-EU	If set to ONE, this Spar(1) bit indicates that the ATU-R is configured to support G.992.1 Annex I-EU.
ⁿ C-PILOT1 ⁼⁶⁴	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 64.
ⁿ C-PILOT1 ⁼⁹⁶	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 96.
ⁿ C-PILOT1 ⁼¹²⁸	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 128.
ⁿ C-PILOT1 ⁼²⁵⁶	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 256.
Amateur radio notch – 1.8 MHz band	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports the 1.8 MHz Amateur radio band notch.
Extended upstream	If set to ONE, this Spar(2) bit indicates that the ATU-R is configured to support extended upstream.
EU-xx	If the Extended upstream Spar(2) bit is set to ONE, these Npar(3) bits indicate the extended upstream masks that the ATU-R supports. For non-overlapped spectrum, extended upstream masks are associated with downstream masks according to Figure I.13. For overlapped spectrum, any EU-xx may be used with the overlapped downstream spectrum specified in §I.4.8.2.
Mode 1 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-R is configured to support upstream mask mode 1 (different masks during FEXT and NEXT periods).
Mode 2 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-R is configured to support upstream mask mode 2 (same mask during FEXT and NEXT periods).
Optional upstream masks for non- overlapped spectrum	If set to ONE, this NPar(3) bit indicates that the ATU-R is configured to support the optional upstream masks when using non-overlapped spectrum downstream.

Table I.10/G.992.1 – ATU-R CLR message NPar(2) bit definitions for Annex I-EU

I.7.3.2.2 MS messages (supplements 10.3.2)

Table I.11.

NSF parameter	Definition
DBM	If set to ZERO, this bit shall indicate Bitmap- N_R and Bitmap- N_C are enabled (Dual
	Bitmap mode) and are used to transmit data. If set to ONE, this bit shall indicate Bitmap-N _R and Bitmap-N _C are disabled (FEXT Bitmap mode), i.e. only Bitmap-F _R and
	Bitmap-F _C are used to transmit data by ATU-C and ATU-R respectively. This mode
	selection shall be only performed by ATU-C. This bit shall be set to ONE if it was set to ONE in a previous CL message.
G.992.1 Annex I-EU	If set to ONE, this Spar(1) bit indicates that the ATU-R is selecting G.992.1 Annex I-EU.
ⁿ C-PILOT1 ⁼⁶⁴	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is selecting the pilot tone on
	subcarrier 64 (Note 1).
ⁿ C-PILOT1 ⁼⁹⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is selecting the pilot tone on subcarrier 96 (Note 1).

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ⁿ C-PILOT1 ⁼¹²⁸	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is selecting the pilot tone on subcarrier 128 (Note 1).
nC-PILOT1=256	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is selecting the pilot tone on
	subcarrier 256 (Note 1).
Amateur radio notch – 1.8 MHz band	This selection shall only be performed by the ATU-C. Therefore, this Npar(2) bit shall either be set to the same value as in a previous CL message or set to ONE.
Additional inband	If set to ONE, this Spar(2) bit indicates that the ATU-R is selecting additional
spectral shaping	downstream inband spectral shaping as defined by the values of
1 10	REDUCED PSD lowband, PSD level at 1622 kHz, and PSD level at 2208 kHz
REDUCED_PSD_lo wband	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU- R wishes to have applied in the passband below 1104 kHz. It is coded in steps of 0.125dB relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz; 00001101 means -41.625 dBm/Hz.
PSD level at 1622	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-
kHz	R wishes to have applied at 1622 kHz. It is coded in steps of 0.125dB relative to
	NOMINAL PSD lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz;
	00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs
	between the REDUCED PSD lowband level at 1104 kHz and the PSD level at 1622
	kHz.
PSD level at 2208	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-
kHz	R wishes to have applied at 2208 kHz. It is coded in steps of 0.125dB relative to
	NOMINAL PSD lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz;
	00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs
	between the PSD level at 1622 kHz and the PSD level at 2208 kHz.
Extended upstream	If set to ONE, this Spar(2) bit indicates that the ATU-R is selecting extended upstream
1	operation.
EU-xx	If set to ONE, this Npar(3) bit indicates that the ATU-R is selecting upstream PSD mask
	US-xx. For non-overlapped spectrum, extended upstream masks are associated used with
	downstream masks according to Figure I.13. For overlapped spectrum, any EU-xx may
	be used with the overlapped downstream spectrum specified in §I.4.8.2.
Mode 1 upstream	If set to ONE, this NPar(3) bit indicates that the ATU-R is selecting upstream mask mode
mask	1 (different masks during FEXT and NEXT periods). (Note 2)
Mode 2 upstream	If set to ONE, this NPar(3) bit indicates that the ATU-R is selecting upstream mask mode
mask	2 (same mask during FEXT and NEXT periods). (Note 2)
Optional upstream	If set to ONE, this NPar(3) bit indicates that the ATU-R is selecting one of the optional
masks for non-	upstream masks when using non-overlapped spectrum downstream.
overlapped spectrum	
	one pilot tone bit shall be set in an MS message.
	one upstream mask mode bit shall be set in an MS message.
· ·· · · · · · · · · · · · · · · · · ·	*

I.7.3.2.3 MP messages (new)

Table I.12.

Table I.12/G.992.1 – ATU-R MP message NPar(2) bit definitions for Annex I-EU
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NSF parameter	Definition
R-ACK1	Proposes that the ATU-C send C-PILOT1A, C-QUIET3A, C-PILOT2 and C-QUIET5 during
	transceiver training.
R-ACK2	Proposes that the ATU-C send C-PILOT1, C-PILOT2 and C-PILOT3 during transceiver
	training.
G.992.1 Annex I-EU	If set to ONE, this Spar(1) bit indicates that the ATU-R is proposing G.992.1 Annex I-EU.
$n_{C-PILOT1}=64$	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the pilot tone on
	subcarrier 64 (Note 1).
ⁿ C-PILOT1 ⁼⁹⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is proposing the pilot tone on
0112011	subcarrier 96 (Note 1).

ⁿ C-PILOT1 ⁼¹²⁸	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the pilot tone on
C-IILOII	subcarrier 128 (Note 1).
ⁿ C-PILOT1 ⁼²⁵⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the pilot tone on
	subcarrier 256 (Note 1).
Amateur radio notch	This selection shall only be performed by the ATU-C. Therefore, this Npar(2) bit shall either
– 1.8 MHz band	be set to the same value as in a previous CL message or set to ONE.
Additional inband	If set to ONE, this Spar(2) bit indicates that the ATU-R is proposing additional downstream
spectral shaping	inband spectral shaping as defined by the values of REDUCED_PSD_lowband, PSD level at
	1622 kHz, and PSD level at 2208 kHz
REDUCED_PSD_lo	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R
wband	wishes to have applied in the passband below 1104 kHz. It is coded in steps of 0.125dB
	relative to NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40
D0D 1 1 1 1 (44	dBm/Hz; 00001101 means -41.625 dBm/Hz.
PSD level at 1622	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R
kHz	wishes to have applied at 1622 kHz. It is coded in steps of 0.125dB relative to
	NOMINAL_PSD_lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz;
	00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs
DCD 1 1 (2200	between the REDUCED_PSD_lowband level at 1104 kHz and the PSD level at 1622 kHz.
PSD level at 2208 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-R
КНХ	wishes to have applied at 2208 kHz. It is coded in steps of 0.125dB relative to NOMINAL PSD lowband (-40dBm/Hz). For example, 00000000 means -40 dBm/Hz;
	00001101 means -41.625 dBm/Hz. The PSD level shall be linearly interpolated in dBs
	between the PSD level at 1622 kHz and the PSD level at 2208 kHz.
Extended upstream	If set to ONE, this Spar(2) bit indicates that the ATU-R is proposing extended upstream
Extended upsiteani	operation.
EU-xx	If set to ONE, this Npar(3) bit indicates that the ATU-R is proposing upstream PSD mask
LO-XX	US-xx. For non-overlapped spectrum, extended upstream masks are associated with
	downstream masks according to Figure I.13. For overlapped spectrum, any EU-xx may be
	used with the overlapped downstream spectrum specified in §I.4.8.2.
Mode 1 upstream	If set to ONE, this NPar(3) bit indicates that the ATU-R is proposing upstream mask mode 1
mask	(different masks during FEXT and NEXT periods).
Mode 2 upstream	If set to ONE, this NPar(3) bit indicates that the ATU-R is proposing upstream mask mode 2
mask	(same mask during FEXT and NEXT periods).
Optional upstream	If set to ONE, this NPar(3) bit indicates that the ATU-R is proposing one of the optional
masks for non-	upstream masks when using non-overlapped spectrum downstream.
overlapped spectrum	
Note 1: More than one	pilot tone bit may be set in an MP message.

I.7.4 Transceiver Training – ATU-C (supplements 10.4)

During transceiver training from C-REVERB1 to C-SEGUE1 except C-PILOTn and C-QUIETn, the ATU-C shall transmit both FEXT_R and NEXT_R symbols when Bitmap-N_R is enabled (Dual Bitmap mode), and shall not transmit the NEXT_R symbols except pilot tone when Bitmap-N_R is disabled (FEXT Bitmap mode). The duration of each state is defined as Figure I.26.

I.7.4.1 C-PILOT1 (supplements 10.4.2)

The ATU-C shall start the N_{SWF} (sliding window frame) counter from 0 immediately after entering C-PILOT1, and increment the N_{SWF} counter modulo 345 after transmission of each DMT symbol. According to the sliding window function and this counter, the ATU-C decides to transmit all of the subsequent symbols in either FEXT_R or NEXT_R symbols (for example, see Figures I.11, I.19 and I.24).

C-PILOT1 has two signals.

The first signal is the pilot tone, a single frequency sinusoid at $f_{C-PILOT1}$ defined as:

$$X_{k} = \begin{cases} 0, & k \neq n_{C-PILOT1}, \ 0 \leq k \leq NSC \\ A_{C-PILOT1}, & k = n_{C-PILOT1} \end{cases}$$

The frequency of the pilot tone shall be selected from one of the following choices during G.994.1 as:

20. *f*_{C-PILOT1} = 276 kHz (*n*_{C-PILOT1} = 64).
 21. *f*_{C-PILOT1} = 414 kHz (*n*_{C-PILOT1} = 96).
 22. *f*_{C-PILOT1} = 552 kHz (*n*_{C-PILOT1} = 128).

23. $f_{C-PILOT1} = 1104 \text{ kHz} (n_{C-PILOT1} = 256).$

Transmitters that support Annex I-EU shall support all of these pilot tones.

The second signal is the TTR indication signal used to transmit $\text{NEXT}_R/\text{FEXT}_R$ information. The ATU-R can detect the phase information of the TTR_C from this signal. The TTR indication signal shall be selected during G.994.1 as:

A48 signal-the constellation encoding of the 48th carrier with 2-bit constellation as follows:

(+, +) to indicate a FEXT_R symbol;

(+, -) to indicate a NEXT_R symbol.

I.7.4.2 C-PILOT1A (supplements 10.4.3)

C-PILOT1A has two signals and it is the same transmitted signal as C-PILOT1 (C.7.4.1).

I.7.4.3 C-REVERB3 (supplements 10.4.11)

In order to synchronize the first symbol of C-RATES1 with the beginning of the hyperframe and to inform the entering timing of C-RATES1 to the ATU-R, the first symbol of C-SEGUE1 shall be transmitted inside of the FEXT_{R} duration as shown in Figure I.22. Therefore, the duration of C-REVERB3 is 3628 DMT symbols.

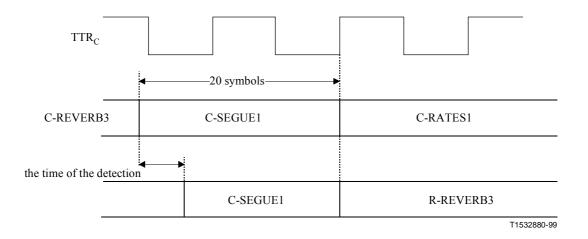


Figure I.22/G.992.1 – Timing diagram from C-SEGUE1 to C-RATES1

I.7.4.4 C-REVERB1 (replaces 10.4.5)

C-REVERB1 is a signal that allows the ATU-C and ATU-R receiver to adjust its automatic gain control (AGC) to an appropriate level. The data pattern used in C-REVERB1 shall be the pseudo-random downstream sequence (PRD), d_n for n = 1 to 2*NSCds, defined in I.4.7.5 and repeated here for convenience:

$$d_n = 1 for n = 1 to 9 (10-1)$$

$$d_n = d_{n-4} \oplus d_{n-9} for n = 10 to 2*NSCds$$

The bits shall be used as follows: the first pair of bits $(d_1 \text{ and } d_2)$ is used for the DC and Nyquist subcarriers (the power assigned to them is, of course, zero, so the bits are effectively ignored); then the first and second bits of subsequent pairs are used to define the X_i and Y_i for i = 1 to NSCds-1 as defined in Table 7-13.

The period of PRD is only 511 bits, so d_{n+511} is equal to d_n . The bits d_1 to d_9 shall be re-initialized for each symbol, so each symbol of C-REVERB1 is identical.

The two bits that modulate the pilot carrier shall be overwritten by $\{0,0\}$: generating the $\{+,+\}$ constellation.

The duration of C-REVERB1 is 512 (repeating) symbols without cyclic prefix.

I.7.4.4.1 Power Cut-back (supplements 10.4.5.1)

For Annex I-EU, see A.3.1.

I.7.5 Transceiver Training – ATU-R (supplements 10.5)

During transceiver training from R-REVERB1 to R-SEGUE1 except R-QUIETn, the ATU-R shall transmit both $FEXT_C$ and $NEXT_C$ symbols when Bitmap-N_C is enabled (Dual Bitmap mode) and shall not transmit $NEXT_C$ symbols when Bitmap-N_C is disabled (FEXT Bitmap mode). The duration of each state is defined as Figure I.26.

I.7.5.1 R-QUIET2 (supplements 10.5.1)

The ATU-R enters R-REVERB1 after it completes timing recovery and Hyperframe synchronization from C-PILOT1/C-PILOT1A.

I.7.5.2 R-REVERB1 (supplements 10.5.2)

The data pattern used in R-REVERB1 is the pseudo-random upstream sequence PRU defined in 8.11.3, repeated as necessary for the selected NSCus:

$$\begin{cases} d_n = 1 & \text{for } n = 1 \text{ to } 6 \\ d_n = d_{n-5} & \oplus d_{n-6} & \text{for } n = 7 \text{ to } 64 \end{cases}$$
(C.10-1)

The period of PRU is only 63 bits, so d_{n+63} is equal to d_n .

The ATU-R shall start its N_{SWF} counter immediately after entering R-REVERB1, and then increment the N_{SWF} counter with modulo 345 from 0 when it transmits each DMT symbol. The ATU-C and ATU-R shall have the same value since hyperframe alignment between the ATU-C and ATU-R shall be maintained. According to the sliding window and this counter, the ATU-R decides to transmit all of the subsequent symbols in either the FEXT_C or the NEXT_C symbol.

I.7.5.3 R-QUIET3 (replaces 10.5.3)

The final symbol of R-QUIET3 accommodates the frame alignment of the transmitter to that of the receiver. It may be shortened by any number of samples. The maximum duration of R-QUIET3 is 6145 DMT symbols.

I.7.5.4 R-REVERB2 (supplements 10.5.5)

After ATU-R detects C-SEGUE1, the ATU-R enters R-SEGUE1. The maximum duration of R-REVERB2 is 3643 DMT symbols.

I.7.6 Channel analysis (ATU-C) (supplements 10.6)

ATU-C shall transmit only FEXT_R symbols, and shall not transmit the NEXT_R symbols except the pilot tone from

C-RATES1 to C-CRC2. During C-MEDLEY, the ATU-C shall transmit both FEXT_R and NEXT_R symbols when Bitmap-N_R is enabled (Dual Bitmap mode). The ATU-C shall not transmit NEXT_R symbols except the pilot tone, when Bitmap-N_R is disabled (FEXT Bitmap mode). The duration of each state is defined in Figure I.26.

I.7.6.1 C-SEGUE1 (supplements 10.6.1)

The duration of C-SEGUE1 is 20 symbols in order that the first symbol of C-SEGUE1 shall be inside of the FEXT_R duration.

I.7.6.2 C-MEDLEY (replaces 10.6.6)

C-MEDLEY is a wideband pseudo-random signal used for estimation at the ATU-R of the downstream SNR. The data to be transmitted are derived from the pseudo-random sequence, PRD_m , defined as:

d_n = 1 for n = 1 to 14 and d_n = d_{n-5} \oplus d_{n-11} \oplus d_{n-12} \oplus d_{n-14} for n> 14,

and modulated as defined in 10.4.5. In contrast to C-REVERB1, the cyclic prefix is used and the data sequence continues from one symbol to the next (i.e. d_1 to d_{14} are not re-initialized for each symbol). Because the sequence is of length 2¹⁴-1, and far fewer bits are used for each symbol, the subcarrier vector for C-MEDLEY changes from one symbol period to the next. For non-overlapped spectrum, 2*(512-mm+1) bits are used each symbol, where mm is the minimum subcarrier specified for PSD mask DS-mm in Table I.13. For overlapped spectrum, 2*507 bits are used each symbol. The pilot subcarrier is overwritten by the (+,+) signal constellation. The duration of C-MEDLEY is as shown in Figure I.26. Following C-MEDLEY the ATU-C shall enter the state C-REVERB4.

With the periodical noise of TCM-ISDN, SNR also changes in the same cycle, as shown in Figure I.23. The ATU-C transmits the signal in both of $NEXT_R$ and $FEXT_R$ symbols, and the ATU-R estimates two SNRs from the received $NEXT_R$ and $FEXT_R$ symbols, respectively, as defined in Figure I.24.

The following formula gives the information that received N_{dmt}-th DMT symbol belongs to:

For $N_{dmt} = 0, 1, ..., 344$ $S = 272 \times N_{dmt} \mod 2760$ if { (S + 271 < a) or (S > d) } then symbol for estimation of FEXT_R SNR if { (S > b) and (S + 271 < c) } then symbol for estimation of NEXT_R SNR where a = 1243, b = 1403, c = 2613, d = 2704

When Bitmap-N_R is disabled (FEXT Bitmap mode), ATU-C shall transmit only the pilot tone as NEXT_R symbol. The number of bits of NEXT_R shall be no more than the number of bits of FEXT_R.

At the transmitter, the PRD_m sequence generator shall continue to be updated during $NEXT_R$ symbols when Bitmap-N_R is disabled (FEXT Bitmap mode).

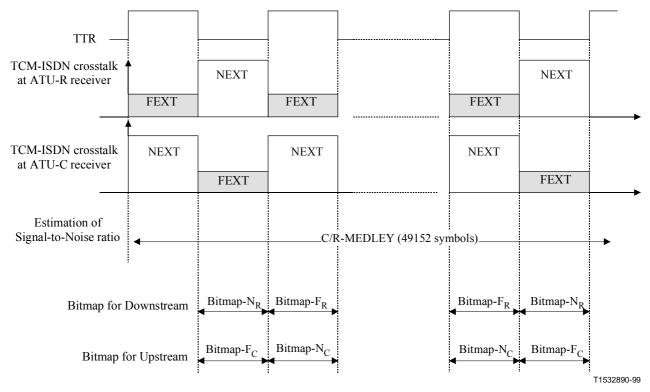


Figure I.23/G.992.1 – Estimation of periodic Signal-to-Noise Ratio

TTR _C	
0	
1	
2	20 21 22 23 24 25 26 27 28
3	30 31 32 33 34 35 36 36 38 39 40
4	41 42 43 44 45 46 47 48 49 50
5	51 52 53 54 55 56 57 58 59 60
6	61 62 63 64 65 66 57 68 69 70
7	71 72 73 74 75 76 78 79 80
8	81 82 83 84 85 36 87 88 99
9	91 92 93 94 95 96 97 98 99 101
10	101 102 103 104 105 106 107 108 109 111
11	112 113 114 115 116 117 128 12
12	122 123 124 125 26 27 728 729 131
13	132 133 134 135 136 137 138 139 140 14
14	142 143 144 145 146 147 148 149 151
15	152 153 154 155 156 157 138 160 161
16	162 163 164 165 166 167 168 169 1770 1772
17	173 174 175 176 177 178 179 188 182
18	183 184 185 186 187 188 189 199 191 192
19	193 194 195 196 197 198 206 201 202
20 21	203 204 205 206 207 208 209 213 214 215 216 217 218 229 223 222 222
22 23	223 224 225 226 227 228 229 238
23 24	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$
25	254 255 256 257 258 259 260 260 262 263
26	264 265 266 267 268 269 279 273 273
20	274 275 276 277 278 279 288 288 283
28	284 285 286 287 288 289 289 299 299 299
29	294 295 296 297 298 299 306 307 303 303
30	304 305 306 307 308 309 334 334 332 333 314
31	315 316 317 318 319 328 324 323 324
32	325 326 327 328 329 338 334 333 334
33	335 336 337 338 339 340 341 342 343 344
	Symbol for estimation of FEXT _R S/N Symbol not used for S/N estimation
	Symbol for estimation of NEXT _R S/N T1535370-0

Figure I.24/G.992.1 – Symbol pattern in a hyperframe for S/N estimation – Downstream

I.7.6.3 C-RATES1 (supplements 10.6.2)

In order to support data rates greater than 16 Mbit/s, the B_I field has 10 bits. The RRSI fields shall use the same extended syntax as defined in I.7.9.4 for C-RATES-RA.

For the S=1/2n framing mode (see §I.4.9), the downstream RS_I shall be the number of parity bytes per sync byte, i.e.,

 $RS_I = R_I / (n*S).$

Suffix(ces) of m_i (Note 1)	Parameter (Note 3)
47-44	Minimum required downstream SNR margin at initialization (Note 2)
43-18	Reserved for future use
17	Trellis coding option
16	Overlapped spectrum option (Note 4)
15	Unused (shall be set to "1")
14-12	Reserved for future use
11	NTR
10-9	Framing mode
8-6	Transmit PSD during initialization
5	Reserved
4-0	Maximum numbers of bits per subcarrier supported
OTE 1 – Within the separate fields	s the least significant bits have the lowest subscripts.
OTE 2 – A positive number of dB;	; binary coded 0-15 dB.
TOTE 2 All	

64014 6G MGG1

I.7.6.4 C-MSG1 (supplements 10.6.4)

NOTE 3 – All reserved bits shall be set to "0".

NOTE 4 – The initialization sequence allows for interworking of overlapped and non-overlapped spectrum implementations. Therefore, this indication is for information only.

I.7.6.4.1 Maximum numbers of bits per subcarrier supported – Bits 4-0 (replaces 10.6.4.8)

The N_{downmax} (transmit) capability shall be binary encoded onto $\{m_4, ..., m_0\}$ (e.g. $10001_2 = 17$). The maximum

number of bits for the upstream data, N_{upmax} , that the ATU-C receiver can support need not be signalled to the ATU-R; it will be implicit in the bits and gains message, C-B&G, which is transmitted after channel analysis.

I.7.7 Channel analysis (ATU-R) (supplements 10.7)

From R-RATES1 to R-CRC2, the ATU-R shall transmit only the FEXT_{C} symbols and shall not transmit the NEXT_{C} symbols. In R-SEGUE2 and R-MEDLEY, the ATU-R shall transmit both FEXT_{C} and NEXT_{C} symbols when Bitmap-N_C is enabled (Dual Bitmap mode) and shall not transmit NEXT_{C} symbols when Bitmap-N_C is disabled (FEXT Bitmap mode). The duration of each state is defined in Figure I.26.

I.7.8 R-SEGUE1 (supplements 10.7.1)

The maximum duration of R-SEGUE1 is 14 symbols (see Figure I.22).

I.7.8.1 R-REVERB3 (supplements 10.7.2)

The ATU-R shall start R-REVERB3 aligned with the beginning of a Hyperframe.

I.7.8.2 R-SEGUE2 (supplements 10.7.3)

The duration of R-SEGUE2 is 13 symbols.

I.7.8.3 R-MEDLEY (replaces 10.7.8)

R-MEDLEY is a wideband pseudo-random signal used for estimation of the upstream SNR at the ATU-C. The data to be transmitted are derived from the pseudo-random sequence PRU_m defined as:

d $_{n}$ = 1 for n = 1 to 23 and d $_{n}$ = d $_{n-18} \oplus$ d $_{n-23}$ for n> 23.

In contrast to R-REVERB1, the cyclic prefix is used and the data sequence continues from one symbol to the next (i.e. d_1 to d_{23} are not re-initialized for each symbol). Because the sequence is of length 2^{23} -1, and $2^*(nn-5)$ bits are used for

each symbol (where nn is the maximum subcarrier specified for PSD mask EU-nn in Table I.18), the subcarrier vector for R-MEDLEY changes from one symbol period to the next. Following R-MEDLEY the ATU-R enters signalling state R-REVERB4. The duration of R-MEDLEY is as shown in Figure I.26.

With the periodical noise of TCM-ISDN, SNR also changes in the same cycle, as shown in Figure I.23. ATU-R shall transmit the signal in both of $NEXT_C$ and $FEXT_C$ symbols, and ATU-C shall estimate two SNRs from the received $NEXT_C$ and $FEXT_C$ symbols, respectively, as defined in Figure I.25.

The following numerical formula gives the information that received N_{dmt}-th DMT symbol belongs to:

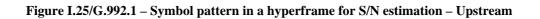
For $N_{dmt} = 0, 1, ..., 344$ $S = 272 \times N_{dmt} \mod 2760$ if { (S > b) and (S + 271 < c) } then symbol for estimation of FEXT_C SNR if { (S + 271 < a) } then symbol for estimation of NEXT_C SNR where a = 1148, b = 1315, c = 2608

When Bitmap-N_C is disabled (FEXT Bitmap mode), the ATU-R shall not transmit NEXT_C symbol. The number of bits of NEXT_C shall be no more than the number of bits of FEXT_C.

At the transmitter, the PRU_m sequence generator shall continue to be updated during $NEXT_C$ symbols when Bitmap- N_C is disabled (FEXT Bitmap mode).

TTR _R								U
0		4		5	6	7	8 9	
1 10	<u> </u>	14	15			7 1	8 19	
2 20 //////////////////////////////////	2	4	25	26	27	28	29	
3 30 //37///////////////////////////////	34		35	36	37	38	39	40
4	A3 44		45	46	47	48	49	50
5	54		55	56	57	58	59	60
6		6	5	66	67	68	69 7	0
7 71 72 73		75	7	6	77	78 7	79 80	
8 81 //82///83	X//84///	85	86	8	7 8	8 89	90	
9 91 //92///93//	99	ł	96	97	98	99	100	101
10 101 102 103	105	:	106	107	108	109	110	111
11	115	<u>. </u>	116	117	118	119	120	121
12	125	1	26	127	128	129		31
13	¥//X/X35//X	13		.37	138		140 14	<u>. </u>
14 142 143 144		146	14				50 151	
15 152 753 754	<u>X/////////</u> X	56	157					
16 162 163 164	16	.	167	168			171	172
17	176	<u>. </u>	177	178	179	180	181	182
18	186		187	188	189	190		192
19	¥5//X/X946///	<u> </u>	97	198	199	200		02
20 /203///204///203		20′					211 21	
21 213 225	//////////////////////////////////////	217	21			20 22		
22 223 224 225	<u>X////////////////////////////////////</u>	27	228					
23 233 234 235	236 23		238	239	240	241	242	243
24	246 247		248	249	250	251	252	253
25 /254//2555////	257	<u>. </u>	258	259	260	260		263
	×6////////////////////////////////////	20 278	58	269	270	271		73
27 284 284 284	<u>////X////////////////////////////////</u>	276 288						
28 284 285 286	//X///////////////////////////////////	i	28 299			91 29		
29 294 293 296 30 304 305 306	297 29	÷		300				314
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	307 308	<u> </u>	309 319	310	311	312		314
	318 318 328	<u>. </u>	319 329	320 330	321	322 332	323	324 334
32 325 325 326 326 326 326 326	1/////////////////////////////////////			340	331 341	342		44
33	////X//????////X	33	39	540	J41	J+2		14
		т				1	T1535290-00	
Symbol for estimation	of FEXT _C S/N	N			_ Symb	ol not use	d for S/N e	stima

Symbol for estimation of NEXT_C S/N



I.7.8.4 R-MSG1 (supplements 10.7.6)

Suffix(ces) of m_i (Note 1)	Parameter (Note 2)				
47-18	Reserved for future use				
17	Trellis coding option				
16	Overlapped spectrum option (Note 3)				
15	Unused (shall be set to "1")				
14	Support of $S = 1/2$ mode (see I.4.9) (Note 4)				
13	Support of dual latency downstream				
12	Support of dual latency upstream				
11	Network Timing Reference				
10, 9	Framing mode				
8-5	Reserved for future use				
4-0	Maximum numbers of bits per subcarrier supported				
NOTE 1 – Within the separate fields t	the least significant bits have the lowest subscripts.				
NOTE 2 - All reserved bits shall be set	et to "0".				
	allows for interworking of overlapped and non-overlapped spectrum				
implementations. Therefore, this indic					
NOTE 4 – Since the $S=1/2$ mode is m	andatory for Annex I-EU, a modem supporting Annex I-EU shall set this bit to				

Table I.14/G.992.1 – Assignment of 48 bits of R-MSG1

NOTE 4 – Since the S=1/2 mode is mandatory for Annex I-EU, a modem supporting Annex I-EU shall set this bit to binary ONE.

I.7.8.4.1 Maximum numbers of bits per subcarrier supported – Bits 4-0 (replaces 10.7.6.6)

The N_{upmax} (transmit) capability is encoded onto $\{m_4, ..., m_0\}$ with a conventional binary representation (e.g. $10001_2 = 17$).

I.7.9 Exchange – ATU-C (supplements 10.8)

During C-RATESn, C-MSGn, C-B&G, and C-CRCn, the ATU-C shall transmit the FEXT_R symbol. In the other signals, the ATU-C shall transmit both $FEXT_R$ and $NEXT_R$ symbols when Bitmap-N_R is enabled (Dual Bitmap mode), and shall not transmit the $NEXT_R$ symbols except pilot tone when Bitmap-N_R is disabled (FEXT Bitmap mode). The duration of each state is defined in Figure I.27.

I.7.9.1 C-MSG2 (supplements 10.8.9)

Replace Table 10-13 with Table I.15.

Suffix(ces) of <i>m_i</i> (Note 1)	Parameter (Note 2)			
31-26	Estimated average loop attenuation			
25-21	Reserved for future use			
20-16	Performance margin with selected rate option			
15-11	Reserved for future use			
10-0	Total number of bits supported			
NOTE 1 – Within the separate fields the least significant bits have the lowest subscripts.				
NOTE 2 – All reserved bits shall be set to "0".				

Table I.15/G.992.1 – Assignment of 32 bits of C-MSG2

For NSCus=32,

 $n_{1C-MSG2} = 43$ $n_{2C-MSG2} = 91$ Otherwise,

 $n_{1C-MSG2} = 139$ $n_{2C-MSG2} = 187$

I.7.9.1.1 Total number of bits per symbol supported (replaces 10.8.9.3)

The ATU-C receiver shall also calculate the maximum number of bits per symbol that the upstream channel can support with the performance margin defined in C-MSG-RA at an error rate of 10^{-7} .

The maximum number of bits per symbol is defined at the reference point B, that is calculated from the FEXT_C and NEXT_C downstream channel performance [e.g. if the maximum numbers of bits that can be supported in FEXT_C and NEXT_C symbols are 111 and 88 {Total number of bits per symbol supported} = $(111 \times 126 + 88 \times 214)/340 = 96$]. This number is encoded into bits 10-0 using a conventional binary representation [e.g. if the maximum number of bits that can be supported is 96 (data rate = 384 kbit/s), { m_{10} , ..., m_0 } = 000011111112].

NOTE – The number of symbols per hyperframe is 340. The number of FEXT symbols is 126. The number of NEXT symbols is 214.

I.7.9.1.2 Estimated average upstream loop attenuation (supplements 10.8.9.1)

For Annex I-EU, see A.3.2.

I.7.9.2 C-B&G (replaces 10.8.13)

C-B&G shall be used to transmit to the ATU-R the bits and gains information, Bitmap-FC { b_1 , g_1 , b_2 , g_2 , ... $b_{NSCus-1}$, $g_{NSCus-1}$ }, and Bitmap-N_C { $b_{NSCus+1}$, $g_{NSCus+1}$, $b_{NSCus+2}$, $g_{NSCus+2}$, ..., $b_{2*NSCus-1}$, $g_{2*NSCus-1}$ }, that are to be used on the upstream carriers. b_i of Bitmap-F_C indicates the number of bits to be coded by ATU-R transmitter onto the *i* th upstream carrier in FEXT_C symbols; g_i of Bitmap-F_C indicates the scale factor, relative to the gain that was used for that carrier during the transmission of R-MEDLEY, that shall be applied to the *i* th upstream carrier in FEXT_C symbols. Similarly, b_i of Bitmap-N_C indicates the number of bits onto the (*i* – NSCus) th upstream carrier in NEXT_C symbols; g_i of Bitmap-N_C indicates the scale factor that shall be applied to the (*i* – NSCus) th upstream carrier in NEXT_C symbols.

Because no bits or energy will be transmitted at DC or one-half the sampling rate, b_0 , g_0 , b_{NSCus} , g_{NSCus} , $b_{2*NSCus}$, and $g_{2*NSCus}$ are all presumed to be zero and shall not be transmitted.

Each b_i shall be represented as an unsigned 5-bit integer, with valid b_i s lying in the range of zero to N_{upmax} , the maximum number of bits that the ATU-R is prepared to modulate onto any subcarrier, which is communicated in R-MSG1.

Each g_i shall be represented as an unsigned 11-bit fixed-point quantity, with the binary point assumed just to the right of

the third most significant bit. For example, a g_i with binary representation (most significant bit listed first)

 001.01000000_2 would instruct the ATU-R to scale the constellation for carrier *i*, by a gain factor of 1.25, so that the power in that carrier shall be 1.94 dB higher than it was during R-MEDLEY.

For subcarriers on which no data are to be transmitted, and the receiver will never allocate bits (e.g. out-of-band subcarriers) both b_i and g_i shall be set to zero (00000₂ and 00000000 000₂, respectively). For subcarriers on which no data are to be currently transmitted, but the receiver may allocate bits later (e.g. as a result of an SNR improvement), the b_i shall be set to zero and the g_i to a value in the 0.19 to 1.33 range (000.00110000₂ to 001.0101010₁).

Let NSCu=128, except when EU-32 is used where NSCu=32. The C-B&G information shall be mapped in a 32*(NSCu-1)-bit (4*(NSCu-1) byte) message *m* defined by:

 $m = \{m_{32*}(NSCu-1)-1, m_{32*}(NSCu-1)-2, ..., m_1, m_0\} = \{g_{2*}NSCu-1, b_{2*}NSCu-1, ..., g_{NSCu+1}, b_{NSCu+1}, g_{NSCu-1}, ..., g_{1}, b_1\},$ (C.10-2)

with the MSB of b_i and g_i in the higher *m* index and m_0 being transmitted first. The message *m* shall be transmitted in 4*(NSCu-1) FEXT_R symbols. When NSCu=32, including C_CRC5, the total length is 336 symbols while for NSCu=128, the total length is 336+3*345=1371 symbols, using the transmission method as described in 10.8.9.

When Bitmap-N_C is disabled (FEXT Bitmap mode), b_i and g_i of Bitmap-N_C shall be set to zero. For index between NSCus+1 and 127, the m values are set to 0.

I.7.9.3 C-SEGUE3 (replaces 10.8.16)

The duration of C-SEGUE3 is 18 symbols. Following C-SEGUE3, the ATU-C completes the initialization and enters C-SHOWTIME. In C-SHOWTIME, ATU-C shall transmit the signal using Bitmap- F_R and Bitmap- N_R with the sliding window.

When Bitmap-N_R is disabled (FEXT Bitmap mode), ATU-C shall transmit only the pilot tone as NEXT_R symbols.

I.7.9.4 C-RATES-RA (supplements 10.8.3)

			←	←bits>					
fields	7	6	5	5 4 3 2 1				0	
RS _F	0	0		value of RS _F					
			MS	MSB LSB					
RSI	$B_8(AS0)$	$B_9(AS0)$		value of RS _I					
			MS	MSB LSB					
S	I9	I_8		value of S					
			MSB LSB						
Ι	I ₇	I ₆	I_5 I_4 I_3 I_2 I_1 I_0						
FS(LS2)	value of FS(LS2) set to $\{0000000_2\}$								

Table I.16/G.992.1 – RRSI fields of C-RATES-RA

The RS_I field has been extended to include the most significant bit B_9 of B_1 (AS0), the number of payload bytes in the AS0 bearer channel in the downstream interleave buffer, in bit 6. This is to support the higher data rates for the optional S=1/4 and S=1/3 modes.

The S field shall be coded $\{100100_2\}$ to indicate S=1/4.

For the S=1/2n framing mode (see §I.4.9), the downstream RS_I shall be the number of parity bytes per sync byte, i.e., $RS_I = R_I/(n^*S)$.

I.7.10 Exchange – ATU-R (supplements 10.9)

ATU-R shall transmit only the FEXT_{C} symbols in R-MSGn, R-RATESn, R-B&G, R-CRCn. In other signals, the ATU-R shall transmit both FEXT_{C} and NEXT_{C} symbols when Bitmap-N_C is enabled (Dual Bitmap mode) and shall not transmit NEXT_{C} symbols when Bitmap-N_C is disabled (FEXT Bitmap mode). The duration of each state is defined in Figure I.27.

I.7.10.1 R-MSG-RA (supplements 10.9.2)

Replace Table 10-15 with Table I.17.

Suffix(ces) of m _i	Parameter
(Note)	All reserved bits shall be set to 0
79-71	Reserved for ITU-T
70	Extension to number of RS payload bytes, K
69, 68	Extension to number of tones carrying data (ncloaded)
67-56	B _{fast-max}
55-49	Number of RS overhead bytes, (R)
48-40	Number of RS payload bytes, K
39-32	Number of tones carrying data (ncloaded)
31-25	Estimated average loop attenuation
24-21	Coding gain
20-16	Performance margin with selected rate option
15	Reserved for ITU-T
14	Extension to total number of bits per DMT symbol, Bmax
13-12	Maximum Interleave Depth downstream
11-0	Total number of bits per DMT symbol, B _{max}
OTE – Within the sep	arate fields the least significant bits have the lowest subscripts.

Table I.17/G.992.1 – Assignment of 80 bits of R-MSG-RA (Annex I-EU)

I.7.10.1.1 Total number of bits supported (B_{max}) (replaces 10.9.2.8)

This parameter shall be defined as in R-MSG2, see I.7.9.1.

I.7.10.1.2 B_{fast-max} (new)

 $B_{fast-max}$ is the maximum number of bits of the fast buffer for fast data transmitted on the condition that the bits of the fast data can be equally assigned to all FEXT-symbols and NEXT-symbols.

Fast Buffered Data B_{fast-max} is t_f.

I.7.10.2 R-MSG2 (supplements 10.9.8)

Suffix(ces) of m _i (Note 1)	Parameter (Note 2)
31-25	Estimated average loop attenuation
24-21	Reserved for future use
20-16	Performance margin with selected rate option
15	Reserved for future use
14	Extension to total number of bits per DMT symbol, B _{max}
13-12	Reserved for future use
11-0	Total number of bits per DMT symbol, Bmax
OTE 1 – Within the separate fi	elds the least significant bits have the lowest subscripts.

Table I.18/G.992.1 – Assignment of 32 bits of R-MSG2

 $N_{1R-MSG2} = 10$ $N_{2R-MSG2} = 20$

I.7.10.2.1 Total number of bits per symbol supported (supplements 10.9.8.3)

The maximum number of bits per symbol that the downstream channel can support is encoded into bits 14 and 11 - 0.

The maximum number of bits per symbol is defined at the reference point B, that is calculated from the FEXT_R and NEXT_R downstream channel performance. For example, if the maximum numbers of bits that can be supported in FEXT_R and NEXT_R symbols are 111 and 88, the total number of bits per symbol supported is (111 x 126 + 88 x 214)/340 = 96.

NOTE – The number of symbols per hyperframe is 340, the number of FEXT symbols is 126, and the number of NEXT symbols is 214.

I.7.10.2.2 Estimated average downstream loop attenuation (supplements 10.9.8.1)

For Annex I-EU, see A.3.3.

I.7.10.3 R-REVERB5 (supplement of 10.9.12)

The duration of R-REVERB5 is 345n-40, 3<=n<=19, when NSCu=128, or 3<=n<=16 when NSCu=32.

I.7.10.4 R-B&G (replaces 10.9.14)

The purpose of R-B&G is to transmit to ATU-C the bits and gains information, Bitmap-F_R { b_1 , g_1 , b_2 , g_2 , ..., $b_{NSCds-1}$, $g_{NSCds-1}$ }, and Bitmap-N_R { $b_{NSCds+1}$, $g_{NSCds+1}$, $b_{NSCds+2}$, $g_{NSCds+2}$, ..., $b_{2*NSCds-1}$, $g_{2*NSCds-1}$ }, to be used on the downstream subcarriers. b_i of Bitmap-F_R indicates the number of bits to be coded by ATU-C transmitter onto the *i* th downstream subcarrier in FEXT_R symbols; g_i of Bitmap-F_R indicates the scale factor that shall be applied to the *i* th downstream subcarrier in FEXT_R symbols, relative to the gain that was used for that carrier during the transmission of C-MEDLEY. Similarly, b_i of Bitmap-N_R indicates the number of bits onto the (*i* – NSCds) th downstream carrier in NEXT_R symbols; g_i of Bitmap-N_R indicates the scale factor that shall be applied to the (*i* – NSCds) th downstream carrier in NEXT_R symbols. Because no bits or energy will be transmitted at DC or one-half the sampling rate, b_0 , g_0 , b_{NSCds} , g_{NSCds} , $b_{2*NSCds}$, and $g_{2*NSCds}$ are all presumed to be zero, and are not transmitted. When subcarrier 64 is reserved as the pilot tone, b_{64} and $b_{NSCds+64}$, shall be set to 0, g_{64} and $g_{NSCds+128}$ shall be set to g_{sync} . When subcarrier 128 is reserved as the pilot tone, b_{128} and $b_{NSCds+128}$, shall be set to 0, g_{256} and $g_{NSCds+256}$ shall be set to g_{sync} . The value g_{sync} represents the gain scaling applied to the sync symbol.

Each b_i is represented as an unsigned 5-bit integer, with valid b_i lying in the range of zero to N_{downmax} , the maximum

number of bits that the ATU-C is prepared to modulate onto any subcarrier, which is communicated in C-MSG1.

Each g_i is represented as an unsigned 11-bit fixed-point quantity, with the binary point assumed just to the right of the

third most significant bit. For example, a g_i with binary representation (most significant bit listed first) 001.010000002 would instruct the ATU-C to scale the constellation for carrier *i* by a gain factor of 1.25, so that the power in that carrier shall be 1.94 dB higher than it was during C-MEDLEY.

For subcarriers on which no data are to be transmitted, and the receiver will never allocate bits (e.g. out-of-band subcarriers) both b_i and g_i shall be set to zero (00000₂ and 00000000 000₂, respectively). For subcarriers on which no data are to be currently transmitted, but the receiver may allocate bits later (e.g. as a result of an SNR improvement), the b_i shall be set to zero and the g_i to a value in the 0.19 to 1.33 range (000.00110000₂ to 001.0101010₁).

The R-B&G information shall be mapped in a (2*NSCds-2)*16-bit ((2*NSCds-2)*2 byte) message *m* defined by:

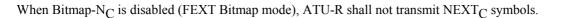
 $m = \{m_{(2*NSCds-2)*16-1}, m_{(2*NSCds-2)*16-2}, ..., m_1, m_0\} = \{g_{2*NSCds-1}, b_{2*NSCds-1}, ..., g_{NSCds+1}, b_{NSCds+1}, b_{NSCds+1}, b_{NSCds-1}, ..., g_{1}, b_{1}\},$ (I.10-3)

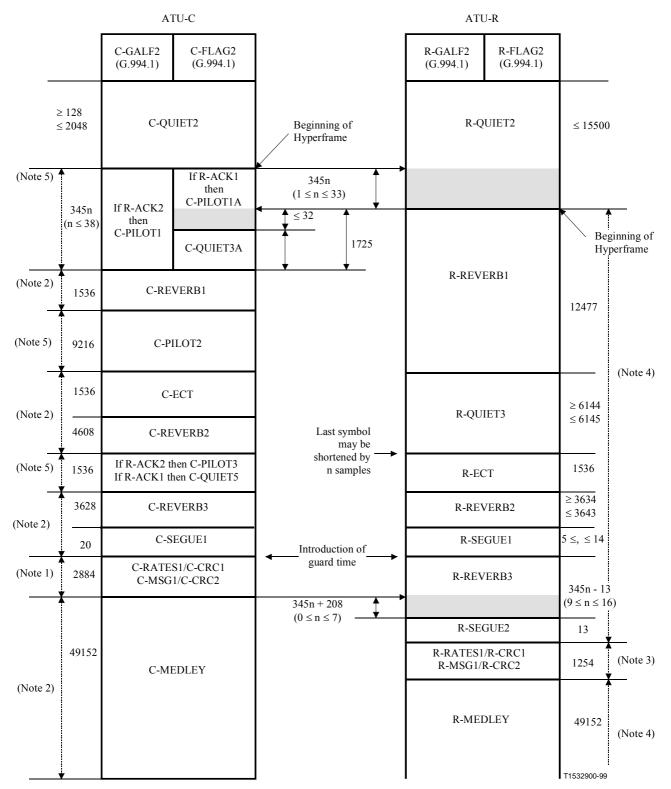
with the MSB of b_i and g_i in the higher *m* index and m_0 being transmitted first. The message *m* shall be transmitted in (2*NSCds-2)*2 symbols, using the transmission method as described in 10.9.8.

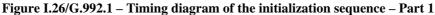
When Bitmap-N_R is disabled (FEXT Bitmap mode), b_i and g_i of Bitmap-N_R shall be set to zero.

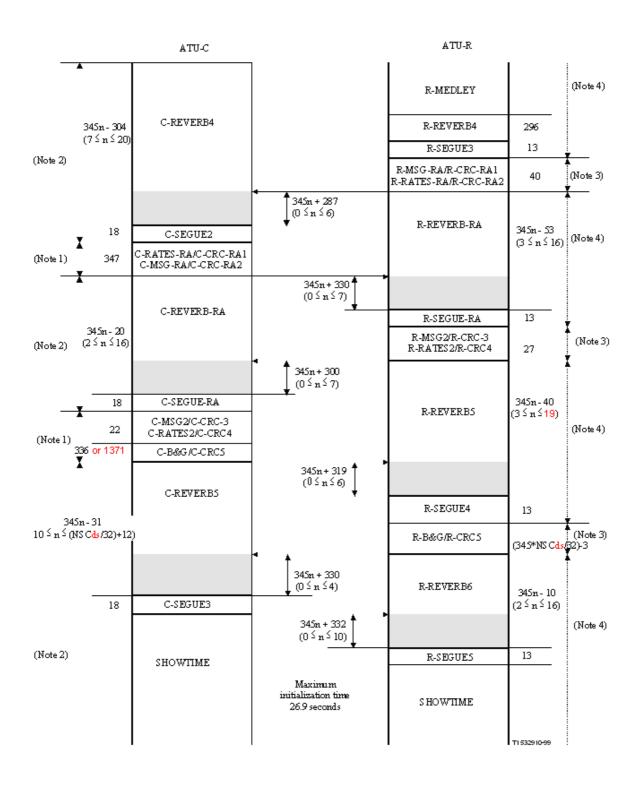
I.7.10.5 R-SEGUE5 (replaces 10.9.17)

The duration of R-SEGUE5 is 13 symbols. Following R-SEGUE-5, ATU-R completes the initialization and enters R-SHOWTIME. In R-SHOWTIME, ATU-R shall transmit the signal using Bitmap- F_C and Bitmap- N_C with the sliding window.









- NOTE 1 The ATU-C shall transmit the FEXTR symbols, and shall not transmit as NEXTR symbols except the pilot tone.
- NOTE 2 The ATU-C shall transmit both FEXTR and NEXTR symbols, when Bitmap-NR is enabled (Dual Bitmap mode). ATU-C shall not transmit the NEXTR symbols except pilot tone, when Bitmap-NR is disabled (FEXT Bitmap mode).
- NOTE 3 The ATU-R shall transmit the FEXTC symbols, and shall not transmit the NEXTC symbols.
- NOTE 4 The ATU-R shall transmit both FEXTC symbols, when Bitmap-NC is enabled (Dual Bitmap mode). ATU-R shall not transmit NEXTC symbols, when Bitmap-NC is disabled (FEXT Bitmap mode).

NOTE 5 – The ATU-C shall transmit both FEXTR and NEXTR symbols.

Figure I.27/G.992.1 – Timing diagram of the initialization sequence – Part 2

[Editor's note: updated Figure I.27 to parameterize the length of C-B&G and the maximum length of R-REVERB5.]

I.8 AOC On-line adaptation and reconfiguration (pertains to clause 11)

I.8.1.1 Bit swap request (replaces 11.2.3)

The receiver shall initiate a bit swap by sending a bit swap request to the transmitter via the AOC channel. This request tells the transmitter which subcarriers are to be modified. The format of the request is shown in Table I.19.

Message header	Message field 1-4			
$\{11111111_2\}$	Bitmap index	Subchannel	Command	Subchannel
(8 bits)	(1 bit)	index – bits 10	(5 bits)	index – bits 8
(*****)		& 9		to 1
		(2 bits)		(8 bits)

Table I.19/G.992.1 – Format of the bit swap request message

The request shall comprise nine bytes as follows:

- an AOC message header consisting of 8 binary ones;
- message fields 1-4, each of which consists of a one-bit bitmap index, subchannel index bits 10 & 9, and a five-bit command followed by bits 8 to 1 of the subchannel index. One-bit bitmap index, subchannel index bits 10 & 9, and valid five-bit commands for the bit swap message shall be as shown in Table I.20. In Table I.20, the MSB for the bit swap request command represents the Bitmap index. For downstream data, Bitmap index equals 0 indicates Bitmap-F_R, and Bitmap index equals 1 indicates Bitmap-N_R. Similarly for upstream data, Bitmap index equals 0 0 indicates Bitmap-F_C, and 1 indicates Bitmap-N_C. The next 2 bits are subchannel index bits 10 & 9. The ten-bit subchannel index is counted from low to high frequencies with the lowest frequency subcarrier having the number zero. The subcarrier index zero shall not be used;
- the bit swap between $FEXT_{C/R}$ symbols and $NEXT_{C/R}$ symbols is not allowed.

Value (8 bit)	Interpretation
yzz000002	Do nothing
yzz000012	Increase the number of allocated bits by one
yzz000102	Decrease the number of allocated bits by one
yzz000112	Increase the transmitted power by 1 dB
yzz001002	Increase the transmitted power by 2 dB
yzz001012	Increase the transmitted power by 3 dB
yzz001102	Reduce the transmitted power by 1 dB
yzz001112	Reduce the transmitted power by 2 dB
yzz01xxx ₂	Reserved for vendor discretionary commands
NOTE – y is "0" for Fl	$EXT_{C/R}$ symbols, and "1" for NEXT _{C/R} symbols of the Sliding Window.
NOTE – subchannel in	dex = zz_2^{*256} + subchannel index value from lower 8 bit field

Table I.20/G.992.1 - Bit swap request command

The bit swap request message (i.e. header and message fields) shall be transmitted five consecutive times.

To avoid g_i divergence between ATU-C and ATU-R after several bit swaps, for a g_i update of Δ dB the new g_i value should be given by:

$$g_i' = (1/256) \times round(256 \times g_i \times 10 \exp(\Delta/20))$$
 (I.11-1)

I.8.1.2 Extended bit swap request (supplements 11.2.4)

The format of the extended bit swap request is shown in Table I.21.

Message header	Message field 1-6			
{11111100 ₂ }	Bitmap index	Subchannel	Command	Subchannel
(8 bits)	(1 bit)	index – bits 10	(5 bits)	index – bits 8
(0 010)		& 9		to 1
		(2 bits)		(8 bits)

In the same manner as the bit swap request, each of the message fields of the extended bit swap request consists of one-bit bitmap index, a five-bit command followed by a related ten-bit subchannel index.

I.8.1.3 Bit swap acknowledge (supplements 11.2.5)

The bit swap superframe counter number shall only indicate the last superframe (SPF#4) of a hyperframe.

The new bit and/or transmit power table(s) shall then take effect starting from the first frame (frame 0) of SPF#0 of a hyperframe.

If the bit swap superframe counter number contained in the received bit swap acknowledge message does not indicate SPF#4, then the new table(s) shall take effect starting from frame 0 of SPF#0 of the next hyperframe.

I.9 POTS splitter

For operation according to G.992.1 Annex I-EU, the Annex E.4/G.992.3 requirements applying over a frequency band up to 1104 kHz, shall be met over a frequency band up to 2208 kHz.

付属資料7

G.992.1 ANNEX C-EU (REVISION 1) PROPRIETARY EXTENSION TO G.992.1 ANNEX C

This document defines G.992.1 Annex C-EU (Single spectrum downstream with extended upstream spectrum), a proprietary extension to G.992.1 Annex C to extend the data rate beyond 2 Mbit/s upstream by way of:

- Increase upstream bandwidth \rightarrow increased number of subcarriers, NSCus=64
- Increased bit loading, beyond 15 bits/bin
- Two new extended reach PSD masks LD-TIF1&2 added.

Due to the increase in upstream data rates, the upstream maximum interleave depth has been increased to 16. Support of this is mandatory.

The attached text is the approved text for Annex C, marked up with revision control to show the changes necessary to support the additional functionality.

Revision 1 text is based on G.992.1 Annex I-EU Revision 1, and supports the following features:

- extended upstream to subcarrier 64
- high bit loading (HBL),
- overlapped spectrum,
- D=16 upstream mandatory

Still to do:

- add the DS PSD masks (done) and code points for LD-TIF1 and 2 (done)
- (for each profile with extended upstream: no change in pilot tone and TTR indication signal done
- C-MSG2 subcarriers for signalling: 91 and 139 done
- go through the document and renumber tables and figures to fix the numbering after adding the new tables/figures.
- Modified timing diagram for initialization in Figure C.22(C-B&G and R-REVERB5 text has been changed. Update Figure C.22 later) -done

ANNEX C-EU

Specific requirements for an ADSL system to support upstream data rates greater than 2 Mbit/s operating in the same cable as ISDN as defined in ITU-T Recommendation G.961 Appendix III

C.1 Scope

This annex describes those specifications that are unique to an ADSL system coexisting in the same binder as TCM-ISDN as defined Recommendation G.961 Appendix III. The subclauses in this annex provide supplementary and replacement material to the clauses in the main body. The nature of the material is parenthetically indicated in the subclause heading. The modifications described in this annex allow a performance improvement from the ADSL system specified in Annex A in an environment coexisting with TCM-ISDN in the same cable. Specifically, this Annex specifies extensions to upstream bandwidth and maximum bit loading to support upstream data rates greater than 2 Mbit/s. This annex also defines those parameters of this ADSL system that have been left undefined in the main body of this Recommendation. An ADSL system implementing Annex C-EU shall support Annex C. It is recommended that an ADSL system implementing Annex A.

This Amendment defines several optional operating modes or "profiles", negotiable through G.994.1, to allow limited independent control of:

- FEXT and NEXT period transmission in both upstream and downstream directions
- overlapped and non-overlapped spectrum downstream during FEXT and NEXT periods

These new optional profiles (defined in Section § C.3.4 as Profiles 1 to 6) offer improved robustness and extended reach compared to the previously defined operating modes.

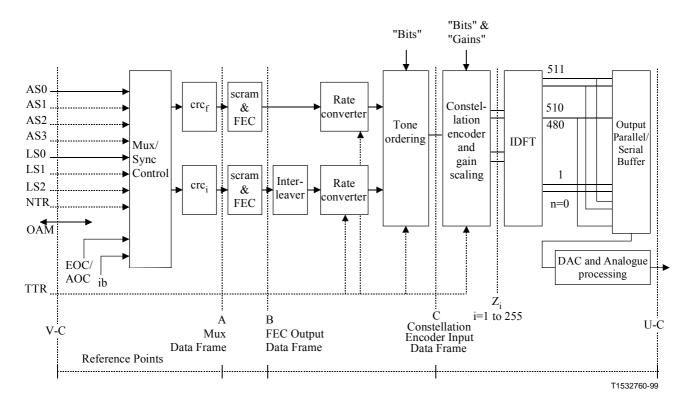
C.2 Definitions

Bitmap-F _C	ATU-R transmitter bitmap under TCM-ISDN FEXT noise generated at ATU-C
Bitmap-F _R	ATU-C transmitter bitmap under TCM-ISDN FEXT noise generated at ATU-R
Bitmap-N _C	ATU-R transmitter bitmap under TCM-ISDN NEXT noise generated at ATU-C
Bitmap-N _R	ATU-C transmitter bitmap under TCM-ISDN NEXT noise generated at ATU-R
Dual Bitmap FEXT Bitmap	The Dual Bitmap method has dual bit rates under the FEXT and NEXT noise from TCM-ISDN Similar to the Dual Bitmap method however transmission only occurs during FEXT noise from TCM-ISDN
FEXT _C duration	TCM-ISDN FEXT duration at ATU-C estimated by the ATU-R
FEXT _C symbol	DMT symbol transmitted by ATU-R during TCM-ISDN FEXT
FEXT _R duration	TCM-ISDN FEXT duration at ATU-R estimated by the ATU-C
FEXT _R symbol	DMT symbol transmitted by ATU-C during TCM-ISDN FEXT
Hyperframe NEXT _C duration	5 Superframes structure which synchronized TTR TCM-ISDN NEXT duration at ATU-C estimated by the ATU-R
NEXT _C symbol	DMT symbol transmitted by ATU-R during TCM-ISDN NEXT
NEXT _R duration	TCM-ISDN NEXT duration at ATU-R estimated by the ATU-C
NEXT _R symbol	DMT symbol transmitted by ATU-C during TCM-ISDN NEXT
NSCus	The highest subcarrier index that can be used for upstream transmission (i.e., the subcarrier index corresponding to the Nyquist frequency) For example, $NSCus = 64$ for an upstream channel using the frequency band up to 276 kHz.
N _{SWF}	Sliding Window frame counter
Subframe	10 consecutive DMT symbols (except for sync symbols) according to TTR timing
TTR	TCM-ISDN Timing Reference
TTR _C	Timing reference used in ATU-C
TTR _R	Timing reference used in ATU-R
UI	Unit Interval

C.3 Reference Models

C.3.1 ATU-C transmitter reference model (replaces figures in 5.1)

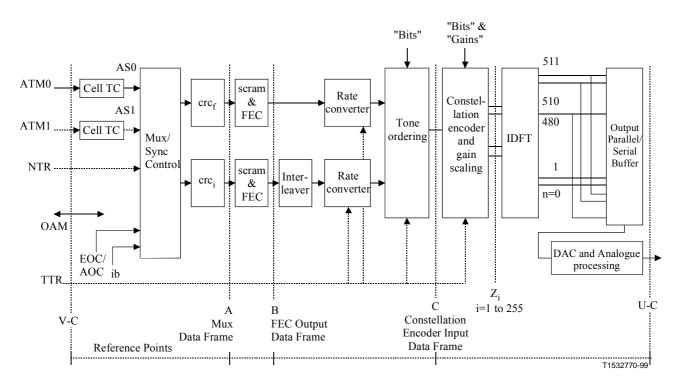
See Figure C.1 and Figure C.2.



NOTE - The TTR may be generated in ATU-C without being provided from the TCM-ISDN clock.

Figure C.1/G.992.1 – ATU-C transmitter reference model for STM transport

Annex C-EU does not currently support STM transport. It only supports ATM transport.

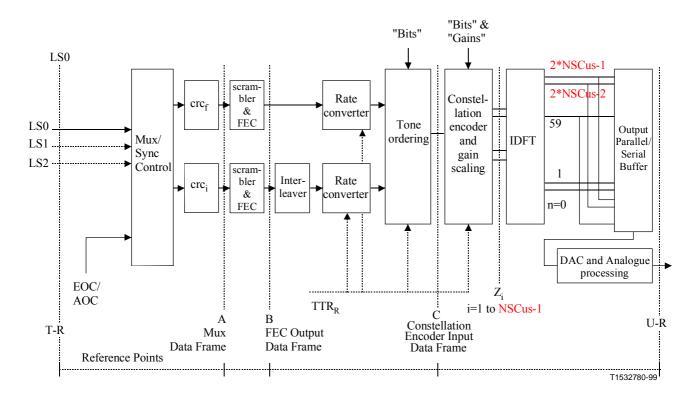


NOTE - The TTR may be generated in ATU-C without being provided from the TCM-ISDN clock.

Figure C.2/G.992.1 – ATU-C transmitter reference model for ATM transport

C.3.2 ATU-R transmitter reference model (replaces figures in 5.2)

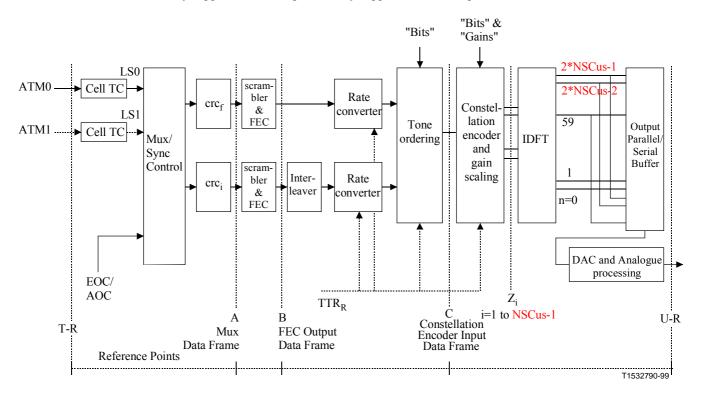
See Figure C.3 and Figure C.4.



NOTE – The TTR_R shall be generated in ATU-R from the received TTR_C signal, and it is locked to 690 periods of upstream sampling clock (276 kHz).

Figure C.3/G.992.1 – ATU-R transmitter reference model for STM transport

Annex C-EU does not currently support STM transport. It only supports ATM transport.



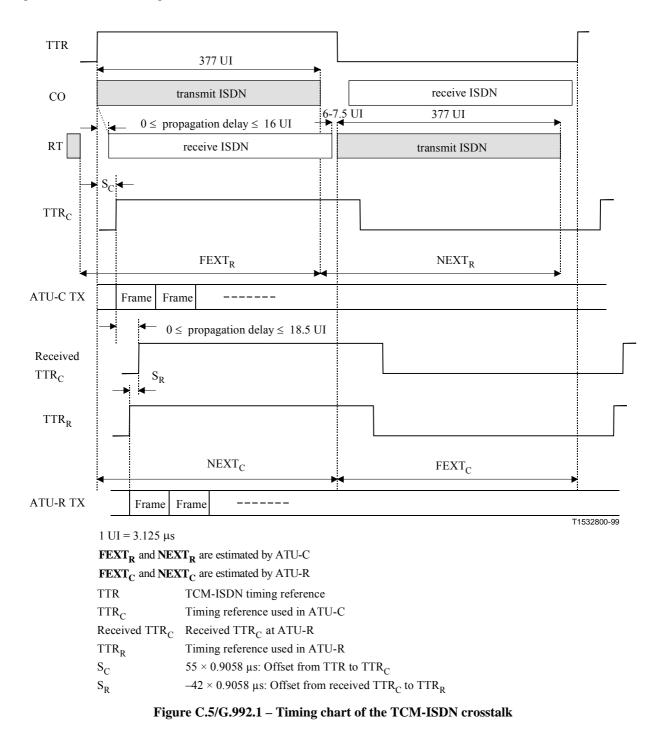
NOTE – The TTR_R shall be generated in ATU-R from the received TTR_C signal, and it is locked to 690 periods of upstream sampling clock (276 kHz).

Figure C.4/G.992.1 – ATU-R transmitter reference model for ATM transport

C.3.3 ATU-C/R transmitter timing model (replacement for 5.3)

C.3.3.1 TCM-ISDN crosstalk timing model (new)

Figure C.5 shows the timing chart of the crosstalk from TCM-ISDN.



The data stream of TCM-ISDN is transmitted in TTR period. CO transmits the stream in the first half of the TTR period

and RT transmits in the second half of the TTR period. ATU-C receives NEXT noise from the ISDN in the first half of the TTR period and FEXT noise from the ISDN in the second half of the TCM-ISDN period. On the other hand, ATU-R receives FEXT noise from the ISDN in the first half of the TTR period and NEXT noise from the ISDN in the second half of the TTR period.

As defined in C.7.6.2 and C.7.8.3, the ATU-C shall estimate the FEXT_R and NEXT_R duration at ATU-R, and the ATU-R shall estimate FEXT_C and NEXT_C duration at ATU-C taking propagation delay on the subscribe line into consideration.

The ATU-C shall transmit any symbols by synchronizing with the TTR_C . The ATU-R shall transmit any symbols synchronizing with the TTR_R generated from received TTR_C .

C.3.3.2 Sliding window (new)

Figure C.6 shows the timing chart of the transmission for the Annex C-EU downstream at ATU-C.

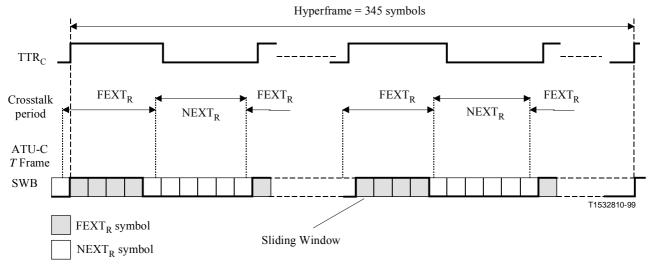


Figure C.6/G.992.1 – Sliding window for downstream symbols

The Sliding Window defines the transmission symbols under the crosstalk noise environment synchronized to the period of TTR. The $\text{FEXT}_{C/R}$ symbol represents the symbol completely inside the $\text{FEXT}_{C/R}$ duration. The $\text{NEXT}_{C/R}$ symbol containing the $\text{NEXT}_{C/R}$ duration. Thus, there are more $\text{NEXT}_{C/R}$ symbols than $\text{FEXT}_{C/R}$ symbols.

The ATU-C decides which transmission symbol is FEXT_R or NEXT_R symbol according to the sliding window and transmits it with the corresponding bit table. Similarly, the ATU-R decides the transmission symbol is a FEXT_C or NEXT_C and transmits it with the corresponding bit table. Although the phase of the sliding window is asynchronous with $\text{TTR}_{C/R}$, the pattern is fixed to the 345 frames of the hyperframe.

C.3.3.3 ATU-C Symbol Synchronization to TTR (new)

345 symbols are 34 cycles with cyclic prefix of TTR_C (or 32 cycles of TTR_C without cyclic prefix). This implies a PLL lock at the ATU-R.

C.3.3.4 Dual Bitmap switching (new)

The ATU-C transmits FEXT_R symbols using Bitmap-F_R (in FEXT_R duration), and transmits NEXT_R symbols using Bitmap-N_R (in NEXT_R duration) according to the result of initialization. The ATU-R transmits FEXT_C symbols using

Bitmap-F_C (in FEXT_C duration), and transmits NEXT_C symbols using Bitmap-N_C (in NEXT_C duration) in the same manner.

The ATU-C shall have the capability to disable Bitmap-N_C and Bitmap-N_R (see C.4.5 and C.5.3). As an option, an ATU-C may have the ability to enable or disable Bitmap-N_C independently of Bitmap-N_R. This is controlled by way of the profiles negotiated through G.994.1.

C.3.3.5 Loop timing at ATU-R (new)

The phase relation between received symbol and transmitted symbol of ATU-R at the reference point U-R shall meet the phase tolerances as shown in Figure C.7.

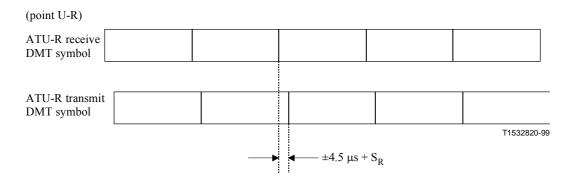


Figure C.7/G.992.1 – Loop timing for ATU-R

C.3.4 Operating modes (new)

The following profiles are defined to support independent control of FEXT and NEXT bitmaps in the upstream and downstream direction, as well as independent control of the downstream spectrum for each downstream bitmap:

Profile 1

For Profile 1, upstream transmission only uses $Bitmap-F_C$, and downstream transmission only uses $Bitmap-F_R$ with non-overlapped spectrum.

Profile 2

For Profile 2, upstream transmission uses both Bitmap- F_C and Bitmap- N_C , and downstream transmission uses both Bitmap- F_R and Bitmap- N_R . Non-overlapped spectrum is used with both downstream bitmaps.

Profile 3

For Profile 3, upstream transmission only uses $Bitmap-F_C$, and downstream transmission only uses $Bitmap-F_R$ with overlapped spectrum. An example of a downstream PSD mask for this operating mode is shown in Figure V.3 and described in Table V.3 in Appendix V.

Profile 4

For Profile 4, upstream transmission uses both Bitmap- F_C and Bitmap- N_C , and downstream transmission uses both Bitmap- F_R and Bitmap- N_R . Overlapped spectrum is used with both downstream bitmaps.

Profile 5

For Profile 5, upstream transmission only uses $Bitmap-F_C$, and downstream transmission uses both $Bitmap-F_R$ and $Bitmap-N_R$. Non-overlapped spectrum is used with $Bitmap-N_R$, and overlapped spectrum is used with $Bitmap-F_R$. An

example of a downstream PSD mask for use with Bitmap- N_R is shown in Figure V.1 and described in Table V.1 in Appendix V. An example of a downstream PSD mask for use with Bitmap- F_R is shown in Figure V.2 and described in Table V.2 in Appendix V.

Profile 6

For Profile 6, upstream transmission uses both Bitmap- F_C and Bitmap- N_C , and downstream transmission uses both Bitmap- F_R and Bitmap- N_R . Non-overlapped spectrum is used with Bitmap- N_R , and overlapped spectrum is used with Bitmap- F_R . An example of a downstream PSD mask for use with Bitmap- N_R is shown in Figure V.1 and described in Table V.1 in Appendix V. An example of a downstream PSD mask for use with Bitmap- F_R is shown in Figure V.2 and described in Table V.2 in Appendix V.

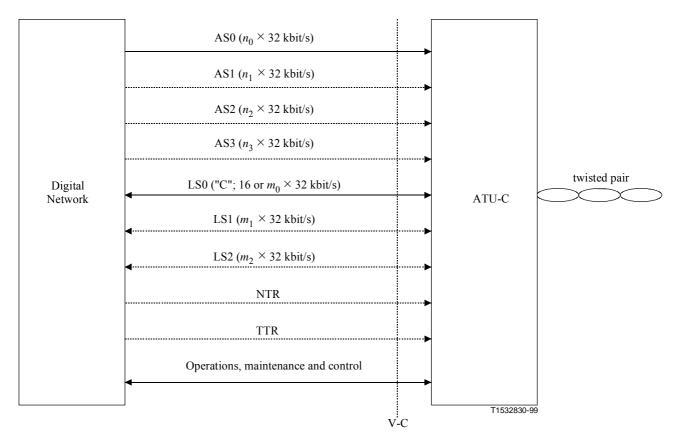
Table 11.5.1/G.994.1 contains the code points to support these profiles.

C.4 ATU-C functional characteristics (pertains to clause 7)

C.4.1 STM transmission protocols specific functionality (pertains to 7.1)

C.4.1.1 ATU-C input and output V interface for STM transport (replaces figure in 7.1.1)

See Figure C.8.



NOTE 1 – Optional bearer channels (both duplex and simplex) and features are shown with dotted lines. NOTE 2 – TTR may be generated in the ATU-C without being provided from the V-C reference point.

Figure C.8/G.992.1 – ATU-C functional interfaces for STM transport at the V-C reference point

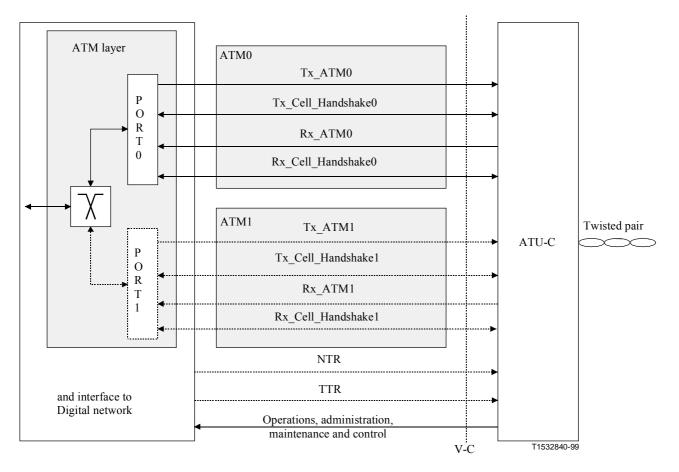
C.4.1.2 Payload transfer delay (supplements 7.1.4)

Since Annex C-EU uses a rate converter, the maximum payload transfer delay is longer than specified values in 7.1.4. The additional one-way transfer delay due to the rate converters shall be less than 1.7 ms for fast data and 13 ms for interleaved data.

C.4.2 ATM transmission protocols specific functionalities (pertains to 7.2)

C.4.2.1 ATU-C Input and Output V interface for ATM transport (replaces figure in 7.2.1)

See Figure C.9.



NOTE - TTR can be generated in the ATU-C without being provided from the V-C reference point.

Figure C.9/G.992.1 – ATU-C functional interfaces to the ATM layer at the V-C reference point

C.4.2.2 Payload transfer delay (supplements 7.2.2)

Since Annex C-EU uses a rate converter, the maximum payload transfer delay is longer than specified values in 7.2.2. The additional one-way transfer delay due to the rate converters shall be less than 1.7 ms for fast data and 13 ms for interleaved data.

C.4.3 Framing (pertains to 7.4)

C.4.3.1 Superframe structure (supplements 7.4.1.1)

Since the rate converter reorders the user data and overhead bit-level data to create hyperframes, the input data frames to the constellation encoder are different than those defined in 7.4.1.1.

C.4.3.2 Hyperframe structure (replaces 7.4.1.3)

Annex C-EU uses the hyperframe structure shown in Figure C.10. Figure C.10 shows the phase relationship between the TTR_C and the hyperframe at the point U-C. Each hyperframe is composed of 5 superframes, which are numbered from 0 to 4. In order to indicate the boundary of the hyperframe, the inverse synch symbol is used for the 4th superframe (SPF#3), which is generated from a tone-by-tone 180-degree phase reversal of the synchronization symbol (see C.4.7.1) except for the pilot tone.

The bit-level data stream from the rate-converter is extracted according to the size of Bitmap- F_R and Bitmap- N_R using the Sliding Window (see C.3.3.2).

In order to make the bit rate to be a multiple of 32 kbit/s, the dummy bits are inserted at the end of hyperframe by the rate converter (see C.4.4.2). The hyperframe is composed of 345 DMT symbols, numbered from 0 to 344. Each symbol is assigned as $FEXT_R$ or $NEXT_R$ symbol in a $FEXT_R$ or $NEXT_R$ duration (see C.2), and the following numerical formula gives the information which duration N_{dmt}-th DMT symbol belongs to at ATU-C transmitter (see Figure C.11).

 $\label{eq:states} \begin{array}{l} \mbox{For $N_{dmt}=0,\,1,\,...,\,344$}\\ S=272\ x\ N_{dmt}\ mod\ 2760$\\ if\ \{\ (S+271< a)\ or\ (S>a+b)\ \} & then\ FEXT_R\ symbol\\ else & then\ NEXT_R\ symbol\\ where\ a=1243,\ b=1461 \end{array}$

Thus, 128 DMT symbols are allocated in the FEXT_R duration, and 217 DMT symbols are allocated in the NEXT_R duration. The symbols are composed of:

FEXT _R s	ymbol:
---------------------	--------

Number of symbol using Bitmap-F _R	= 126
Number of synch symbol	= 1
Number of inverse synch symbol	= 1
NEXT _R symbol:	
Number of symbol using Bitmap-N _R	= 214
Number of synch symbol	= 3

For modems not using any of the profiles defined in C.3.4, and modems using Profile 1, during FEXT Bitmap mode, the ATU-C shall transmit only the pilot tone in NEXT_R symbols. For Profile 3, the ATU-C shall not transmit any signal in NEXT_R symbols. The remaining Profiles, i.e. Profiles 2, 4, 5, and 6 use the dual bit map technique.

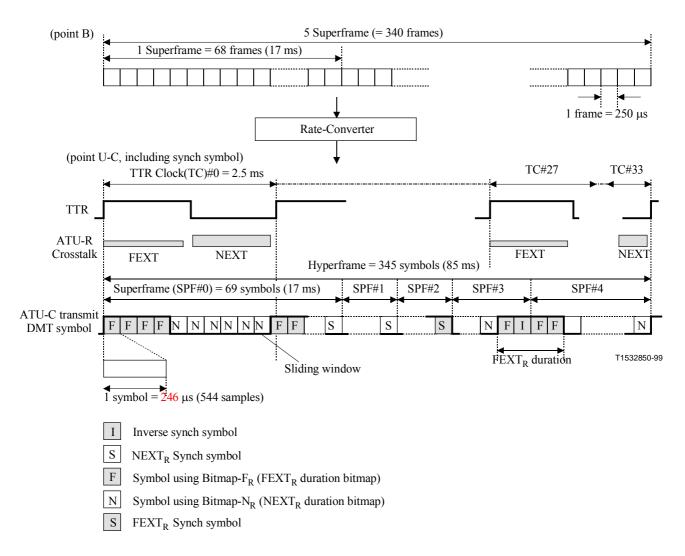


Figure C.10/G.992.1 – Hyperframe structure for downstream

2									
0	0 1 2	3	4	5		6	7	8	9
1	10 11 12	13	14	15	16	5 17	7 18	3 1	9
2	20 21 22	23	24	25	26	27	28	29	
3	30 31 32	33 3	34	35	36	37	38	39	40
4	41 42	43 44	4	45	46	47	48	49	50
5	51 52 5	3 54		55	56	57	58	59	60
6	61 62 63	64	6	5 6	6	67	SS	69	70
7	71 72 73	74	75	76	7	7 7	8 7	9 8	30
8	81 82 83	84	85	86	87	88	89) 9()
9	91 92 93	94	95	96	97	98	99	100	101
10	101 102 103	104 10	05	106	107	108	109	110	111
11		14 11:		116	117	118	119	120	121
12	122 123 12				127	128	129	130	131
13	132 133 134	135	13						141
14	142 143 144	145	146						51
15	152 153 154	155	156		158				
16	162 163 164		166	167	168	169	170	171	172
17			76	177	178	179	180	181	182
18	183 184 1 193 194 19	85 180 5 196		187 97 1	188 98	189 199	190 200	191 201	192
19 20	203 204 205	5 196 SS	20		· · ·		· · ·		202
20	203 204 203 213 214 215	216	217	· · · · ·		<u> </u>			212 22
21	213 214 213 223 224 225	226	227		229	·			
22	233 234 235		227	238	239	240	241	242	243
23		246 24		248	249	250	251	252	253
25		56 257		258	259	260	260	262	263
26	264 265 26					270	271	272	273
27	274 ISS 276	277	27		9 2	80 2	81 2	82 2	283
28	284 285 286	287	288	289	29	0 29	1 29	2 29)3
29	294 295 296	297	298	299	300	301	302	303	;
30	304 305 306	307 3	08	309	310	311	312	313	314
31	315 316 3	317 31	8	319	320	321	322	323	324
32	325 326 32	27 328	3	329	330	331	332	333	334
33	335 336 337	7 338	3	39 3	40	341	342	343	SS
	ISS Inverse synch sym	bol S	SS F	EXT _r Sy	/nch syn	nbol SS	NEXT	Г _R synch	symbol
	FEXT _R data symbol	ol 🗌	N	IEXT _R da	ata symb	ol		T1	535330-00

Figure C.11/G.992.1 – Symbol pattern in a hyperframe with cyclic prefix – Downstream

C.4.3.3 Subframe Structure (replaces 7.4.1.4)

A subframe is 10 consecutive DMT symbols (except for synch symbols) as shown in Table C.1. The 34 subframes form a hyperframe.

Subframe No.	DMT symbol No.	Note
0	0-9	
1	10-19	
2	20-29	
3	30-39	
4	40-49	
5	50-59	
6	60-70	#68 is Synch Symbol
7	71-80	
8	81-90	
9	91-100	
10	101-110	
11	111-120	
12	121-130	
13	131-141	#137 is Synch Symbol
14	142-151	
15	152-161	
16	162-171	
17	172-181	
18	182-191	
19	192-201	
20	202-212	#206 is Synch Symbol
21	213-222	
22	223-232	
23	233-242	
24	243-252	
25	253-262	
26	263-272	
27	273-283	#275 is Inverse Synch Symbol
28	284-293	
29	294-303	
30	304-313	
31	314-323	
32	324-333	
33	334-344	#344 is Synch Symbol

Table C.1/G.992.1 – Subframe (downstream)

C.4.4 Dual Bitmapping and Rate Conversion (replaces 7.15)

The functions of the rate converter (see C.4.4.2), tone ordering (see C.4.6), constellation encoding, and gain scaling shall use one of two bitmaps stored in the ATU. This method is called the dual bitmap.

C.4.4.1 Dual Bitmap (new)

The Dual Bitmap method has individual bit rates under the FEXT and NEXT noise, and this needs an additional bit and gain table, $\{b_i, g_i\}$, and ordered bit table, b'_i , for the tone ordering. The dual bitmaps are switched synchronized with the sliding window pattern of NEXT/FEXT symbols. The number of bits and the relative gains to be used for every tone are calculated in the bit loading algorithm during the initialization sequence, and transmitted in R-B&G.

C.4.4.2 Rate Converter (new)

The rate converter buffering changes the data frame boundaries between the reference points B and C according to Bitmap- F_R , Bitmap- N_R and the Sliding Window. Two independent rate converters are prepared for fast data and interleaved data. The amount of fast and interleaved data in Bitmap- F_R and Bitmap- N_R shall be calculated with the following formulae and illustrated in Figure C.12:

If $t_{Rf} \le n_{Rmax}$:

$$n_{Rf} = t_{Rf}$$
$$n_{Ri} = n_R - n_{Rf}$$
$$f_{Rf} = t_{Rf}$$
$$f_{Ri} = f_R - f_{Rf}$$

If $t_{Rf} > n_{Rmax}$:

$$n_{Rf} = n_{R \max}$$

$$n_{Ri} = 0$$

$$f_{Rf} = \begin{cases} f_{Rf4} = \left\lceil \frac{t_{Rf} \times 10 - n_{Rf} \times 6}{4} \right\rceil \\ f_{Rf3} = \left\lceil \frac{t_{Rf} \times 10 - n_{Rf} \times 7}{3} \right\rceil \\ f_{Ri} = \begin{cases} f_{Ri4} = f_{R} = f_{Rf4} \\ f_{Ri3} = f_{R} - f_{Rf3} \end{cases}$$

Where:

1	lere.	
	^t Rf	is the number of allocated bits in one frame for fast bytes at the reference point B.
	^t Ri	is the number of allocated bits for interleaved bytes at the reference point B.
	fRf and nRf	are the numbers of fast bits in Bitmap- F_R and Bitmap- N_R , respectively.
	f _{Rf3}	is the number of fast bits in Bitmap- F_R if the subframe (see C.4.3.3) contains 3 Bitmap- F_R except for
	f _{Rf4}	synch symbols. is the number of fast bits in Bitmap- F_R if the subframe contains 4 Bitmap- F_R except for synch
		symbols.
	f _{Ri} and n _{Ri}	are the numbers of interleaved bits in Bitmap- F_R and Bitmap- N_R , respectively.
	nR	is the number of total bits in Bitmap- N_R , which is specified in the B&G tables.

During FEXT Bitmap mode, n_{Rf} and n_{Ri} are zero.

To convert the bit rate to be a multiple of 32 kbit/s, the dummy bits for fast data are inserted to the tail of each subframe, and the dummy bits for interleaved data are inserted to the end of the Hyperframe. The number of the dummy bits shall be as follows:

If $t_{Rf} \le n_{Rmax}$:

$$dummy_{Rf} = 0$$
$$dummy_{Ri} = (f_{Ri} \times 126 + n_{Ri} \times 214) - t_{Ri} \times 340$$

If $t_{Rf} > n_{Rmax}$:

$$dummy_{Rf4} = (f_{Rf} \times 4 + n_{Rf} \times 6) - t_{Rf} \times 10$$

$$dummy_{Rf3} = (f_{Rf} \times 3 + n_{Rf} \times 7) - t_{Rf} \times 10$$

$$dummy_{Ri} = (f_{Ri4} \times 96 + f_{Ri3} \times 30) - t_{Ri} \times 340$$

If the fast data buffer uses single latency only, additional dummy bits are inserted at the tail of each FEXT symbol in the 4 Bitmap- F_R constructed subframe. The number of additional dummy bits inserted at the tail of each FEXT symbol shall be as follows:

 $dummy_{SRf} = f_{Rf3} - f_{Rf4}$

The receiver shall determine Bitmap- F_R and Bitmap- N_R so that $dummy_{Ri}$ is less than 126, $dummy_{Rf4}$ is less than 4 and $dummy_{Rf3}$ is less than 3 in the initialization sequence. At the receiver, the inserted dummy bits shall be removed.

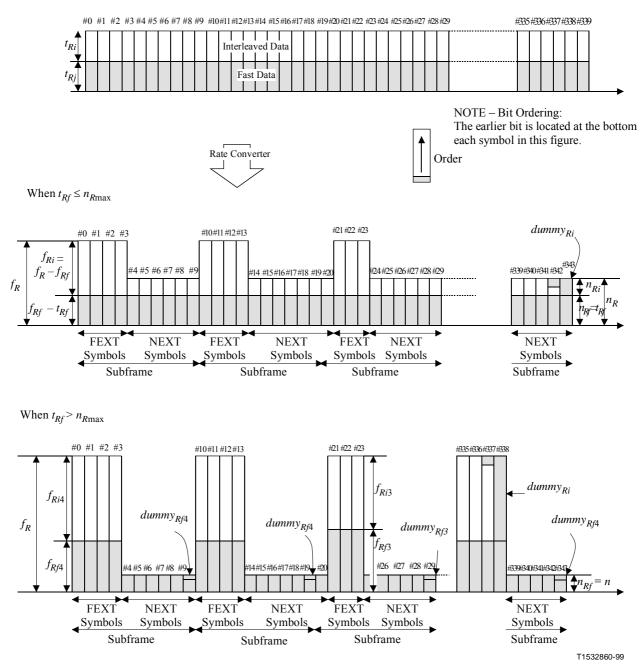


Figure C.12/G.992.1 – Bit distribution for Rate Converter under Dual latency and Dual Bitmap mode

C.4.5 FEXT Bitmapping (replaces 7.16)

The FEXT Bitmapping mode uses the Dual Bitmapping technique (C.4.4) to transmit data only during FEXT. As an option, modems may have the ability to enable or disable Bitmap- N_R independently of Bitmap- N_C in order to control the FEXT Bitmapping mode upstream and downstream independently. For modems not using any of the profiles defined in C.3.4 and modems using Profile 1, the ATU-C shall transmit only the pilot tone during the NEXT_R symbol.

For Profile 3, the ATU-C shall not transmit any signal in NEXT_R symbols. The ATU-R disables Bitmap-N_C and shall not transmit any signal during the NEXT_C symbol (see Figures C.10 and C.13).

For modems not using any of the profiles defined in §C.3.4, the Dual versus FEXT bitmapping mode is selected during G.994.1 using bit "DBM" (see 10.2 and 10.3). For modems using any of the profiles defined in §C.3.4, the bitmapping mode is selected during G.994.1.

C.4.6 Tone Ordering (replacement for 7.7)

A DMT time-domain signal has a high peak-to-average ratio (its amplitude distribution is almost Gaussian), and large values may be clipped by the digital-to-analogue converter. The error signal caused by clipping can be considered as an additive negative impulse for the time sample that was clipped. The clipping error power is almost equally distributed across all tones in the symbol in which clipping occurs. Clipping is therefore most likely to cause errors on those tones that, in anticipation of a higher received SNR, have been assigned the largest number of bits (and therefore have the densest constellations). These occasional errors can be reliably corrected by the FEC coding if the tones with the largest number of bits have been assigned to the interleave buffer.

The numbers of bits and the relative gains in two bitmaps to be used for every tone are calculated in ATU-R receiver, and sent back to ATU-C according to a defined protocol (see 10.9.14). The pairs of numbers are typically stored, in ascending order of frequency or tone numbers i, in bit and gain tables for Bitmap-F_R and Bitmap-N_R.

For Bitmap- F_R , the "tone-ordered" encoding shall first assign f_{Rf} bits from the rate converter (see C.4.4.2) to the tones with the smallest number of bits assigned to them, and the remaining f_{Ri} bits to the remaining tones. For Bitmap- N_R , it shall first assign n_{Rf} bits from the rate converter to the tones with the smallest number of bits assigned to them, and the remaining n_{Ri} bits to the remaining tones.

All tones shall be encoded with the number of bits assigned to them; one tone in each bitmap may therefore have a mixture of bits from the fast and interleaved buffers.

The ordered bit tables b'_{iF} and b'_{iN} shall be based on the original bit tables b_{iF} and b_{iN} as follows:

For k = 0 to N_{downmax} {

From the bit table, find the set of all *i* with the number of bits per tone $b_i = k$ Assign b_i to the ordered bit allocation table in ascending order of *i*

}

Two ordered bit tables for Bitmap- F_R and Bitmap- N_R shall be prepared. A complementary de-ordering procedure should be performed in ATU-R receiver. It is not necessary, however, to send the results of the ordering process to the receiver because the bit tables F_R and N_R were originally generated in ATU-R, and therefore those tables have all the information necessary to perform the de-ordering.

C.4.7 Modulation (pertains to 7.11)

C.4.7.1 Inverse Synchronization Symbol (replaces 7.11.4)

Except for the pilot tone, Inverse Synchronization symbol shall be generated from a tone-by-tone 180 degree phase reversal of Synchronization symbol (i.e. + maps to -, and - maps to +, for each of the 4-QAM signal constellation).

C.4.7.2 Synchronization symbol (supplements 7.11.3)

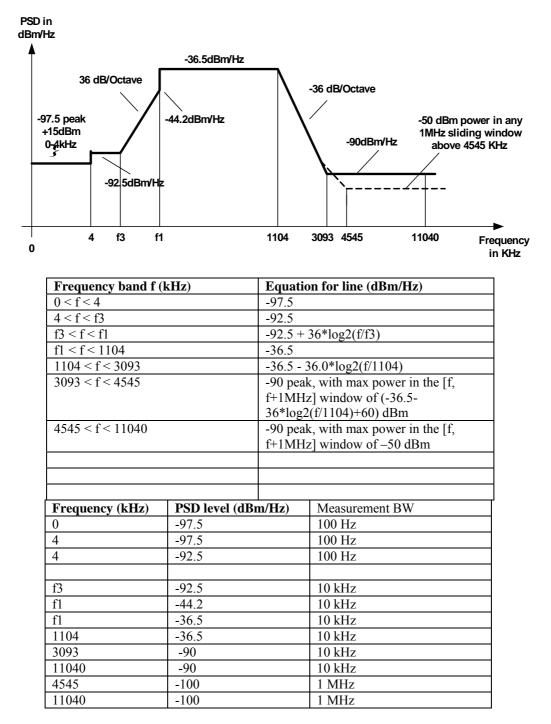
Bits d_{2i+1} and d_{2i+2} , which modulate the pilot carrier that has tone index i, shall be overwritten by $\{0,0\}$, generating the (+,+) constellation point.

C.4.8 ATU-C Downstream transmit spectral mask (replaces 7.14)

The downstream spectral masks of Annex C-EU are as specified in this section. When C-MSG1 bit 16 is 0, the PSD mask as specified in § C.4.8.1 shall be used. When C-MSG1 bit 16 is 1, the PSD mask as specified in § C.4.8.2 shall be used.

C.4.8.1 Downstream non-overlapped PSD mask definition

The non-overlapped PSD masks are defined with absolute peak values in Figure C.xx. The low frequency stop band is defined for frequencies below f1 kHz (tone n1); the high frequency stop band is defined at frequencies greater than 1104 kHz (tone 256). The in-band region of these PSD masks is the frequency band from f1 kHz to 1104 kHz.



The corner frequencies f1 and f3 depend on the associated upstream PSD mask used, see §I.5.6) and are defined as follows:

Mask designator (DS-mm)Associated upstream mask		f1 (kHz)	f3 (kHz)
DS-32	EU-32	138	54.45
DS-36	EU-36	155.25	61.26
DS-40	EU-40	172.5	68.06
DS-44	EU-44	189.75	74.87
DS-48	EU-48	207	81.67
DS-52	EU-52	224.25	88.48
DS-56	EU-56	241.5	95.29
DS-60	EU-60	258.75	102.09
DS-64	EU-64	276	108.9

- 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. The breakpoints in the tables shall be connected by linear straight lines on a dB/log(f) plot.
- NOTE 3 MBW specifies the Measurement Bandwidth. The MBW specified for a certain breakpoint with frequency fi is applicable for all frequencies satisfying fi< $f \le fj$, where fj is the frequency of the next specified breakpoint.
- NOTE 4 The power in a 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency i.e. power in the [f, f + 1 MHz] window shall conform to the specification at frequency f.
- 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.

Figure C.xx: Non-overlapped Downstream Channel PSD Masks.

For modems not using any of the profiles defined in §C.3.4, when C-MSG1 bit 16 is 0, the PSD mask specified in A.1.3 shall be used. When C-MSG1 bit 16 is 1, the PSD mask specified in A.1.2 shall be used.

For modems complying with Profiles 1 & 2, C-MSG1 bit 16 shall be set to 0. For modems complying with Profiles 3 to 6, C-MSG1 bit 16 shall be set to 1.

The ATU-C may use different PSD masks during FEXT_R symbols and NEXT_R symbols. These masks may differ from, but shall fall within, the masks defined in Annex A. Example PSD masks can be found in Appendix V.

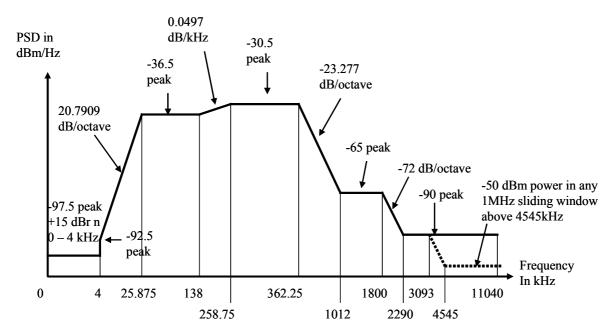
C.4.8.2 Downstream overlapped PSD mask definition

The overlapped PSD mask is as defined in G.992.1 A.1.2. The low frequency stop band is defined for frequencies below 25.875 kHz (tone 6); the high frequency stop band is defined at frequencies greater than 1104 kHz (tone 256). The in-band region of this PSD mask is the frequency band from 25.875 kHz to 1104 kHz.

C.4.8.3 Downstream PSD mask definition for Profile 3

Besides the PSD defined in G.992.1 Annex C Amendment 1 Appendix V, two new PSD masks are defined for Profile 3 mode of operation: LD-TIF1 and LD-TIF2. The mask is selected in the code points in handshake. C.4.8.3.1 LD-TIF1 LD-TIF1 is defined in Figure C. TIF1.

Figure C.TIF1 The PSD mask for LD-TIF1

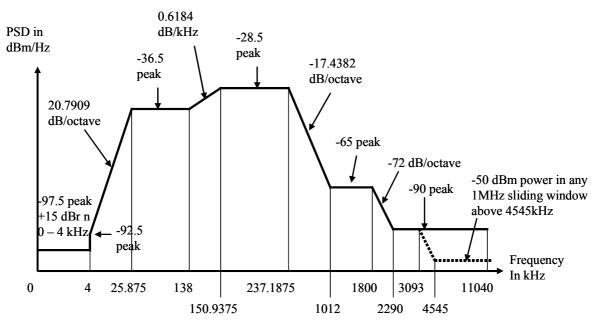


Frequency f (KHz)	PSD (dBm/Hz) Peak values	
$0 \le f \le 4$	-97.5, with max power in the in 0-4 kHz band of +15 dBrn	
4< <i>f</i> ≤25.875	-92.5+20.7909*log ₂ (f/4)	
25.875< <i>f</i> ≤138	-36.5	
$138 < f \le 258.75$	-43.3571+0.0497*f	
$258.75 \le f \le 362.25$	-30.5	
$362.25 < f \le 1012$	-30.5-23.277*log ₂ (f/362.25)	
$1012 < f \le 1800$	-65	
$1800 < f \le 2290$	$-65 - 72 \times \log_2(f/1800)$	
$2290 < f \le 3093$	-90	
$3093 < f \le 4545$	-90 peak, with max power in the [f, f + 1 MHz] window of	
	$(-36.5 - 36 \times \log_2 (f/1104) + 60) \text{ dBm}$	
$4545 < f \le 11\ 040$	-90 peak, with max power in the [f, f + 1 MHz] window of -50 dBm	

C.4.8.3.2 LD-TIF2

LD-TIF2 is defined in Figure C.TIF2.





Frequency f (KHz)	PSD (dBm/Hz) Peak values
$0 \le f \le 4$	-97.5, with max power in the in 0-4 kHz band of +15 dBrn
$4 \le f \le 25.875$	-92.5+20.7909*log ₂ (f/4)
$25.875 \le f \le 138$	-36.5
$138 < f \le 150.9375$	-121.8333+0.6184*f
$150.9375 \le f \le 237.1875$	-28.5
$237.1875 < f \le 1012$	-28.5-17.4382*log ₂ (f/237.1875)
$1012 < f \le 1800$	-65
$1800 < f \le 2290$	$-65 - 72 \times \log_2(f/1800)$
$2290 < f \le 3093$	-90
$3093 < f \le 4545$	-90 peak, with max power in the [f, f + 1 MHz] window of
	$(-36.5 - 36 \times \log_2 (f/1104) + 60)$ dBm
$4545 < f \le 11\ 040$	-90 peak, with max power in the [f, f + 1 MHz] window of -50 dBm

C.5 ATU-R Functional Characteristics (pertains to clause 8)

C.5.1 Framing (pertains to 8.4)

C.5.1.1 Superframe structure (replaces 8.4.1.1)

The superframe structure of ATU-R transmitter is identical to that of ATU-C transmitter, as specified in C.4.3.1.

C.5.1.2 Hyperframe structure (replaces 8.4.1.3)

The hyperframe structure of ATU-R transmitter is functionally similar to that of ATU-C transmitter, except that the inverse synch symbol is used in the 1st superframe (SPF#0) (see Figure C.13). The hyperframe is composed of 345 DMT symbols, numbered from 0 to 344. Each symbol is under $FEXT_C$ or $NEXT_C$ duration (see C.5.3), and the following numerical formula gives the information which duration N_{dmt}-th DMT symbol belongs to at ATU-R transmitter (see Figure C.14).

For $N_{dmt} = 0, 1, ..., 344$ $S = 272 \times N_{dmt} \mod 2760$ if { (S > a) and (S + 271 < a + b) } then FEXT_C symbol else then NEXT_C symbol where a = 1315, b = 1293

128 DMT symbols are allocated in the FEXT_{C} duration, and 217 DMT symbols are allocated in the NEXT_{C} duration. The symbols are composed of:

FEXT _C symbol:				
Number of symbol using Bitmap-F _C	= 126			
Number of synch symbol	= 1			
Number of inverse synch symbol	= 1			
NEXT _C symbol:				
Number of symbol using Bitmap-N $_{\rm C}$	= 214			
Number of synch symbol	= 3			

During FEXT Bitmapping mode, the ATU-R shall not transmit any signal.

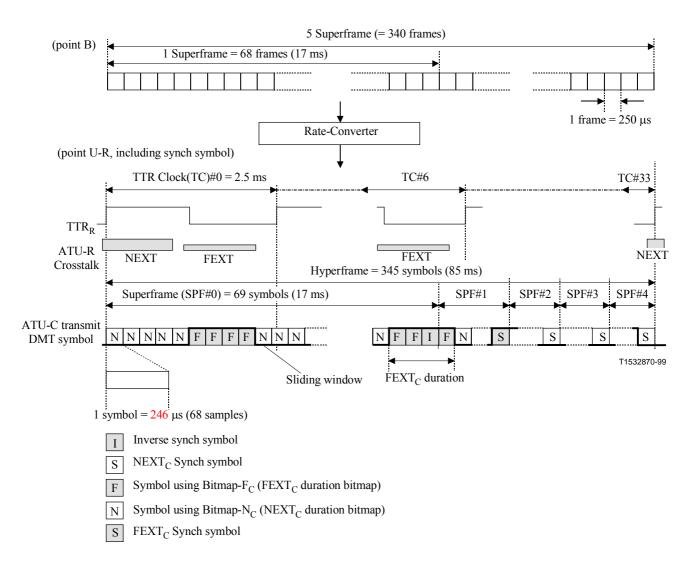


Figure C.13/G.992.1 – Hyperframe structure for upstream

ттр	
TTR _R	
0	0 1 2 3 4 5 6 7 8 9
1	10 11 12 13 14 15 16 17 18 19
2	20 21 22 23 24 25 26 27 28 29
3	30 31 32 33 34 35 36 37 38 39 40
4	41 42 43 44 45 46 47 48 49 50
5	51 52 53 54 55 56 57 58 59 60
6	61 62 63 64 65 66 67 ISS 69 70
7	71 72 73 74 75 76 77 78 79 80
8	81 82 83 84 85 86 87 88 89 90
9	91 92 93 94 95 96 97 98 99 100 101
10	101 102 103 104 105 06 107 108 109 110 111
11	112 113 114 115 1 6 117 118 119 120 21
12	122 123 124 125 126 127 128 129 130 131
13	132 133 134 135 136 SS 138 139 140 141
14	142 143 144 145 146 147 148 149 150 151
15	152 153 154 155 156 157 158 159 160 161
16	162 163 164 165 166 167 168 169 170 171 172
17	173 174 175 176 77 178 179 180 181 82
18	183 184 185 186 187 188 189 190 191 92
19	193 194 195 196 197 198 199 200 201 202
20	203 204 205 SS 207 208 209 210 211 212
21	213 214 215 216 217 218 219 220 221 222
22	223 224 225 226 227 228 229 230 231 232
23	233 234 235 236 237 238 239 240 241 242 243
24	244 245 246 247 248 249 250 251 252 253
25	254 255 256 257 258 259 260 260 262 263
26	264 265 266 267 268 269 270 271 272 273
27	274 SS 276 277 278 279 280 281 282 283
28	284 285 286 287 288 289 290 291 292 293
29	294 295 296 297 298 299 300 301 302 303
30	304 305 306 307 308 309 310 311 312 313 314
31	<u>315</u> <u>316</u> <u>317</u> <u>318</u> <u>319</u> <u>320</u> <u>321</u> <u>322</u> <u>323</u> <u>324</u>
32	325 326 327 328 329 330 331 332 333 334
33	335 336 337 338 339 340 341 342 343 S5
	ISS Inverse synch symbol SS FEXT _R Synch symbol SS NEXT _R synch symbol
	FEXT _R data symbol NEXT _R data symbol T1535340-00

Figure C.14/G.992.1 – Symbol pattern in a hyperframe with cyclic prefix – Upstream

C.5.1.3 Subframe structure (replaces 8.4.1.4)

A subframe is 10 consecutive DMT symbols (except for synch symbols) as shown in Table C.2. The 34 subframes form a hyperframe.

Subframe No.	DMT symbol No.	Note
0	0-9	
1	10-19	
2	20-29	
3	30-39	
4	40-49	
5	50-59	
6	60-70	#68 is Inverse Synch Symbol
7	71-80	
8	81-90	
9	91-100	
10	101-110	
11	111-120	
12	121-130	
13	131-141	#137 is Synch Symbol
14	142-151	
15	152-161	
16	162-171	
17	172-181	
18	182-191	
19	192-201	
20	202-212	#206 is Synch Symbol
21	213-222	
22	223-232	
23	233-242	
24	243-252	
25	253-262	
26	263-272	
27	273-283	#275 is Synch Symbol
28	284-293	
29	294-303	
30	304-313	
31	314-323	
32	324-333	
33	334-344	#344 is Synch Symbol

Table C.2/G.992.1 – Subframe (upstream)

C.5.2 Dual Bitmapping and rate conversion (replaces 8.15)

The function of the rate converter (see C.5.2.2), tone ordering (see C.5.4), constellation encoding, and gain scaling shall use one of two bitmaps stored in the ATU. This method is called the dual bitmap.

C.5.2.1 Dual Bitmap (new)

The Dual Bitmap switching shall be the same as for the downstream data, specified in C.4.4.1. The number of bits and the relative gains to be used for every tone are calculated in the bit loading algorithm during the initialization sequence, and transmitted in C-B&G.

C.5.2.2 Rate Converter (new)

The rate converter buffering changes the data frame boundaries between the reference points B and C according to Bitmap- F_C , Bitmap- N_C and the Sliding Window. Two independent rate converters are prepared for fast data and interleaved data. The amounts of fast and interleaved data in Bitmap- F_C and Bitmap- N_C shall be calculated in the following formulae:

If $t_{Cf} \le n_{Cmax}$:

$$n_{Cf} = t_{Cf}$$
$$n_{Ci} = n_C - n_{Cf}$$
$$f_{Cf} = t_{Cf}$$
$$f_{Ci} = f_C - f_{Cf}$$

If $t_{Cf} > n_{Cmax}$:

$$n_{Cf} = n_{C \max}$$

$$n_{Ci} = 0$$

$$f_{Cf4} = \left[\frac{t_{Cf} \times 10 - n_{Cf} \times 6}{4}\right]$$

$$f_{Cf3} = \left[\frac{t_{Cf} \times 10 - n_{Cf} \times 7}{3}\right]$$

$$f_{Ci} = \begin{cases} f_{Ci4} = f_C - f_{C4} \\ f_{Ci3} = f_C - f_{Cf3} \end{cases}$$

Where:

^t Cf	is the number of allocated bits in one frame for fast bytes at the reference point B.
^t Ci	is the number of allocated bits for interleaved bytes at the reference point B.
f _{Cf} and n _{Cf}	are the numbers of fast bits in Bitmap- F_C and Bitmap- N_C , respectively.
fCf3	is the number of fast bits in Bitmap-F _C if the subframe (see C.5.1.3) contains 3 Bitmap-F _C except for
f _{Cf4}	synch symbols. is the number of fast bits in Bitmap- F_C if the subframe contains 4 Bitmap- F_C except for synch
	symbols.
f _{Ci} and n _{Ci}	are the numbers of interleaved bits in Bitmap- F_C and Bitmap- N_C , respectively.
nC	is the number of total bits in Bitmap-N _C , which is specified in the B&G tables.

During FEXT Bitmap mode, n_{Cf} and n_{Ci} are zero.

To convert the bit rate to be a multiple of 32 kbit/s, the dummy bits for fast data are inserted to the tail of each subframe, and the dummy bits for interleaved data are inserted to the end of the Hyperframe. The number of the dummy bits shall be as follows:

If $t_{Cf} \le n_{Cmax}$:

$$dummy_{Cf} = 0$$
$$dummy_{Ci} = (f_{Ci} \times 126 + n_{Ci} \times 214) - t_{Ci} \times 340$$

If $t_{Cf} > n_{Cmax}$:

$$dummy_{Cf 4} = (f_{Cf} \times 4 + n_{Cf} \times 6) - t_{Cf} \times 10$$

$$dummy_{Cf 3} = (f_{Cf} \times 3 + n_{Cf} \times 7) - t_{Cf} \times 10$$

$$dummy_{Ci} = (f_{Ci4} \times 96 + f_{Ci3} \times 30) - t_{Ci} \times 340$$

,

If the fast data buffer uses single latency only, additional dummy bits are inserted at the tail of each FEXT symbol in the 4 Bitmap-F_C constructed subframe. The number of additional dummy bits inserted at the tail of each FEXT symbol shall be as follows:

$$dummy_{SCf} = f_{Cf3} - f_{Cf4}$$

The receiver shall determine Bitmap-F_C and Bitmap-N_C so that $dummy_{Ci}$ is less than 126, $dummy_{Cf4}$ is less than 4 and $dummy_{Cf3}$ is less than 3 in the initialization sequence. At the receiver, the inserted dummy bits shall be removed.

C.5.3 FEXT Bitmapping (replaces 8.16)

The FEXT Bitmapping mode uses the Dual Bitmapping technique (C.4.4) to transmit data only during FEXT. As an option, modems may have the ability to enable or disable Bitmap- N_R independently of Bitmap- N_C in order to control the FEXT Bitmapping mode upstream and downstream independently. For modems not using any of the profiles defined in §C.3.4 and modems using Profile 1, the ATU-C shall transmit only the pilot tone during the NEXT_R symbol. For Profile 3, the ATU-C shall not transmit any signal in NEXT_R symbols. The ATU-R disables Bitmap- N_C and shall not transmit any signal during the NEXT_C symbol (see Figures C.10 and C.13).

For modems not using any of the profiles defined in §C.3.4, the Dual versus FEXT bitmapping mode is selected during G.994.1 using bit "DBM" (see 10.2 and 10.3). For modems using any of the profiles defined in§C.3.4, the bitmapping mode is selected during G.994.1.

C.5.4 Tone Ordering (pertains to 8.7)

The tone ordering algorithm shall be the same as for the downstream data, specified in C.4.4.

For Bitmap-F_C, the "tone-ordered" encoding shall first assign f_{Cf} bits from the rate converter (see C.5.2.2) to the tones with the smallest number of bits assigned to them, and the remaining f_{Ci} bits to the remaining tones. For Bitmap-N_C, it shall first assign n_{Cf} bits from the rate converter to the tones with the smallest number of bits assigned to them, and the remaining n_{Ci} bits to the remaining tones. Two ordered bit tables for Bitmap-F_C and Bitmap-N_C shall be prepared.

C.5.5 Modulation (pertains to 8.11)

C.5.5.1 Inverse synchronization symbol (replaces 8.11.4)

Inverse Synchronization symbol shall be generated from a tone-by-tone 180 degree phase reversal of Synchronization symbol (i.e. + maps to -, and - maps to +, for each of the 4-QAM signal constellation).

C.5.5.2 Gain scaling in synchronization symbol (new)

At initialization time, the sync symbol reference transmit PSD level shall be set at the nominal PSD level $+10\log(g_{sync}^2) dBm/Hz$, with g_{sync}^2 defined as the average g_i^2 value over the used (i.e. $b_i > 0$) subcarriers in the NEXT or FEXT bitmap, whichever results in the highest average gain. The sync symbol reference transmit PSD shall not be updated with used subcarrier gain changes during SHOWTIME.

C.5.5.3 Nyquist frequency (supplements 8.11.1.2)

The upstream Nyquist frequency for Annex C-EU shall be at subcarrier NSCus (f = 4.3125*NSCus kHz)..

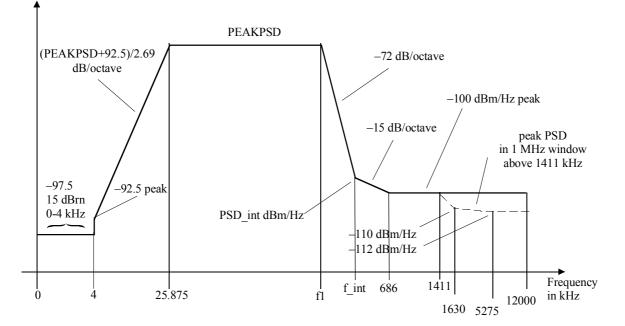
C.5.6 ATU-R Upstream Transmit Spectral Mask (replaces 8.14)

The upstream PSD masks of Annex C-EU are defined with absolute peak values in Figure C.zz. The low frequency stop band is defined for frequencies below 25.875 kHz; the high frequency stop band is defined at frequencies greater than f1 kHz (tone n1). The in-band region of these PSD masks is the frequency band from 25.875 kHz to f1 kHz.

and the ATU-x may optionally support upstream masks EU-36 to EU-64 specified in Figure C.zz.

NOTE: The value of MAXNOMATPus may be limited by regional regulations.





Frequency band f (kHz)	Equation for line (dBm/Hz)
0 < f < 4	-97.5
4 < f < 25.875	-92.5+(PEAKPSD+92.5)* log ₂ (f/4)/log ₂ (25.875/4)
25.875 < f < f1	PEAKPSD
f1< f< f_int	$PEAKPSD-72*log_2(f/f1)$
f_int < f < 686	PSD_int-15*log2(f/f_int)
f > 686	-100

Frequency (kHz)	PSD level (dBm/Hz)	Measurement BW
0	-97.5	100 Hz
4	-97.5	100 Hz
4	-92.5	100 Hz
25.875	PEAKPSD	10 kHz
f1	PEAKPSD	10 kHz
f_int	PSD_int	10 kHz
686 - 12000	-100	10 kHz

Additionally the PSD masks shall satisfy the following requirements:

Frequency (kHz)	PSD level (dBm/Hz)	Measurement BW
1411	-100	1 MHz
1630	-110	1 MHz
5275	-112	1 MHz
12000	-112	1 MHz

NSCus is a function of the upstream mask parameters, which are defined as follows:

Parameters in FEXT bitmap for mode 1, both bitmaps for mode 2 (see §C.7.3):	Parameters in FEXT bitma	p for mode 1, both bitm	aps for mode 2 (see	§C.7.3):
---	--------------------------	-------------------------	---------------------	----------

Designator (EU-nn)	NSCus	Template Nominal PSD P ₀ (dBm/Hz)	Template Maximum Aggregate Transmit Power (dBm)	PEAKPSD (dBm/Hz)	Frequency f1 (kHz)	Intercept Frequency f_int (kHz)	Intercept PSD Level PSD_int (dBm/Hz)
EU-32	32	-38.0	12.5	-34.5	138.00	242.92	-93.2
EU-36	64	-38.5	12.5	-35.0	155.25	274.03	-94.0
EU-40	64	-39.0	12.5	-35.5	172.50	305.06	-94.7
EU-44	64	-39.4	12.5	-35.9	189.75	336.33	-95.4
EU-48	64	-39.8	12.5	-36.3	207.00	367.54	-95.9
EU-52	64	-40.1	12.5	-36.6	224.25	399.07	-96.5
EU-56	64	-40.4	12.5	-36.9	241.50	430.58	-97.0
EU-60	64	-40.7	12.5	-37.2	258.75	462.04	-97.4
EU-64	64	-41.0	12.5	-37.5	276.00	493.45	-97.9

Parameters in NEXT bitmap for mode 1 (see §C.7.3):

Designator (EU-nn)	NSCus	Template Nominal PSD P ₀ (dBm/Hz)	Template Maximum Aggregate Transmit Power (dBm)	PEAKPSD (dBm/Hz)	Frequency f1 (kHz)	Intercept Frequency f_int (kHz)	Intercept PSD Level PSD_int (dBm/Hz)
EU-32	32	-38.0	12.5	-34.5	138.00	242.92	-93.2
EU-36	64	-38.7	12.5	-35.2	155.25	273.47	-94.0
EU-40	64	-39.9	12.5	-36.4	172.50	302.26	-94.7
EU-44	64	-40.7	12.5	-37.2	189.75	331.87	-95.3
EU-48	64	-41.4	12.5	-37.9	207.00	361.55	-95.8
EU-52	64	-41.8	12.5	-38.3	224.25	392.16	-96.4
EU-56	64	-42.1	12.5	-38.6	241.50	423.12	-96.9
EU-60	64	-42.3	12.5	-38.8	258.75	454.51	-97.3
EU-64	64	-42.3	12.5	-38.8	276.00	486.91	-97.8

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. The breakpoints in the tables shall be connected by linear straight lines on a dB/log(f) plot.

NOTE 3 – MBW specifies the Measurement Bandwidth. The MBW specified for a certain breakpoint with frequency fi is applicable for all frequencies satisfying fi< $f \le fj$, where fj is the frequency of the next specified breakpoint.

NOTE 4 – The power in a 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency i.e. power in the [f, f + 1 MHz] window shall conform to the specification at frequency f.

NOTE 5 – The step in the PSD mask at 4 kHz is to protect V.90 performance. Originally, the PSD mask continued the 21.5 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-R interface (see Figures I.3 & I.4).

Figure C.zz: Upstream Channel PSD Masks

C.5.7 Forward error correction (supplements 8.6)

The minimum FEC coding capabilities (Table 8-3) for an ATU-R shall include the following interleave depths for the interleaved buffer:

D = 1, 2, 4, 8, and 16

C.6 EOC Operation and Maintenance (pertains to clause 9)

C.6.1 ADSL line related primitives (supplements 9.3.1)

C.6.1.1 ADSL line related near-end defects (supplements 9.3.1.3)

Two near-end defects are further defined:

- *Loss-of-signal (LOS)*: The ADSL power shall be measured only in the FEXT_C duration at ATU-C, or only in the FEXT_R duration at ATU-R.
- Severely errored frame (SEF): A SEF defect occurs when the content of two consecutively received ADSL synchronization symbols in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-R, does not correlate with the expected content over a subset of the tones. An SEF defect terminates when the content of two consecutively received ADSL synchronization symbols in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-C, or in the FEXT_R duration at ATU-R, does not consecutively received ADSL synchronization symbols in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-R, correlate with the expected contents over the same subset. The correlation method, the selected subset of tones, and the threshold for declaring these defect conditions are implementation discretionary.

C.6.1.2 ADSL line related far-end defects (supplements 9.3.1.4)

Loss-of-signal is further defined:

• *Loss-of-signal (LOS)*: The ADSL power shall be measured only in the FEXT_C duration at ATU-C, or only in the FEXT_R duration at ATU-R.

C.6.2 Test Parameters (supplements 9.5)

C.6.2.1 Near-end test parameters (supplements 9.5.1)

The near-end primitives are further defined:

- Attenuation (ATN): The received signal power shall be measured only in the FEXT_{C} duration at ATU-C, or only in the FEXT_{R} duration at ATU-R.
- *Signal-to-Noise ratio (SNR) margin*: During FEXT Bitmap mode, this primitive represents the snr margin in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-R.

C.6.2.2 Far-end test parameters (supplements 9.5.2)

The far-end primitives are further defined:

- *Attenuation (ATN)*: The received signal power shall be measured only in the FEXT_C duration at ATU-C, or only in the FEXT_R duration at ATU-R.
- *Signal-to-Noise ratio SNR margin*: During FEXT Bitmap mode, this primitive represents the snr margin in the FEXT_C duration at ATU-C, or in the FEXT_R duration at ATU-R.

C.7 Initialization

C.7.1 Initialization with Hyperframe (replaces 10.1.5)

The exchange of messages between ATU-C and ATU-R shall be performed in $FEXT_C$ and $FEXT_R$. The DMT symbol has two symbol rates: one is 4.3125 kbaud for the symbol without a cyclic prefix, and the other is 4 x 69/68 kbaud for the symbol with a cyclic prefix. 32 times of the TTR has the same period as 345 times of the 4.3125 kbaud, and 34 times of the TTR is the same as 345 times of 4 x 69/68 kHz.

During FEXT Bitmap mode, the ATU-R shall not transmit any signal during the NEXT_C symbols duration.

For modems not using any of the profiles defined in §C.3.4 and modems using Profile 1, the ATU-C shall transmit only

the pilot tone as the NEXT_R signal except:

- C-PILOT1 (C-PILOT1A) which is accompanied by a signal to allow the ATU-C to indicate the phase of TTR_C to the ATU-R (see C.7.4.1);
- C-QUIETn where no signal is transmitted.

For Profile 3, the ATU-C shall not transmit any signal in NEXT_R symbols.

For Profiles 2, 4, 5, and 6, the ATU-C may transmit data and pilot during the NEXT_R symbols.

The ATU-C begins transmitting C-PILOT1 at the beginning of the hyperframe without cyclic prefix. The ATU-C informs the phase of the TTR_C to ATU-R during C-PILOT1. The ATU-R begins transmitting R-REVERB1 at the beginning of the hyperframe without cyclic prefix. The ATU-R performs the training of any receiver equalizer using this phase information of the TTR_R generated from received TTR_C .

From C-PILOT1 to C-SEGUE1, the following numerical formula gives the information which duration N_{dmt}-th DMT symbol belongs to at ATU-R (see Figure C.15).

For $N_{dmt} = 0, 1, \dots 344$ $S = 256 \times N_{dmt} \mod 2760$ if { (S + 255 < a) or (S > a + b) } then FEXT_R symbols else then NEXT_R symbols where a = 1243, b = 1461

In order to enter C-RATES1 at the beginning of the hyperframe with cyclic prefix, the number of symbols from C-PILOT1 to C-SEGUE1 shall be a multiple of 345 DMT symbols.

From R-REVERB1 to R-SEGUE1, the following numerical formula gives the information which duration N_{dmt}-th symbol belongs to at ATU-C (see Figure C.16).

For $N_{dmt} = 0, 1, ..., 344$, $S = 256 \times N_{dmt} \mod 2760$ if { (S > a) and (S + 255 < a + b) } then FEXT_C symbols else then NEXT_C symbols where a = 1315, b = 1293

From C-RATES1 to C-SEGUE3, the number of symbols is a multiple of 345 DMT symbols. The following numerical formula gives the information which duration N_{dmt} -th DMT symbol belongs to. ATU-C transmits the message data in FEXT_R symbols (see Figure C.11).

For $N_{dmt} = 0, 1, ..., 344$ $S = 272 \times N_{dmt} \mod 2760$ if { (S + 271 ≥ a) and (S ≤ a + b) } then NEXT_R symbols else then FEXT_R symbols where a = 1243, b = 1461

The ATU-R enters R-REVERB3 at the beginning of the hyperframe with cyclic prefix, which is extracted from received signal. From R-REVERB3 to R-SEGUE5, the number of symbols is a multiple of 345 DMT symbols. The following numerical formula gives the information which duration N_{dmt} -th DMT symbol belongs to. ATU-R transmits the message data in FEXT_C symbols (see Figure C.14).

For $N_{dmt} = 0, 1, ..., 344$ $S = 272 \times N_{dmt} \mod 2760$ if { (S > a) and (S + 271 < a + b) } then FEXT_C symbols

then $\ensuremath{\mathsf{NEXT}}_C$ symbols

else
where a = 1315, b = 1293

				ı			١
TTR _C			:				
0	0 1 2	3	4	5	6	7 8	9 10
1	11 12 1	3 14	15	16	17	18	19 20 21
2	22 23	24 25	26	27	28	29	30 31
3	32 33 34	35 36	37	38	39	40	41 42
4	43 44 45	46 4	47 4	8 4	9 50) 51	52 53
5	54 55 56	57	58	59	60	61 62	
6		67 68	69	70	71	72	73 74
7	75 76 77	78 79	80	81	82	83	84 85
8	86 87 88	89 90		92		94	95 96
9	97 98 99		i			04 105	
10	108 109 11		112	113	114		16 117 118
11	119 120	121 122	123	124	125	126	127 128
12	129 130 131	132 133		135	136	137	138 139
13	140 141 142		44 14				149 150 9 160 161
14 15	151 152 153 162 163 1	64 165	155 1 166	167	168	158 15 169 1	
13	173 174	175 176	100	107	108	180	170 171 172 181 182
10	183 184 185	186 18					192 193
18	194 195 196				00 20		
10	205 206 20			210		212 21	
20		218 219	220	221	222		224 225
21	226 227 228	229 230		232	233	234	235 236
22	237 238 239	240 24	41 24	2 24	3 24	4 245	246 247
23	248 249 250	251	252 2	253 2	254 2	255 25	6 257 258
24	259 260 20	51 262	263	264	265	266 2	267 268 269
25	270 271	272 273	274	275	276	277	278 279
26	280 281 282	283 284	4 285	286	287	288	289 290
27	291 292 293	294 2	.95 29	96 29	97 29	98 299	300 301
28	302 303 30	4 305		307	308	309 31	10 311 312
29		315 316	317	318	319		321 322
30	323 324 325	326 327	328	329	330	331	332 333
31	334 335 336	337 33	38 33	9 34	0 34	1 342	343 344
	FEXT _R symbo	1					T1535350-00
	TEAT _R symbol	1					1133330-00
	NEXT _R symb	ol					

Figure C.15/G.992.1 – Symbol pattern in a hyperframe without cyclic prefix – Downstream

-		-	
Έ	Ľ	Ъ.	
1	T	17	R

ſ																	
R								. L									
0	0	1	2		3		4	4	5	6		7		8		9	10
1	11	12		13	14	4	15		16		17	1	8	19	1	20	21
2	22	2	3	24		25	26	5	27		28		29		30	31	
3	32 33	3	34	3	5	36		37	3	38	3	9	40		41		42
4	43	44	45		46	4	7	48		49		50	4	51	5	2	53
5	54	55	5		57		58	- i	59	6		61		62		63	64
6	65	66		67		58	69	<u> </u>	70		71	_	72	7.		74	
7	75 76		77	78		79		30	81		82		83		84		5
8		37	88		89	90		91		92	┶┯	93	9		95	_	96
9	97	98	99		100		01	10	_	103		104		105		06	107
10	108	109		10	11		112		113		14	11		116		117	118
11	119	12		121		22	12		124	_	125		126		27	128	
12	129 13		131	13		133		34	_	35	13		137		138		39
13		41	142		143	14		145		146		147		48	14	-	150
14	151	152	15		154		155	1:		15		158		159	_	160	161
15	162	163		164	16		166	-i -	167	_	168	_	69	17		171	17
16	173		74	175	I	176		77	17		179		180		181	18	
17		34	185	_	86	187		188	_	.89		90	19		192		193
18		195	196		197		98	19	_	200		201	_	202	2	03	204
19	205	206	20		208		209	-	210	2		21		213		214	215
20	216	21		218		19	220		221		222		223		24	225	
21	226 22	· .	228	22		230		231	23		23		234		235		36
22 22		238	239		240	24		242	_	243		244		45	24	-	247 258
23	248	249	250		251		252	25		25		255		256		257	L;
24	259	260		261	26		263		264	_	265	26		267		268	269
25 26	270 280 28		71 282	272	83	273 	27		27:	286	276	87	277 28		289 289	27	
26 27		292	282		83 294		95	285 290	_	297		87 298		8 299	_	/ <u>/</u>)0	290 301
27 28	302	292 303	293		294 305				07	297		298 30		310		311	301
28 29	313	303		315			306 317				319	30		310			
	323 324		325	313		327		28	318		319	_	331		.1 332	322	33
30 31		35	336	_	8 337	327	<u> </u>	28 339		.9 340		341	331		332 34		344
51	3 + 6	55	330		151	33	0			340	1 -) 4 1	32	† <i>2</i>	34.		544
	F	EXT _C	symbo	ol												T18	535360-0
		e															
		EXT _C	symbo	bl													

Figure C.16/G.992.1	_ Symbol natter	n in a hynerframe	without evelie i	orefix _ Unstream
rigure C.10/G.772.1	- Symbol patter	п ш а пурегнаше	e without cyclic j	prent – Opsu cam

C.7.2 Handshake – Non-standard information block (new)

This section defines the format of the G.994.1 non-standard information block to support Annex C-EU, and tabulates the parameters used by Annex C-EU. The use of these parameters is described in §C.7.3 and §C.7.4.

C.7.2.1 Non-standard information block format (new)

Figure C.aa defines the format of the non-standard information block.

8	7	6	5	4	3	2	1
		Non-star		nation length octet)	n = M + 6		
				ntry code see Note 1)			
		Provid		ndor identifi see Note 2)	cation)		
		Ve		fic informati – Note 3)	on		

NOTE 1 – The value of this field shall be B5 00, the country code for USA

NOTE 2 – The value of this field shall be 43 45 4E 54, ASCII "CENT" for Centillium Communications

NOTE 3 – These octets are defined in C.7.2.2. Formatting of these octets shall comply with the parsing rules defined in G.994.1 9.2.1 to 9.2.3

Figure C.aa – Non-standard information block format

C.7.2.2 Non-standard information block parameters (new)

The G.994.1 non-standard parameters for Annex C-EU are listed in Tables C.a to C.b.4.2 below.

In order to minimize message length, the parameters for additional inband spectral shaping (Spar(2) octet and its related Npar(3) octets) shall only be included in MP or MS messages, and shall not be included in CLR or CL messages. All Annex C-EU modems shall support additional inband spectral shaping.

Note - This deviates from the rules specified in G.994.1 for standard information fields, where it is stated in §9.6:

"Once a Transaction C (see 10.1) has been completed, any subsequent MS message within the same G.994.1 session shall only contain those octets of the identification (I) and standard information (S) fields, and those blocks of non-standard information (NS) that were contained in both the CLR and CL messages of the previous Transaction C".

Bits								
8	7	6	5	4	3	2	1	NPar(1)s
x	х	х	х	х	х	х	1	Reserved for future use
х	x	х	х	х	х	1	х	Reserved for future use
х	x	х	х	х	1	х	х	Reserved for future use
х	х	х	х	1	Х	х	х	Reserved for future use
х	x	х	1	х	х	х	х	Reserved for future use
х	x	1	х	х	х	х	х	Reserved for future use
х	1	х	х	х	х	х	х	Reserved for future use
х	0	0	0	0	0	0	0	No parameters in this octet

Table C.a – Non-standard information field – NPar(1) coding

Bits								
8	7	6	5	4	3	2	1	SPar(1)s
x	х	х	х	х	х	х	1	G.992.1 Annex Q (and Annex Q-EU)
x	х	х	х	х	х	1	х	G.992.1 Annex I-EU
x	х	х	х	х	1	х	х	G.992.1 Annex C-EU
х	х	х	х	1	х	х	х	Reserved for future use
x	х	х	1	х	х	х	х	Reserved for future use
х	х	1	х	х	х	х	х	Reserved for future use
x	1	Х	х	Х	Х	х	х	Reserved for future use
x	0	0	0	0	0	0	0	No parameters in this octet

Table C.b – Non-standard information field – SPar(1) coding

Table C.b.5 – Non-standard information field – G.992.1 Annex C-EU NPar(2) coding – Octet 1

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex C-EU NPar(2)s
Х	х	х	х	х	х	х	1	$n_{\text{C-PILOT1}} = 64$
Х	х	х	х	х	х	1	х	$n_{\text{C-PILOT1}} = 128$
х	х	х	х	х	1	х	х	Reserved for future use
Х	х	х	х	1	х	х	х	Reserved for future use
Х	х	х	1	х	х	х	х	Reserved for future use
Х	х	1	х	х	х	х	х	$n_{\text{C-PILOT1}} = 96$
Х	х	0	0	0	0	0	0	No parameters in this octet

Table C.b.5.1 – Non-standard information field – G.992.1 Annex C-EU NPar(2) coding – Octet 2

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex C-EU NPar(2)s – Octet 2
х	х	х	х	х	Х	Х	1	R-ACK1
х	х	х	х	х	х	1	х	R-ACK2
х	х	х	х	х	1	х	х	DBM
х	х	х	х	1	Х	х	х	$n_{\text{C-PILOT1}} = 48$
х	х	х	1	х	х	х	х	$n_{\text{C-PILOT1}} = 32$
х	х	1	х	х	х	х	х	G.997.1 – Clear EOC OAM
х	х	0	0	0	0	0	0	No parameters in this octet
Since Ar	nnex C	-EU on	ly supp	orts A7	M trar	nsport, S	STM a	nd ATM parameters are not specified.

Bit	S							
8	7	6	5	4	3	2	1	G.992.1 Annex C-EU NPar(2)s – Octet 3
x	х	x	х	х	х	х	1	$n_{\text{C-PILOT1}} = 16$
x	х	х	х	х	х	1	х	$\mathbf{A}_{48} \ / \ \mathbf{B}_{48}$
x	х	х	х	х	1	х	х	C-REVERB33-63
x	Х	х	х	1	х	х	х	A ₂₄ / B ₂₄
x	х	х	1	х	х	х	х	C-REVERB6-31
x	Х	1	х	х	х	х	х	Reserved for future use
x	X	0	0	0	0	0	0	No parameters in this octet

Table C.b.5.2 – Non-standard information field – G.992.1 Annex C-EU NPar(2) coding – Octet 3

Table C.b.5.3 – Non-standard information field – G.992.1 Annex C-EU NPar(2) coding – Octet 4

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex C-EU NPar(2)s – Octet 3
х	х	х	х	х	х	х	1	Profile 1
х	х	х	х	х	х	1	Х	Profile 2
х	х	х	х	х	1	х	х	Profile 3
х	х	х	х	1	х	х	х	Profile 4
х	х	х	1	х	х	х	Х	Profile 5
х	х	1	х	х	х	х	х	Profile 6
х	Х	0	0	0	0	0	0	No parameters in this octet

Table C.b.6 – Non-standard information field – G.992.1 Annex C-EU SPar(2) coding

r

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex C-EU SPar(2)s
х	х	х	х	х	х	х	1	Reserved for future use
х	х	х	х	х	х	1	х	Extended upstream
х	х	х	х	х	1	х	х	Profile 3 downstream PSD
х	х	х	х	1	х	Х	х	Reserved for future use
х	х	х	1	х	х	х	х	Reserved for future use
х	х	1	х	х	х	х	х	Reserved for future use
х	х	0	0	0	0	0	0	No parameters in this octet

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex C-EU Extended upstream NPar(3)s – Octet 1
X	Х	х	Х	Х	Х	Х	1	Mode 1 upstream mask
х	х	х	х	х	х	1	х	Mode 2 upstream mask
х	х	х	х	х	1	х	х	Optional upstream masks for non-overlapped spectrum
х	х	х	х	1	х	х	х	EU-64
х	х	х	1	х	х	х	х	EU-32
х	х	1	х	х	х	х	х	EU-36
х	Х	0	0	0	0	0	0	No parameters in this octet

Table C.b.6.2 – Non-standard information field – G.992.1 Annex C-EU Extended upstream NPar(3) coding Octet 1

Table C.b.6.2.1 – Non-standard information field – G.992.1 Annex C-EU Extended upstream NPar(3) coding Octet 2

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex C-EU Extended upstream NPar(3)s Octet 2
x	Х	х	х	х	х	х	1	EU-40
х	Х	х	х	х	х	1	х	EU-44
х	Х	х	х	х	1	х	х	EU-48
х	Х	х	х	1	х	х	Х	EU-52
х	х	х	1	х	х	х	х	EU-56
х	х	1	х	х	х	х	х	EU-60
x	х	0	0	0	0	0	0	No parameters in this octet

Table C.b.6.3 – Non-standard information field – G.992.1 Annex C-EU Profile 3 downstream PSD NPar(3) coding Octet 1

Bits								
8	7	6	5	4	3	2	1	G.992.1 Annex C-EU Profile 3 downstream NPar(3)s Octet 1
x	Х	х	х	х	х	х	1	LD-TIF1
x	х	х	х	х	х	1	х	LD-TIF2
x	х	х	х	х	1	х	х	FBMsOL
х	х	х	х	1	х	х	х	Reserved for future use
х	х	х	1	х	х	х	х	Reserved for future use
x	х	1	х	х	х	х	х	Reserved for future use
x	Х	0	0	0	0	0	0	No parameters in this octet

C.7.3 Handshake – Parameter definitions (supplements 10.2)

C.7.3.1 Handshake – ATU-C (supplements 10.2)

From C-SILENT1, the ATU-C may transition to either C-TONES or C-INIT under instruction of the network operator.

C.7.3.1.1 CL messages (supplements 10.2.1)

NSF parameter	Definition
DBM	If set to ZERO, this bit shall indicate Bitmap-N _R and Bitmap-N _C are enabled (Dual
	Bitmap mode) and are used to transmit data. If set to ONE, this bit shall indicate Bitmap- N_R and Bitmap- N_C are disabled (FEXT Bitmap mode), i.e. only Bitmap- F_R and
	Bitmap-F _C are used to transmit data by ATU-C and ATU-R respectively. This mode
	selection shall be only performed by the ATU-C. If it is set to ONE in a CL message, it must be set to ONE in subsequent MS messages from either the ATU-C or ATU-R (only applicable for G.992.1 Annex C/C-EU). (Note 1)
Profile 1	If set to ONE, this bit shall indicate that the ATU-C supports Profile 1
Profile 2	If set to ONE, this bit shall indicate that the ATU-C supports Profile 2
Profile 3	If set to ONE, this bit shall indicate that the ATU-C supports Profile 3
Profile 4	If set to ONE, this bit shall indicate that the ATU-C supports Profile 4
Profile 5	If set to ONE, this bit shall indicate that the ATU-C supports Profile 5
Profile 6	If set to ONE, this bit shall indicate that the ATU-C supports Profile 6
G.992.1 Annex C-EU	If set to ONE, this Spar(1) bit indicates that the ATU-C is configured to support G.992.1 Annex C-EU. An Annex C-EU ATU-C shall support negotiation of the optional pilot tones, TTR indication signals, and profiles.
ⁿ C-PILOT1 ⁼¹²⁸	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 128.
ⁿ C-PILOT1 ⁼⁹⁶	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 96.
ⁿ C-PILOT1 ⁼⁶⁴	This NPar(2) bit shall also be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 64.
ⁿ C-PILOT1 ⁼⁴⁸	This NPar(2) bit shall also be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 48.
ⁿ C-PILOT1 ⁼³²	This NPar(2) bit shall also be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 32.
ⁿ C-PILOT1 ⁼¹⁶	This NPar(2) bit shall also be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 16.
A_{48} / B_{48}	This NPar(2) bit shall also be set to ONE, indicating that the ATU-C supports transmission of TTR indication signal A_{48} / B_{48} .
A ₂₄ / B ₂₄	This NPar(2) bit shall also be set to ONE, indicating that the ATU-C supports transmission of TTR indication signal A_{24} / B_{24} .
C-REVERB33-63	This NPar(2) bit shall also be set to ONE, indicating that the ATU-C supports transmission of TTR indication signal C-REVERB33-63.
C-REVERB6-31	This NPar(2) bit shall also be set to ONE, indicating that the ATU-C supports transmission of TTR indication signal C-REVERB6-31.
Extended upstream	If set to ONE, this Spar(2) bit indicates that the ATU-C is configured to support extended upstream.
Profile 3 downstream PSD	If set to ONE, this Spar(2) bit indicates that the ATU-C is configured to support profile 3.
EU-xx	If the Extended upstream Spar(2) bit is set to ONE, these Npar(3) bits indicate the extended upstream masks that the ATU-C supports. For non-overlapped spectrum, extended upstream masks are associated with downstream masks according to Figure C.xx. For overlapped spectrum, any EU-xx may be used with the overlapped downstream spectrum specified in §C.4.8.2.
Mode 1 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-C is configured to support upstream mask mode 1 (different masks during FEXT and NEXT periods).

Table C.3/G.992.1 – ATU-C CL message bit definitions for Annex C-EU

Mada 2	If act to ONE this NDer(2) hit is directed that the ATU C is configured to summary unstructure
Mode 2 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-C is configured to support upstream
	mask mode 2 (same mask during FEXT and NEXT periods).
Optional upstream	If set to ONE, this NPar(3) bit indicates that the ATU-C is configured to support the
masks for non-	optional upstream masks when using non-overlapped spectrum downstream.
overlapped spectrum	
LD-TIF1	If set to ONE, this NPar(3) bit indicates that the ATU-C is configured to support the
	optional LD-TIF1 downstream PSD of profile 3.
LD-TIF2	If set to ONE, this NPar(3) bit indicates that the ATU-C is configured to support the
	optional LD-TIF2 downstream PSD of profile 3.
FBMsOL	If set to ONE, this NPar(3) bit indicates that the ATU-C is configured to support the
	optional FBMsOL downstream PSD of profile 3.
Note 1: The DBM bit is o	only used to maintain backward compatibility with G.992.1 (1999) Annex C. If any of the
profile bits (Table 11.5.1.	(G.994.1) are set to ONE in a received CLR message, DBM shall be set to ONE in the CL
message and shall be ign	ored by the ATU-R.
Note 2: Only one of LD-	FIF1, LD-TIF2 and FBMsOL bits can be set to 1.

C.7.3.1.2 MS messages (supplements 10.2.2)

NSF parameter	Definition
DBM	If set to ZERO, this bit shall indicate Bitmap- N_R and Bitmap- N_C are enabled (Dual Bitmap
	mode) and are used to transmit data. If set to ONE, this bit shall indicate Bitmap-N _R and
	Bitmap-N _C are disabled (FEXT Bitmap mode), i.e. only Bitmap-F _R and Bitmap-F _C are
	used to transmit data by ATU-C and ATU-R respectively. This mode selection shall be only
	performed by ATU-C. This bit shall be set to ONE if it was set to ONE in a previous CL
	message (only applicable for G.992.1 Annex C/C-EU). (Note 1)
Profile 1	If set to ONE, this bit shall indicate that the ATU-C is selecting Profile 1
Profile 2	If set to ONE, this bit shall indicate that the ATU-C is selecting Profile 2
Profile 3	If set to ONE, this bit shall indicate that the ATU-C is selecting Profile 3
Profile 4	If set to ONE, this bit shall indicate that the ATU-C is selecting Profile 4
Profile 5	If set to ONE, this bit shall indicate that the ATU-C is selecting Profile 5
Profile 6	If set to ONE, this bit shall indicate that the ATU-C is selecting Profile 6
G.992.1 Annex C-EU	If set to ONE, this Spar(1) bit indicates that the ATU-C is selecting G.992.1 Annex C-EU. An Annex C-EU ATU-C shall support negotiation of the optional pilot tones, TTR
	indication signals, and profiles.
ⁿ C-PILOT1 ⁼¹²⁸	If set to ONE, this NPar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 128 (Note 2).
ⁿ C-PILOT1 ⁼⁹⁶	If set to ONE, this bit NPar(2) shall indicate that the ATU-C is selecting the pilot tone on subcarrier 96 (Note 2).
ⁿ C-PILOT1 ⁼⁶⁴	If set to ONE, this NPar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 64 (Note 2).
ⁿ C-PILOT1 ⁼⁴⁸	If set to ONE, this NPar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 48 (Note 2).
ⁿ C-PILOT1 ⁼³²	If set to ONE, this NPar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 32 (Note 2).
ⁿ C-PILOT1 ⁼¹⁶	If set to ONE, this NPar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 16 (Note 2).
A_{48} / B_{48}	If set to ONE, this NPar(2) bit shall indicate that the ATU-C is selecting TTR indication signal A_{48} / B_{48} (Note 2).
A_{24} / B_{24}	If set to ONE, this NPar(2) bit shall indicate that the ATU-C is selecting TTR indication signal A_{24} / B_{24} (Note 2).
C-REVERB33-63	If set to ONE, this NPar(2) bit shall indicate that the ATU-C is selecting TTR indication signal C-REVERB33-63 (Note 2).
C-REVERB6-31	If set to ONE, this NPar(2) bit shall indicate that the ATU-C is selecting TTR indication signal C-REVERB6-31 (Note 2).
Extended upstream	If set to ONE, this Spar(2) bit indicates that the ATU-C is selecting extended upstream operation.
Profile 3 downstream PSD	If set to ONE, this Spar(2) bit indicates that the ATU-C is selecting profile 3.
EU-xx	If set to ONE, this Npar(3) bit indicates that the ATU-C is selecting upstream PSD mask
	US-xx. For non-overlapped spectrum, extended upstream masks are associated with
	downstream masks according to Figure C.13. For overlapped spectrum, any EU-xx may be used with the overlapped downstream spectrum specified in §C.4.8.2.
Mode 1 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-C is selecting upstream mask mode 1 (different masks during FEXT and NEXT periods). (Note 2)
Mode 2 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-C is selecting upstream mask mode 2 (same masks during FEXT and NEXT periods). (Note 2)

Table C.4/G.992.1 – ATU-C MS message bit definitions for Annex C-EU

Optional upstream masks for non- overlapped spectrum	If set to ONE, this NPar(3) bit indicates that the ATU-C is selecting one of the optional upstream masks when using non-overlapped spectrum downstream.			
LD-TIF1	If set to ONE, this NPar(3) bit indicates that the ATU-C is selecting the optional LD-TIF1 downstream PSD of profile 3.			
LD-TIF2	If set to ONE, this NPar(3) bit indicates that the ATU-C is selecting the optional LD-TIF2 downstream PSD of profile 3.			
FBMsOL	If set to ONE, this NPar(3) bit indicates that the ATU-C is selecting the optional FBMsOL downstream PSD of profile 3.			
	Note 1: The DBM bit is only used to maintain backward compatibility with G.992.1 (1999) Annex C. Note 2: One and only one pilot tone bit, and one and only one TTR indication signal bit shall be set in an MS message.			

C.7.3.2 Handshake – ATU-R (supplements 10.3)

Upon command from the host controller, the ATU-R shall initiate handshaking by transitioning from the R-SILENT0 state to either the G.994.1 R-TONES-REQ state or the R-INIT state.

C.7.3.2.1 CLR messages (supplements 10.3.1)

NSF parameter	Definition
DBM	This bit shall be set to ONE.
Profile 1	If set to ONE, this bit shall indicate that the ATU-R supports Profile 1
Profile 2	If set to ONE, this bit shall indicate that the ATU-R supports Profile 2
Profile 3	If set to ONE, this bit shall indicate that the ATU-R supports Profile 3
Profile 4	If set to ONE, this bit shall indicate that the ATU-R supports Profile 4
Profile 5	If set to ONE, this bit shall indicate that the ATU-R supports Profile 5
Profile 6	If set to ONE, this bit shall indicate that the ATU-R supports Profile 6
G.992.1 Annex C-	If set to ONE, this Spar(1) bit indicates that the ATU-R is configured to support G.992.1 Annex
EU	C-EU.
ⁿ C-PILOT1 ⁼¹²⁸	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 128.
ⁿ C-PILOT1 ⁼⁹⁶	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 96.
ⁿ C-PILOT1 ⁼⁶⁴	This bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 64.
ⁿ C-PILOT1 ⁼⁴⁸	If set to ONE, this bit shall indicate that the ATU-R supports reception of pilot tone on subcarrier 48.
ⁿ C-PILOT1 ⁼³²	If set to ONE, this bit shall indicate that the ATU-R supports reception of pilot tone on subcarrier 32.
ⁿ C-PILOT1 ⁼¹⁶	If set to ONE, this bit shall indicate that the ATU-R supports reception of pilot tone on subcarrier 16.
A_{48} / B_{48}	This bit shall be set to ONE, indicating that the ATU-R supports reception of either TTR indication signal A_{48} or B_{48} (Note 1)
A ₂₄ / B ₂₄	If set to ONE, this bit shall indicate that the ATU-R supports reception of either TTR indication signal A_{24} or B_{24} (Note 1)
C-REVERB33-63	If set to ONE, this bit shall indicate that the ATU-R supports reception of TTR indication signal C-REVERB33-63
C-REVERB6-31	If set to ONE, this bit shall indicate that the ATU-R supports reception of TTR indication signal C-REVERB6-31
Extended upstream	If set to ONE, this Spar(2) bit indicates that the ATU-R is configured to support extended upstream.
Profile 3 downstream PSD	If set to ONE, this Spar(2) bit indicates that the ATU-R is configured to support profile 3.
EU-xx	If the Extended upstream Spar(2) bit is set to ONE, these Npar(3) bits indicate the extended upstream masks that the ATU-R supports. For non-overlapped spectrum, extended upstream masks are associated with downstream masks according to Figure C.13. For overlapped spectrum, any EU-xx may be used with the overlapped downstream spectrum specified in §C.4.8.2.
Mode 1 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-R is configured to support upstream mask mode 1 (different masks during FEXT and NEXT periods).
Mode 2 upstream	If set to ONE, this NPar(3) bit indicates that the ATU-R is configured to support upstream mask
mask	mode 2 (same mask during FEXT and NEXT periods).
Optional upstream	If set to ONE, this NPar(3) bit indicates that the ATU-R is configured to support the optional
masks for non-	upstream masks when using non-overlapped spectrum downstream.
overlapped spectrum	
LD-TIF1	If set to ONE, this NPar(3) bit indicates that the ATU-R is configured to support the optional LD-TIF1 downstream PSD of profile 3.
LD-TIF2	If set to ONE, this NPar(3) bit indicates that the ATU-R is configured to support the optional LD-TIF2 downstream PSD of profile 3.

Table C.5/G.992.1 – ATU-R CLR message bit definitions for Annex C-EU

FBMsOL	If set to ONE, this NPar(3) bit indicates that the ATU-R is configured to support the optional FBMsOL downstream PSD of profile 3.
Note $1 - A_{48}$ and A_{24} shall not be used for Profile 3.	

C.7.3.2.2 MS messages (supplements 10.3.2)

NSF parameter	Definition
DBM	If set to ZERO, this bit shall indicate Bitmap- N_R and Bitmap- N_C are enabled (Dual
	Bitmap mode) and are used to transmit data. If set to ONE, this bit shall indicate
	Bitmap-N _R and Bitmap-N _C are disabled (FEXT Bitmap mode), i.e. only Bitmap-F _R and
	Bitmap-F _C are used to transmit data by ATU-C and ATU-R respectively. This mode
	selection shall be only performed by ATU-C. This bit shall be set to ONE if it was set to
	ONE in a previous CL message (only applicable for G.992.1 Annex C/C-EU). (Note 1)
Profile 1	If set to ONE, this bit shall indicate that the ATU-R is selecting Profile 1
Profile 2	If set to ONE, this bit shall indicate that the ATU-R is selecting Profile 2
Profile 3	If set to ONE, this bit shall indicate that the ATU-R is selecting Profile 3
Profile 4	If set to ONE, this bit shall indicate that the ATU-R is selecting Profile 4
Profile 5	If set to ONE, this bit shall indicate that the ATU-R is selecting Profile 5
Profile 6	If set to ONE, this bit shall indicate that the ATU-R is selecting Profile 6
G.992.1 Annex C-EU	
ng pu om =128	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is selecting the pilot tone on
ⁿ C-PILOT1 ⁼¹²⁸	subcarrier 128 (Note 2).
ⁿ C-PILOT1 ⁼⁹⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is selecting the pilot tone on
C-HLOTI	subcarrier 96 (Note 2).
ⁿ C-PILOT1 ⁼⁶⁴	If set to ONE, this NPar(2) bit shall indicate that the ATU-R is selecting the pilot tone on
	subcarrier 64 (Note 2).
ⁿ C-PILOT1 ⁼⁴⁸	If set to ONE, this NPar(2) bit shall indicate that the ATU-R is selecting the pilot tone on
	subcarrier 48 (Note 2).
ⁿ C-PILOT1 ⁼³²	If set to ONE, this NPar(2) bit shall indicate that the ATU-R is selecting the pilot tone on
n −16	subcarrier 32 (Note 2). If set to ONE, this NPar(2) bit shall indicate that the ATU-R is selecting the pilot tone on
ⁿ C-PILOT1 ⁼¹⁶	subcarrier 16 (Note 2).
A ₄₈ / B ₄₈	If set to ONE, this NPar(2) bit shall indicate that the ATU-R is selecting the TTR
148 / 248	indication signal A_{48} / B_{48} (Note 2).
A ₂₄ / B ₂₄	If set to ONE, this NPar(2) bit shall indicate that the ATU-R is selecting the TTR
1124 / 1224	indication signal A_{24} / B_{24} (Note 2).
C-REVERB33-63	If set to ONE, this NPar(2) bit shall indicate that the ATU-R is selecting the TTR
C-REVERD55-05	indication signal C-REVERB33-63 (Note 2).
C-REVERB6-31	If set to ONE, this NPar(2) bit shall indicate that the ATU-R is selecting the TTR
	indication signal C-REVERB6-31 (Note 2).
Extended upstream	If set to ONE, this Spar(2) bit indicates that the ATU-R is selecting extended upstream
	operation.
Profile 3 downstream	If set to ONE, this Spar(2) bit indicates that the ATU-R is selecting profile 3.
PSD	
EU-xx	If set to ONE, this Npar(3) bit indicates that the ATU-R is selecting upstream PSD mask
	US-xx. For non-overlapped spectrum, extended upstream masks are associated used with downstream masks according to Figure C 13. For overlapped spectrum, any EU vy may be
	downstream masks according to Figure C.13. For overlapped spectrum, any EU-xx may b used with the overlapped downstream spectrum specified in §I.4.8.2.
	used with the overlapped downsuleant spectrum spectrue in §1.4.6.2.

Mode 1 upstream mask	If set to ONE, this NPar(3) bit indicates that the ATU-R is selecting upstream mask mode 1 (different masks during FEXT and NEXT periods). (Note 2)		
Mode 2 upstream	If set to ONE, this NPar(3) bit indicates that the ATU-R is selecting upstream mask mode		
mask	2 (same mask during FEXT and NEXT periods). (Note 2)		
Optional upstream	If set to ONE, this NPar(3) bit indicates that the ATU-R is selecting one of the optional		
masks for non-	upstream masks when using non-overlapped spectrum downstream.		
overlapped spectrum			
LD-TIF1	If set to ONE, this NPar(3) bit indicates that the ATU-R is selecting the optional LD-TIF1		
	downstream PSD of profile 3.		
LD-TIF2	If set to ONE, this NPar(3) bit indicates that the ATU-R is selecting the optional LD-TIF2		
	downstream PSD of profile 3.		
FBMsOL	If set to ONE, this NPar(3) bit indicates that the ATU-R is selecting the optional FBMsOL		
	downstream PSD of profile 3.		
Note 1: The DBM bit is only used to maintain backward compatibility with G.992.1 (1999) Annex C.			
Note 2 – One and only one pilot tone bit, and one and only one TTR indication signal bit shall be set in an MS			
message			

C.7.3.2.3 MP messages (new)

NSF parameter	Definition
R-ACK1	Proposes that the ATU-C send C-PILOT1A, C-QUIET3A, C-PILOT2 and C-QUIET5
	during transceiver training.
R-ACK2	Proposes that the ATU-C send C-PILOT1, C-PILOT2 and C-PILOT3 during transceiver
	training.
G.992.1 Annex C-EU	If set to ONE, this Spar(1) bit indicates that the ATU-R is proposing G.992.1 Annex I-EU.
DBM	This bit shall be set to ONE if it was set to ONE in a previous CL message (Note 1)
Profile 1	If set to ONE, this bit shall indicate that the ATU-R is proposing to use Profile 1
Profile 2	If set to ONE, this bit shall indicate that the ATU-R is proposing to use Profile 2
Profile 3	If set to ONE, this bit shall indicate that the ATU-R is proposing to use Profile 3
Profile 4	If set to ONE, this bit shall indicate that the ATU-R is proposing to use Profile 4
Profile 5	If set to ONE, this bit shall indicate that the ATU-R is proposing to use Profile 5
Profile 6	If set to ONE, this bit shall indicate that the ATU-R is proposing to use Profile 6
110ml 0	
C-PILOT	If set to ONE, this bit shall indicate that the ATU-R wishes to propose a pilot tone and
	TTR indication signal. This bit shall be set to ONE to propose one of the profiles defined
	in §C.3.4.
ⁿ C-PILOT1 ⁼¹²⁸	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the pilot tone on
e milerr	subcarrier 128 (Note 2).
ⁿ C-PILOT1 ⁼⁹⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is proposing the pilot tone on
e fillett	subcarrier 96 (Note 2).
ⁿ C-PILOT1 ⁼⁶⁴	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the use of pilot
CTILOTT	tone on subcarrier 64 (Note 2).
ⁿ C-PILOT1 ⁼⁴⁸	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the use of pilot
CILOII	tone on subcarrier 48 (Note 2).
ⁿ C-PILOT1 ⁼³²	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the use of pilot
CILOII	tone on subcarrier 32 (Note 2).
ⁿ C-PILOT1 ⁼¹⁶	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the use of pilot
CTILOTT	tone on subcarrier 16 (Note 2).
A ₄₈ / B ₄₈	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the use of TTR
10 10	indication signal A_{48} / B_{48} (Note 2).
A ₂₄ / B ₂₄	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the use of TTR
1124 / D24	indication signal A_{24} / B_{24} (Note 2).
C-REVERB33-63	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the use of TTR
C DEVEDD(21	indication signal C-REVERB33-63 (Note 2).
C-REVERB6-31	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the use of TTR
F (1.1.)	indication signal C-REVERB6-31 (Note 2).
Extended upstream	If set to ONE, this Spar(2) bit indicates that the ATU-R is proposing extended upstream
D. C1. 2 1	operation.
Profile 3 downstream	If set to ONE, this Spar(2) bit indicates that the ATU-R is proposing profile 3.
PSD	
EU-xx	If set to ONE, this Npar(3) bit indicates that the ATU-R is proposing upstream PSD mask
	US-xx. For non-overlapped spectrum, extended upstream masks are associated with
	downstream masks according to Figure C.13. For overlapped spectrum, any EU-xx may be
Mada 1 and	used with the overlapped downstream spectrum specified in §C.4.8.2.
Mode 1 upstream	If set to ONE, this NPar(3) bit indicates that the ATU-R is proposing upstream mask mode
mask	1 (different masks during FEXT and NEXT periods).
Mode 2 upstream	If set to ONE, this NPar(3) bit indicates that the ATU-R is proposing upstream mask mode
mask	2 (same mask during FEXT and NEXT periods).
Optional upstream	If set to ONE, this NPar(3) bit indicates that the ATU-R is proposing one of the optional
masks for non-	upstream masks when using non-overlapped spectrum downstream.
overlapped spectrum	

LD-TIF1	If set to ONE, this NPar(3) bit indicates that the ATU-R is proposing the optional LD- TIF1 downstream PSD of profile 3.	
LD-TIF2	If set to ONE, this NPar(3) bit indicates that the ATU-R is proposing the optional LD- TIF2 downstream PSD of profile 3.	
FBMsOL	If set to ONE, this NPar(3) bit indicates that the ATU-R is proposing the optional FBMsOL downstream PSD of profile 3.	
Note 1: The DBM bit is only used to maintain backward compatibility with G.992.1 (1999) Annex C. Note 2: One and only one pilot tone bit, and one and only one TTR indication signal bit shall be set in an MP message.		

C.7.4 Transceiver Training – ATU-C (supplements 10.4)

During transceiver training from C-REVERB1 to C-SEGUE1 except C-PILOTn and C-QUIETn, the ATU-C shall transmit both FEXT_R and NEXT_R symbols when Bitmap-N_R is enabled (Dual Bitmap mode). For modems not using any of the profiles defined in §C.3.4 and modems using Profile 1, the ATU-C shall not transmit the NEXT_R symbols except pilot tone when Bitmap-NR is disabled (FEXT Bitmap mode). For Profile 3, the ATU-C shall not transmit any signal in NEXT_R symbols. The duration of each state is defined as Figure C.21.

C.7.4.1 C-PILOT1 (supplements 10.4.2)

The ATU-C shall start the N_{SWF} (sliding window frame) counter from 0 immediately after entering C-PILOT1, and increment the NSWF counter modulo 345 after transmission of each DMT symbol. According to the sliding window function and this counter, the ATU-C decides to transmit all of the subsequent symbols in either $FEXT_R$ or $NEXT_R$ symbols (for example, see Figures C.11, C.15 and C.19).

C-PILOT1 has two signals.

The first signal is the pilot tone as a single frequency sinusoid.

For Profiles 1 & 2, the frequency of the pilot tone shall be selected from one of the following choices:

- 1. $f_{\rm C-PILOT1} = 276 \, \rm kHz \, (n_{\rm C-PILOT1} = 64);$
- 2. $f_{\text{C-PILOT1}} = 207 \text{ kHz} (n_{\text{C-PILOT1}} = 48).$

For Profiles 3 to 6, the frequency of the pilot tone shall be selected from one of the following choices:

- $f_{\text{C-PILOT1}} = 276 \text{ kHz} (n_{\text{C-PILOT1}} = 64);$ 1.
- 2. $f_{\rm C-PILOT1} = 207 \, \text{kHz} \, (n_{\rm C-PILOT1} = 48);$
- $f_{\text{C-PILOT1}} = 138 \text{ kHz} (n_{\text{C-PILOT1}} = 32);$ 3.
- <mark>4</mark>. $f_{\text{C-PILOT1}} = 69 \text{ kHz} (n_{\text{C-PILOT1}} = 16).$

For modems not using any of the profiles defined in §C.3.4, the frequency of the pilot tone shall be: $f_{\text{C-PILOT1}} = 276 \text{ kHz} (n_{\text{C-PILOT1}} = 64)$

Editor's note: We need to decide how much extended upstream to support for each profile and then which pilot tones are necessary for this. For example, Profile 3 is long reach. It probably does not make sense to support all the way to subcarrier 64 upstream, in which case, there is no need for any pilot tone above tone 64.

Transmitters that use any of the profiles defined in §C.3.4 shall support all of the pilot tones specified for the supported profiles. For backwards compatibility, receivers shall support $n_{C-PII,OT1} = 64$. Support of the other pilot tones by a receiver is optional. The pilot tone shall be selected during G.994.1.

The second signal is the TTR indication signal used to transmit NEXT_R/FEXT_R information. The ATU-R can detect the phase information of the TTR_C from this signal.

For Profiles 1 & 2, the TTR indication signal shall be selected from one of the following choices: 1. A_{48} signal –the constellation encoding of the 48th carrier with 2-bit constellation as follows:

(+ , +) to indicate a FEXT_R symbol;

(+ , –) to indicate a NEXT_R symbol.

1

2. C-REVERB33-63 – subcarriers 33 through 63 of C-REVERB, transmitted only in the first four DMT symbols of each hyperframe in C-PILOT1 to indicate the beginning of the hyperframe.

For Profile 3, the TTR indication signal shall be selected from one of the following choices:

B₄₈ signal –the constellation encoding of the 48th carrier with 2-bit constellation as follows:

(+ , –) to indicate the first and the last symbol in consecutive $\text{FEXT}_{\mathbf{R}}$ symbols;

(+, +) to indicate the other symbols in consecutive FEXT_R symbols.

2. B₂₄ signal – the constellation encoding of the 24th carrier with 2-bit constellation as follows:

(+, -) to indicate the first and the last symbol in consecutive FEXT_R symbols;

(+, +) to indicate the other symbols in consecutive FEXT_R symbols.

 C-REVERB6-31 – subcarriers 6 through 31 of C-REVERB, transmitted only in the first four DMT symbols of each hyperframe in C-PILOT1 to indicate the beginning of the hyperframe.
 For Profiles 4 to 6, the TTR indication signal shall be selected from one of the following choices:

1. A₄₈ signal – the constellation encoding of the 48th carrier with 2-bit constellation as follows:

(+ , +) to indicate a FEXT_R symbol;

(+ , –) to indicate a NEXT_R symbol.

 A₂₄ signal – the constellation encoding of the 24th carrier with 2-bit constellation as follows: (+, +) to indicate a FEXT_R symbol;

(+ , –) to indicate a NEXT_R symbol.

 C-REVERB6-31 – subcarriers 6 through 31 of C-REVERB, transmitted only in the first four DMT symbols of each hyperframe in C-PILOT1 to indicate the beginning of the hyperframe.

For modems not using any of the profiles defined in §C.3.4, the TTR indication signal shall be: A₄₈ signal – the constellation encoding of the 48th carrier with 2-bit constellation as follows:

(+ , +) to indicate a FEXT_R symbol; (+ , –) to indicate a NEXT_R symbol.

Editor's note: We need to decide how much extended upstream to support for each profile and then which TTR indication signals are necessary for this.

Transmitters that use any of the profiles defined in C.3.4 shall support all of the TTR indication signals specified for the supported profiles. For backwards compatibility, receivers shall support TTR indication signal A₄₈. Support for the other TTR indication signals by a receiver is optional. The TTR signal shall be selected during G.994.1.

C.7.4.2 C-PILOT1A (supplements 10.4.3)

C-PILOT1A has two signals and it is the same transmitted signal as C-PILOT1 (C.7.4.1).

C.7.4.3 C-REVERB3 (supplements 10.4.11)

In order to synchronize the first symbol of C-RATES1 with the beginning of the hyperframe and to inform the entering timing of C-RATES1 to the ATU-R, the first symbol of C-SEGUE1 shall be transmitted inside of the FEXT_R duration as shown in Figure C.17. Therefore, the duration of C-REVERB3 is 3628 DMT symbols.

C.7.4.4 C-REVERB1 (supplements 10.4.5)

Bits d_{2i+1} and d_{2i+2} , which modulate the pilot carrier that has tone index i, shall be overwritten by $\{0,0\}$, generating

the (+,+) constellation point.

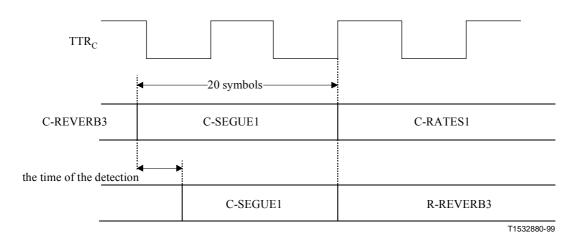


Figure C.17/G.992.1 – Timing diagram from C-SEGUE1 to C-RATES1

C.7.5 Transceiver Training – ATU-R (supplements 10.5)

During transceiver training from R-REVERB1 to R-SEGUE1 except R-QUIETn, the ATU-R shall transmit both FEXT_C and NEXT_C symbols when Bitmap-N_C is enabled (Dual Bitmap mode) and shall not transmit NEXT_C symbols when Bitmap-N_C is disabled (FEXT Bitmap mode). The duration of each state is defined as Figure C.21.

C.7.5.1 R-QUIET2 (supplements 10.5.1)

The ATU-R enters R-REVERB1 after it completes timing recovery and Hyperframe synchronization from C-PILOT1/C-PILOT1A.

C.7.5.2 R-REVERB1 (supplements 10.5.2)

The data pattern used in R-REVERB1 is the pseudo-random upstream sequence PRU defined in 8.11.3 , repeated as necessary for the selected NSCus:

$$\begin{cases} d_n = 1 & \text{for } n = 1 \text{ to } 6 \\ d_n = d_{n-5} & \oplus d_{n-6} & \text{for } n = 7 \text{ to } 64 \end{cases}$$
(C.10-1)

The period of PRU is only 63 bits, so d_{n+63} is equal to d_n .

The ATU-R shall start its N_{SWF} counter immediately after entering R-REVERB1, and then increment the N_{SWF} counter with modulo 345 from 0 when it transmits each DMT symbol. The ATU-C and ATU-R shall have the same value since hyperframe alignment between the ATU-C and ATU-R shall be maintained. According to the sliding window and this counter, the ATU-R decides to transmit all of the subsequent symbols in either the FEXT_C or the NEXT_C symbol.

C.7.5.3 R-QUIET3 (replaces 10.5.3)

The final symbol of R-QUIET3 accommodates the frame alignment of the transmitter to that of the receiver. It may be shortened by any number of samples. The maximum duration of R-QUIET3 is 6145 DMT symbols.

C.7.5.4 R-REVERB2 (supplements 10.5.5)

After ATU-R detects C-SEGUE1, the ATU-R enters R-SEGUE1. The maximum duration of R-REVERB2 is 3643 DMT symbols.

C.7.6 Channel analysis (ATU-C) (supplements 10.6)

The ATU-C shall transmit only FEXT_R symbols from C-RATES1 to C-CRC2. For modems not using any of the profiles defined in §C.3.4 and modems using Profiles 1, 2, 4, 5 and 6, the ATU-C shall not transmit the NEXT_R symbols except for the pilot tone. For Profile 3, the ATU-C shall not transmit any signal in NEXT_R symbols. During C-MEDLEY, the ATU-C shall transmit both FEXT_R and NEXT_R symbols when Bitmap-N_R is enabled (Dual Bitmap mode). For modems not using any of the profiles defined in §C.3.4 and modems using Profile 1, the ATU-C shall not transmit NEXT_R symbols except the pilot tone, when Bitmap-N_R is disabled (FEXT Bitmap mode). For Profile 3, the ATU-C shall not transmit any signal in NEXT_R symbols. The duration of each state is defined in Figure C.21.

C.7.6.1 C-SEGUE1 (supplements 10.6.1)

The duration of C-SEGUE1 is 20 symbols in order that the first symbol of C-SEGUE1 shall be inside of the FEXT_R duration.

C.7.6.2 C-MEDLEY (replaces 10.6.6)

C-MEDLEY is a wideband pseudo-random signal used for estimation at the ATU-R of the downstream SNR. The data to be transmitted are derived from the pseudo-random sequence, PRD_m , defined as:

d_n = 1 for n = 1 to 14 and d_n = d_{n-5} \oplus d_{n-11} \oplus d_{n-12} \oplus d_{n-14} for n> 14,

and modulated as defined in 10.4.5. In contrast to C-REVERB1, the cyclic prefix is used and the data sequence continues from one symbol to the next (i.e. d_1 to d_{14} are not re-initialized for each symbol). Because the sequence is of length 2¹⁴-1, and far fewer bits are used for each symbol, the subcarrier vector for C-MEDLEY changes from one symbol period to the next. For non-overlapped spectrum, 2*(256-mm+1) bits are used each symbol, where mm is the minimum subcarrier specified for PSD mask DS-mm in Table C.13. For overlapped spectrum, 2*251 bits are used each symbol. The pilot subcarrier is overwritten by the (+,+) signal constellation. The duration of C-MEDLEY is as shown in Figure C.26. Following C-MEDLEY the ATU-C shall enter the state C-REVERB4.

With the periodical noise of TCM-ISDN, SNR also changes in the same cycle, as shown in Figure C.18. When Bitmap-N_R is enabled ATU-C transmits the signal in both of NEXT_R and FEXT_R symbols, and the ATU-R estimates two SNRs from the received NEXT_R and FEXT_R symbols, respectively, as defined in Figure C.19.

The following formula gives the information that received N_{dmt} -th DMT symbol belongs to:

 $\begin{array}{l} \mbox{For $N_{dmt}=0,1,\ldots,344$} \\ \mbox{$S=272$ x N_{dmt} mod 2760} \\ \mbox{$if \{ (S+271<a)$ or $(S>d) \} $$ then symbol for estimation of $FEXT_R$ SNR $$ if \{ (S>b)$ and $(S+271<c) $$ then symbol for estimation of $NEXT_R$ SNR $$ where $a=1243$, $b=1403$, $c=2613$, $d=2704$ $ \end{array}$

When Bitmap-N_R is disabled (FEXT Bitmap mode), the ATU-C only transmits the signal in FEXT_R symbols, and the ATU-R estimates the SNR from the received FEXT_R symbols. For modems not using any of the profiles defined in §C.3.4 and modems using Profile 1, the ATU-C shall transmit only the pilot tone as NEXT_R symbol. For Profile 3, the ATU-C shall not transmit any signal in NEXT_R symbols. The number of bits of NEXT_R shall be no more than the number of bits of FEXT_R.

For modems that use any of the profiles defined in C.3.4, the PRDm sequence generator at the transmitter shall continue to be updated during NEXT_R symbols when Bitmap-N_R is disabled (FEXT Bitmap mode).

NOTE - For modems not using any of the profiles defined in C.3.4, the PRDm sequence generator at the transmitter is either always updated or always stopped during NEXT_R symbol when Bitmap-N_R is disabled (FEXT Bitmap mode). The receiver should be able to support both modes of transmitter operation.

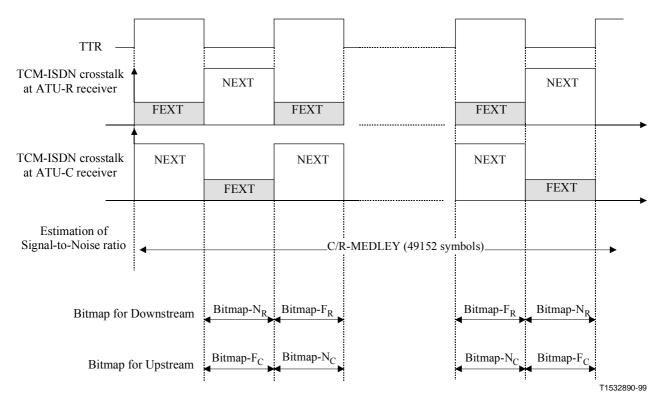


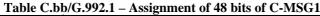
Figure C.18/G.992.1 – Estimation of periodic Signal-to-Noise Ratio

$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	TTR _C	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	-	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		
$ \begin{bmatrix} 6 & 61 & 62 & 63 & 64 & 65 & 66 & 67 & 68 & 69 & 79 \\ 7 & 71 & 72 & 73 & 74 & 75 & 76 & 77 & 78 & 79 & 80 \\ 8 & 82 & 83 & 84 & 85 & 86 & 87 & 38 & 89 & 99 & 100 & 101 \\ 10 & 102 & 103 & 104 & 105 & 106 & 107 & 108 & 109 & 110 & 111 \\ 112 & 113 & 114 & 115 & 116 & 117 & 148 & 119 & 120 & 22 \\ 122 & 123 & 124 & 125 & 26 & 127 & 128 & 129 & 130 & 141 \\ 132 & 133 & 134 & 135 & 136 & 137 & 138 & 39 & 140 & 144 \\ 142 & 143 & 144 & 145 & 146 & 147 & 148 & 149 & 560 & 151 \\ 152 & 153 & 154 & 155 & 156 & 157 & 158 & 159 & 160 & 161 & 147 \\ 162 & 163 & 164 & 165 & 166 & 167 & 168 & 169 & 170 & 171 & 72 \\ 173 & 174 & 175 & 176 & 177 & 178 & 179 & 180 & 181 & 82 \\ 183 & 184 & 185 & 186 & 187 & 188 & 189 & 190 & 191 & 52 \\ 19 & 193 & 194 & 195 & 196 & 197 & 198 & 199 & 206 & 260 & 261 & 262 \\ 203 & 204 & 205 & 206 & 207 & 208 & 209 & 210 & 211 & 212 \\ 213 & 214 & 215 & 216 & 217 & 218 & 219 & 220 & 221 & 222 \\ 223 & 224 & 225 & 226 & 227 & 228 & 229 & 236 & 231 & 232 & 14 \\ 244 & 245 & 246 & 247 & 248 & 249 & 256 & 251 & 252 & 256 \\ 264 & 265 & 266 & 267 & 288 & 269 & 270 & 271 & 273 & 273 \\ 274 & 275 & 276 & 277 & 278 & 279 & 286 & 281 & 822 & 283 \\ 284 & 285 & 286 & 287 & 288 & 289 & 290 & 291 & 292 & 293 \\ 294 & 295 & 296 & 297 & 298 & 299 & 300 & 301 & 302 & 303 & 134 \\ 304 & 305 & 306 & 307 & 308 & 309 & 316 & 317 & 312 & 313 & 314 \\ 315 & 316 & 317 & 318 & 319 & 320 & 331 & 332 & 333 & 34 \\ 336 & 335 & 336 & 337 & 338 & 39 & 340 & 341 & 342 & 343 & 344 \\ \hline \end{bmatrix}$		
7 71 72 73 74 75 76 77 78 79 80 8 81 82 83 84 85 86 87 38 89 99 100 101 101 102 103 104 105 106 107 108 109 110 111 111 112 113 114 115 116 117 118 119 120 22 122 123 124 125 26 127 128 129 130 141 14 142 143 144 145 146 147 148 149 360 151 15 152 153 154 155 156 157 158 159 160 167 168 169 170 178 179 180 181 82 16 162 163 164 165 166 167 168 169 170 178 179 180 181 82		
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$		
9 91 92 93 94 95 96 97 98 99 100 101 10 102 103 104 105 106 107 108 109 130 111 111 112 113 114 115 116 117 118 119 120 22 22 122 123 124 125 226 327 128 329 130 131 13 132 133 134 135 136 137 138 139 140 144 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 138 159 160 161 16 162 163 164 165 166 167 178 179 180 181 82 183 184 185 186 187 188 189 190 191 192 <td< td=""><td></td><td></td></td<>		
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	9	
11 112 113 114 115 116 117 118 119 120 12 12 122 123 124 125 26 127 128 129 130 131 13 132 133 134 135 136 137 138 139 140 14 14 142 143 144 145 146 147 148 149 150 151 15 152 153 154 155 156 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 82 18 183 184 185 186 187 188 189 190 191 192 19 193 194 195 196 197 198 199 206 201 202 203 204 205 206 207 208 219 230 231 232 24	10	
132 133 134 135 136 137 138 139 140 144 14 142 143 144 145 146 147 148 149 150 151 15 152 153 154 155 156 157 138 159 160 161 1 16 162 163 164 165 166 167 168 169 170 171 178 179 186 181 182 18 183 184 185 186 187 188 189 190 191 92 19 193 194 195 196 197 198 199 200 201 202 20 203 204 205 206 207 208 209 230 231 232 1 213 214 215 216 217 218 219 230 231 232 24 24 244 245 246 247	11	
14 142 143 144 145 146 147 148 149 150 151 15 152 153 154 155 156 157 158 159 160 161 171 16 162 163 164 165 166 167 168 169 170 171 172 17 173 174 175 176 177 178 179 180 181 82 18 183 184 185 186 187 188 188 199 200 201 202 202 20 203 204 205 206 207 208 209 210 211 212 21 21 213 214 215 216 217 218 219 230 231 242 243 24 244 245 246 247 248 249 250 251 252 251 254 255 256 257 258	12	122 123 124 125 E 26 727 728 729 730 131
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	13	132 133 134 135 136 137 138 139 149 141
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	14	142 143 144 145 146 147 148 149 159 151
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	15	152 153 154 155 156 157 738 759 768 769
18 183 184 185 186 187 188 189 190 191 92 19 193 194 195 196 197 198 199 206 201 292 20 203 204 205 206 207 208 209 216 211 212 21 213 214 215 216 217 218 219 220 223 222 223 23 233 234 235 236 237 238 239 240 241 242 243 24 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 283 29 294 295 296 297 298 299 306 301 302	16	162 163 164 165 166 167 168 169 179 172
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	17	173 174 175 176 177 78 182
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	18	183 184 185 186 187 188 189 192
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	19	
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		203 204 205 206 207 208 209 200 212
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		
28 284 285 286 287 288 289 290 291 292 293 29 294 295 296 297 298 299 300 301 302 303 30 304 305 306 307 308 309 310 311 312 313 314 31 315 316 317 318 319 320 321 322 323 324 32 325 326 327 328 229 330 331 332 333 334 33 335 336 337 338 39 340 341 342 343 344		
29 294 295 296 297 298 299 300 301 302 303 30 304 305 306 307 308 309 310 311 312 313 314 31 315 316 317 318 319 320 321 322 323 324 32 325 326 327 328 329 330 334 334 334 33 335 336 337 338 39 340 344 342 343 344		
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		
32 325 326 327 328 329 330 331 332 333 334 33 335 336 337 338 39 340 341 342 343 344 Symbol for estimation of FEXT _R S/N Symbol not used for S/N estimation		
33 335 336 337 338 389 340 344 344 344 344 344 344 344 344 344		
Symbol for estimation of FEXT _R S/N Symbol not used for S/N estimation		
	-	
Symbol for estimation of NEXT _R S/N T1535370-		Symbol for estimation of FEXT _R S/N Symbol not used for S/N estimation
		Symbol for estimation of NEXT _R S/N T1535370-C

Figure C.19/G.992.1 – Symbol pattern in a hyperframe for S/N estimation – Downstream

I.7.6.3 C-MSG1 (supplements 10.6.4)

Suffix(ces) of <i>m_i</i> (Note 1) Parameter (Note 3)	
47-44	Minimum required downstream SNR margin at initialization (Note 2)
43-18	Reserved for future use
17	Trellis coding option
16	Overlapped spectrum option (Note 4)
15	Unused (shall be set to "1")
14-12	Reserved for future use
11	NTR
10-9	Framing mode
8-6	Transmit PSD during initialization
5	Reserved
4-0	Maximum numbers of bits per subcarrier supported
NOTE 1 – Within the separate fields	the least significant bits have the lowest subscripts.
NOTE 2 – A positive number of dB;	
NOTE 3 – All reserved bits shall be	set to "0".
NOTE 4 – The initialization sequence	e allows for interworking of overlapped and non-overlapped spectrum



NOTE 4 – The initialization sequence allows for interworking of overlapped and non-overlapped spectrum implementations. Therefore, this indication is for information only.

I.7.6.3.1 Maximum numbers of bits per subcarrier supported – Bits 4-0 (replaces 10.6.4.8)

The N_{downmax} (transmit) capability shall be binary encoded onto $\{m_4, ..., m_0\}$ (e.g. $10001_2 = 17$). The maximum number of bits for the upstream data, N_{upmax} , that the ATU-C receiver can support need not be signalled to the ATU-R; it will be implicit in the bits and gains message, C-B&G, which is transmitted after channel analysis.

C.7.7 Channel analysis (ATU-R) (supplements 10.7)

From R-RATES1 to R-CRC2, the ATU-R shall transmit only the FEXT_{C} symbols and shall not transmit the NEXT_{C} symbols. In R-SEGUE2 and R-MEDLEY, the ATU-R shall transmit both FEXT_{C} and NEXT_{C} symbols when Bitmap-N_C is enabled (Dual Bitmap mode) and shall not transmit NEXT_{C} symbols when Bitmap-N_C is disabled (FEXT Bitmap mode). The duration of each state is defined in Figure C.21.

C.7.8 R-SEGUE1 (supplements 10.7.1)

The maximum duration of R-SEGUE1 is 14 symbols (see Figure C.17).

C.7.8.1 R-REVERB3 (supplements 10.7.2)

The ATU-R shall start R-REVERB3 aligned with the beginning of a Hyperframe.

C.7.8.2 R-SEGUE2 (supplements 10.7.3)

The duration of R-SEGUE2 is 13 symbols.

C.7.8.3 R-MEDLEY (replaces 10.7.8)

R-MEDLEY is a wideband pseudo-random signal used for estimation of the upstream SNR at the ATU-C. The data to be transmitted are derived from the pseudo-random sequence PRU_m defined as:

$$d_n = 1$$
 for $n = 1$ to 23 and $d_n = d_{n-18} \oplus d_{n-23}$ for $n > 23$.

In contrast to R-REVERB1, the cyclic prefix is used and the data sequence continues from one symbol to the next (i.e. d_1 to d_{23} are not re-initialized for each symbol). Because the sequence is of length 2^{23} -1, and $2^*(nn-5)$ bits are used for each symbol (where nn is the maximum subcarrier specified for PSD mask EU-nn in Table C.zz), the subcarrier vector for R-MEDLEY changes from one symbol period to the next. Following R-MEDLEY the ATU-R enters signalling state R-REVERB4. The duration of R-MEDLEY is as shown in Figure C.26.

With the periodical noise of TCM-ISDN, SNR also changes in the same cycle, as shown in Figure C.18. When Bitmap-N_C is enabled, the ATU-R shall transmit the signal in both of NEXT_C and FEXT_C symbols, and ATU-C shall estimate two SNRs from the received NEXT_C and FEXT_C symbols, respectively, as defined in Figure C.20.

The following numerical formula gives the information that received N_{dmt} -th DMT symbol belongs to:

For $N_{dmt} = 0, 1, ..., 344$ $S = 272 \times N_{dmt} \mod 2760$ if { (S > b) and (S + 271 < c) } then symbol for estimation of FEXT_C SNR if { (S + 271 < a) } then symbol for estimation of NEXT_C SNR where a = 1148, b = 1315, c = 2608

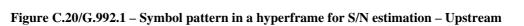
When Bitmap-N_C is disabled (FEXT Bitmap mode), the ATU-R only transmits the signal in FEXT_C symbols, and the ATU-C estimates the SNR from the received FEXT_C symbols. The number of bits of NEXT_C shall be no more than the number of bits of FEXT_C.

For modems that use any of the profiles defined in C.3.4, the PRUm sequence generator at the transmitter shall continue to be updated during NEXT_C symbols when Bitmap-N_C is disabled (FEXT Bitmap mode).

NOTE - For modems not using any of the profiles defined in C.3.4, the PRUm sequence generator at the transmitter is either always updated or always stopped during NEXT_C symbol when Bitmap-N_C is disabled (FEXT Bitmap mode). The receiver should be able to support both modes of transmitter operation.

TTR _R		ŢĹ					
0			5	6	7	8	9
1		1.	5 10	5 17	18	8 19)
2	20 23 22 23 24	25	26	27	28	29	
3	30 33 32 33 34	35	36	37	38	39	40
4	41 42 43 44	45	46	47	48	49	50
5	51 52 53 54	55	56	57	58	59	60
6	67 63 64 6	5	66	67	68	69	70
7	71 75 75	7	6 7	7 7	8 7	79 8	0
8	81 82 83 84 85	86	87	7 88	89	90	
9	91 92 93 94 95	96	97	98	99	100	101
10	101 102 103 104 105	106	107	108	109	110	111
11	112 113 114 115	116	117	118	119	120	121
12		26	127	128	129	130	131
13	132 133 134 135 13						41
14				48 14			51
15	152 153 154 155 156	157			_		<u> </u>
16		167	168	169	170	171	172 182
17 18	173 174 175 176 183 184 185 186	177 187	178 188	179 189	180 190	181 191	192
18		97	198		200	201	202
20	203 204 205 206 20						12
21	213 214 215 216 217	21					2
22	223 224 225 226 227	228			231		
23	233 234 235 236 231	238	239	240	241	242	243
24	244 245 247 247	248	249	250	251	252	253
25	254 255 257 257	258	259	260	260	262	263
26	264 265 266 267 2	68	269	270	271	272	273
27	274 275 276 277	3 2	79 2	.80 2	31 2	.82 2	83
28	284 285 286 287 288	28	9 29	0 29	1 29	2 29	3
29	294 295 296 291 298	299	300	301	302	303	
30	304 305 306 307 308	309	310	311	312	313	314
31	315 316 317 318	319	320	321	322	323	324
32		329	330	331	332	333	334
33	335 336 337 338 33	39	340	341	342	343	344
	-	ł		1		T1535290-0)
	Symbol for estimation of FEXT _C S/N						

Symbol for estimation of NEXT_C S/N



C.7.8.4 R-MSG1 (supplements 10.7.6)

Table C.cc/G.992.1 – Assignment of 48 bits of R-MSG1		
Suffix(ces) of m_i (Note 1) Parameter (Note 2)		
47-18	Reserved for future use	
17	Trellis coding option	
16	Overlapped spectrum option (Note 3)	
15	Unused (shall be set to "1")	
14	Support of $S = 1/2$ mode (see I.4.9) (Note 4)	
13	Support of dual latency downstream	
12	Support of dual latency upstream	
11	Network Timing Reference	
10, 9	Framing mode	
8-5	Reserved for future use	
4-0 Maximum numbers of bits per subcarrier supported		
NOTE 1 – Within the separate fields the least significant bits have the lowest subscripts.		
NOTE 2 – All reserved bits shall be set to "0".		
NOTE 3 – The initialization sequence allows for interworking of overlapped and non-overlapped spectrum		
implementations. Therefore, this indication is for information only.		
NOTE 4 – Since the S=1/2 mode is mandatory for Annex C-EU, a modem supporting Annex C-EU shall set this bit to		

Table C.cc/G.992.1 – Assignment of 48 bits of R-MSG1

C.7.8.4.1 Maximum numbers of bits per subcarrier supported – Bits 4-0 (replaces 10.7.6.6)

The N_{upmax} (transmit) capability is encoded onto $\{m_4, ..., m_0\}$ with a conventional binary representation (e.g. $10001_2 = 17$).

C.7.9 Exchange – ATU-C (supplements 10.8)

During C-RATESn, C-MSGn, C-B&G, and C-CRCn, the ATU-C shall transmit the FEXT_R symbol. In the other signals, the ATU-C shall transmit both FEXT_R and NEXT_R symbols when Bitmap-N_R is enabled (Dual Bitmap mode), and, for modems not using any of the profiles defined in §C.3.4 and modems using Profile 1, shall not transmit the NEXT_R symbols except pilot tone when Bitmap-N_R is disabled (FEXT Bitmap mode). For Profile 3, the ATU-C shall not transmit any signal in NEXT_R symbols. The duration of each state is defined in Figure C.22.

C.7.9.1 C-MSG2 (supplements 10.8.9)

Replace Table 10-13 with Table C.dd.

binary ONE.

Suffix(ces) of m _i (Note 1) Parameter (Note 2)	
31-26	Estimated average loop attenuation
25-21	Reserved for future use
20-16	Performance margin with selected rate option
15-11	Reserved for future use
10-0 Total number of bits supported	
NOTE 1 – Within the separate fields the least significant bits have the lowest subscripts.	
NOTE 2 – All reserved bits shall be set to "0".	

Table C.dd/G.992.1 – Assignment of 32 bits of C-MSG2

For modems not using any of the profiles defined in §C.3.4 and modems using Profiles 1, 2, 4, 5 or 6 : For NSCus=32:

 $n_{1C-MSG2} = 43$

 $n_{2C-MSG2} = 91$

Otherwise	e,
1	1 1C-MSG2 = 91
1	¹ 2C-MSG2 = 139
rofile 3:	
ⁿ 1C-MSC	32 = 13
ⁿ 2C-MSC	3 <mark>2 = 25</mark>

For F

C.7.9.1.1 Total number of bits per symbol supported (replaces 10.8.9.3)

The ATU-C receiver shall also calculate the maximum number of bits per symbol that the upstream channel can support with the performance margin defined in C-MSG-RA at an error rate of 10^{-7} .

The maximum number of bits per symbol is defined at the reference point B, that is calculated from the FEXT_C and NEXT_C downstream channel performance [e.g. if the maximum numbers of bits that can be supported in FEXT_C and NEXT_C symbols are 111 and 88 {Total number of bits per symbol supported} = $(111 \times 126 + 88 \times 214)/340 = 96$]. This number is encoded into bits 10-0 using a conventional binary representation [e.g. if the maximum number of bits that can be supported is 96 (data rate = 384 kbit/s), { $m_{10}, ..., m_0$ } = 000011111112].

NOTE – The number of symbols per hyperframe is 340. The number of FEXT symbols is 126. The number of NEXT symbols is 214.

C.7.9.2 C-B&G (replaces 10.8.13)

C-B&G shall be used to transmit to the ATU-R the bits and gains information, Bitmap-FC { b_1 , g_1 , b_2 , g_2 , ... $b_{NSCus-1}$, $g_{NSCus-1}$ }, and Bitmap-N_C { $b_{NSCus+1}$, $g_{NSCus+1}$, $b_{NSCus+2}$, $g_{NSCus+2}$, ..., $b_{2*NSCus-1}$, $g_{2*NSCus-1}$ }, that are to be used on the upstream carriers. b_i of Bitmap-F_C indicates the number of bits to be coded by ATU-R transmitter onto the *i* th upstream carrier in FEXT_C symbols; g_i of Bitmap-F_C indicates the scale factor, relative to the gain that was used for that carrier during the transmission of R-MEDLEY, that shall be applied to the *i* th upstream carrier in FEXT_C symbols. Similarly, b_i of Bitmap-N_C indicates the number of bits onto the (*i* – NSCus) th upstream carrier in NEXT_C symbols; g_i of Bitmap-N_C indicates the scale factor that shall be applied to the (*i* – NSCus) th upstream carrier in NEXT_C symbols.

Because no bits or energy will be transmitted at DC or one-half the sampling rate, b_0 , g_0 , b_{NSCus} , g_{NSCus} , $b_{2*NSCus}$, and $g_{2*NSCus}$ are all presumed to be zero and shall not be transmitted.

Each b_i shall be represented as an unsigned 5-bit integer, with valid b_i s lying in the range of zero to N_{upmax} , the maximum number of bits that the ATU-R is prepared to modulate onto any subcarrier, which is communicated in R-MSG1.

Each g_i shall be represented as an unsigned 11-bit fixed-point quantity, with the binary point assumed just to the right of the third most significant bit. For example, a g_i with binary representation (most significant bit listed first)

 001.01000000_2 would instruct the ATU-R to scale the constellation for carrier *i*, by a gain factor of 1.25, so that the power in that carrier shall be 1.94 dB higher than it was during R-MEDLEY.

For subcarriers on which no data are to be transmitted, and the receiver will never allocate bits (e.g. out-of-band subcarriers) both b_i and g_i shall be set to zero (00000₂ and 00000000 000₂, respectively). For subcarriers on which no data are to be currently transmitted, but the receiver may allocate bits later (e.g. as a result of an SNR improvement), the b_i shall be set to zero and the g_i to a value in the 0.19 to 1.33 range (000.00110000₂ to 001.0101010₁).

Let NSCu=128, except when EU-32 is used where NSCu=32. The C-B&G information shall be mapped in a 32*(NSCu-1)-bit (4*(NSCu-1) byte, the same number of FEXT_R symbols. When NSCu=32, including C_CRC5, the total length is 336 symbols while for NSCu=128, the total length is 336+3*345=1371 symbols) message *m* defined by:

 $m = \{m_{32}*(\text{NSCu-1})-1, m_{32}*(\text{NSCu-1})-2, \dots, m_1, m_0\} = \{g_2*\text{NSCu-1}, b_2*\text{NSCu-1}, \dots, g_{\text{NSCu+1}}, b_{\text{NSCu+1}}, g_{\text{NSCu-1}}, \dots, g_1, b_1\},$ (C.10-2)

with the MSB of b_i and g_i in the higher *m* index and m_0 being transmitted first. The message *m* shall be transmitted in 4*(NSCu-1) symbols, using the transmission method as described in 10.8.9.

When Bitmap-N_C is disabled (FEXT Bitmap mode), b_i and g_i of Bitmap-N_C shall be set to zero. For index between NSCus+1 and 127, the m values are set to 0.

C.7.9.3 C-SEGUE3 (replaces 10.8.16)

The duration of C-SEGUE3 is 18 symbols. Following C-SEGUE3, the ATU-C completes the initialization and enters C-SHOWTIME. In C-SHOWTIME, ATU-C shall transmit the signal using Bitmap- F_R and Bitmap- N_R with the sliding window.

When Bitmap-N_R is disabled (FEXT Bitmap mode), for modems not using any of the profiles defined in C.3.4 and modems using Profile 1, the ATU-C shall transmit only the pilot tone as NEXT_R symbols. For Profile 3, the ATU-C shall not transmit any signal in NEXT_R symbols.

C.7.10 Exchange – ATU-R (supplements 10.9)

ATU-R shall transmit only the FEXT_{C} symbols in R-MSGn, R-RATESn, R-B&G, R-CRCn. In other signals, the ATU-R shall transmit both FEXT_{C} and NEXT_{C} symbols when Bitmap-N_C is enabled (Dual Bitmap mode) and shall not transmit NEXT_{C} symbols when Bitmap-N_C is disabled (FEXT Bitmap mode). The duration of each state is defined in Figure C.22.

C.7.10.1 R-MSG-RA (supplements 10.9.2)

Replace Table 10-15 with Table C.7.

Suffix(ces) of m _i (Note)	Parameter All reserved bits shall be set to 0	
, ,	Deserved for ITLLT	
79-68	Reserved for ITU-T	
67-56	B _{fast-max}	
55-49	Number of RS overhead bytes, (R)	
48-40	Number of RS payload bytes, K	
39-32	Number of tones carrying data (ncloaded)	
31-25	Estimated average loop attenuation	
24-21	Coding gain	
20-16	Performance margin with selected rate option	
15-14	Reserved for ITU-T	
13-12	Maximum Interleave Depth downstream	
11-0	Total number of bits per DMT symbol, B _{max}	
NOTE – Within the sep	OTE – Within the separate fields the least significant bits have the lowest subscripts.	

C.7.10.1.1 Total number of bits supported (B_{max}) (replaces 10.9.2.8)

This parameter shall be defined as in R-MSG2, see C.7.9.1.

C.7.10.1.2 B_{fast-max} (new)

 $B_{fast-max}$ is the maximum number of bits of the fast buffer for fast data transmitted on the condition that the bits of the fast data can be equally assigned to all FEXT-symbols and NEXT-symbols.

Fast Buffered Data B_{fast-max} is t_f.

C.7.10.2 R-MSG2 (supplements 10.9.8)

 $N_{1R-MSG2} = 10$ $N_{2R-MSG2} = 20$

C.7.10.2.1 Total number of bits per symbol supported (supplements 10.9.8.3)

The maximum number of bits per symbol is defined at the reference point B, that is calculated from the FEXT_R and NEXT_R downstream channel performance. For example, if the maximum numbers of bits that can be supported in FEXT_R and NEXT_R symbols are 111 and 88, the total number of bits per symbol supported is (111 x 126 + 88 x 214)/340 = 96.

NOTE – The number of symbols per hyperframe is 340, the number of FEXT symbols is 126, and the number of NEXT symbols is 214.

C.7.10.3 R-REVERB5 (supplement of 10.9.12)

The duration of R-REVERB5 is 345n-40, 3<=n<=19, when NSCu=128, or 3<=n<=16 when NSCu=32.

C.7.10.4 R-B&G (replaces 10.9.14)

The purpose of R-B&G is to transmit to ATU-C the bits and gains information, Bitmap-F_R { b_1 , g_1 , b_2 , g_2 , ..., b_{255} , g_{255} , and Bitmap-N_R { b_{257} , g_{257} , b_{258} , g_{258} , ..., b_{511} , g_{511} }, to be used on the downstream subcarriers. b_i of Bitmap- F_R indicates the number of bits to be coded by ATU-C transmitter onto the *i* th downstream subcarrier in FEXT_R symbols; g_i of Bitmap-F_R indicates the scale factor that shall be applied to the *i* th downstream subcarrier in FEXT_R symbols, relative to the gain that was used for that carrier during the transmission of C-MEDLEY. Similarly, b_i of Bitmap-N_R indicates the number of bits onto the (i-256) th downstream carrier in NEXT_R symbols; g_i of Bitmap-N_R indicates the scale factor that shall be applied to the (i - 256) th downstream carrier in NEXT_R symbols. Because no bits or energy will be transmitted at DC or one-half the sampling rate, b_0 , g_0 , b_{256} , g_{256} , b_{512} , and g_{512} are all presumed to be zero, and are not transmitted. When subcarrier 128 is reserved as the pilot tone, b_{128} and b_{384} shall be set to 0, and, for modems not using any of the profiles defined in §C.3.4 and modems using Profiles 1, 2, 4, 5 or 6, g_{128} and g_{384} shall be set to g_{sync} . For Profile 3, g_{128} shall be set to g_{sync} and g_{384} shall be set to 0. When subcarrier 96 is reserved as the pilot tone, b_{96} and b_{352} shall be set to 0, and, for modems not using any of the profiles defined in §C.3.4 and modems using Profiles 1, 2, 4, 5 or 6, g96 and g352 shall be set to gsync. For Profile 3, g96 shall be set to g_{sync} and g_{352} shall be set to 0. When subcarrier 64 is reserved as the pilot tone, b_{64} and b_{320} shall be set to 0, and, for modems not using any of the profiles defined in §C.3.4 and modems using Profiles 1, 2, 4, 5 or 6, g₆₄ and g_{320} shall be set to g_{sync} . For Profile 3, g_{64} shall be set to g_{sync} and g_{320} shall be set to 0. When subcarrier 48 is reserved as the pilot tone, b_{48} and b_{304} , shall be set to 0, and, for modems not using any of the profiles defined in C.3.4 and modems using Profiles 1, 2, 4, 5 or 6, g_{48} and g_{304} shall be set to g_{sync} . For Profile 3, g_{48} shall be set to g_{sync} and g_{304} shall be set to 0. When subcarrier 32 is reserved as the pilot tone, b_{32} and b_{288} , shall be set to 0, and, for modems not using any of the profiles defined in §C.3.4 and modems using Profiles 1, 2, 4, 5 or 6, g₃₂ and g₂₈₈ shall be set to g_{sync} . For Profile 3, g_{32} shall be set to g_{sync} and g_{288} shall be set to 0. When subcarrier 16 is reserved as the pilot tone, b_{16} and b_{272} , shall be set to 0, and, for modems not using any of the profiles defined in §C.3.4 and modems using Profiles 1, 2, 4, 5 or 6, g_{16} and g_{272} shall be set to g_{sync} . For Profile 3, g_{16} shall be set to g_{sync} and g_{272} shall be set to 0. The value g_{sync} represents the gain scaling applied to the sync symbol.

The R-B&G information shall be mapped in a 8160-bit (1020 byte) message *m* defined by:

$$m = \{m_{8159}, m_{8158}, \dots, m_1, m_0\} = \{g_{511}, b_{511}, \dots, g_{257}, b_{257}, g_{255}, b_{255}, \dots, g_1, b_1\},$$
(C.10-3)

with the MSB of b_i and g_i in the higher *m* index and m_0 being transmitted first. The message *m* shall be transmitted in 1020 symbols, using the transmission method as described in 10.9.8.

When Bitmap-N_R is disabled (FEXT Bitmap mode), b_i and g_i of Bitmap-N_R shall be set to zero.

C.7.10.5 R-SEGUE5 (replaces 10.9.17)

The duration of R-SEGUE5 is 13 symbols. Following R-SEGUE-5, ATU-R completes the initialization and enters R-SHOWTIME. In R-SHOWTIME, ATU-R shall transmit the signal using Bitmap- F_C and Bitmap- N_C with the sliding window.

When Bitmap-N_C is disabled (FEXT Bitmap mode), ATU-R shall not transmit NEXT_C symbols.

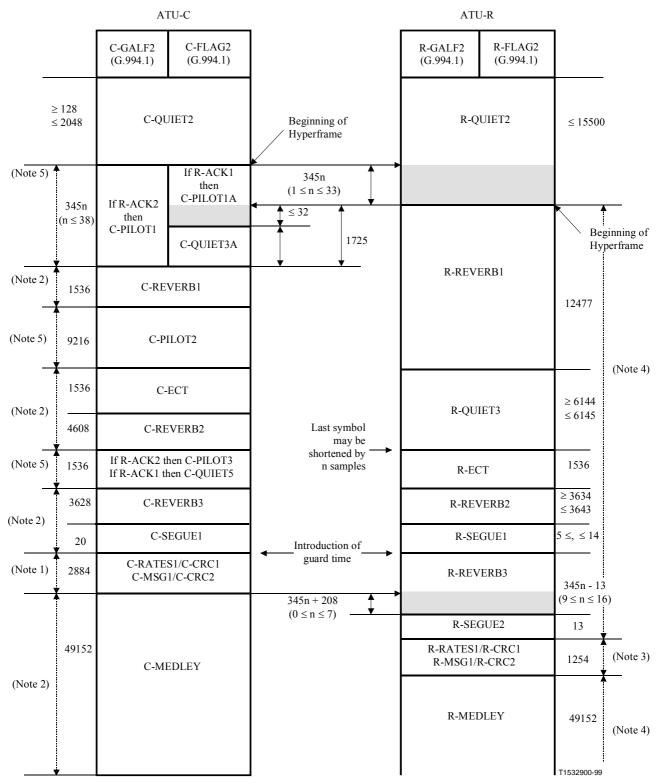
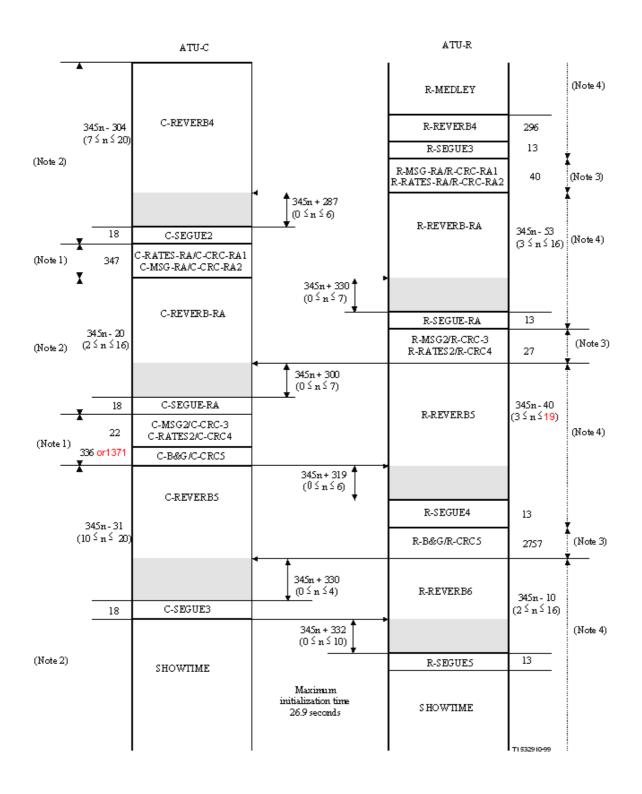


Figure C.21/G.992.1 – Timing diagram of the initialization sequence – Part 1



NOTE 1 – The ATU-C shall transmit the FEXTR symbols, and shall not transmit as NEXTR symbols except the pilot tone.

NOTE 2 – The ATU-C shall transmit both FEXTR and NEXTR symbols, when Bitmap-NR is enabled (Dual Bitmap mode).

ATU-C shall not transmit the NEXTR symbols except pilot tone, when Bitmap-NR is disabled (FEXT Bitmap mode).

NOTE 3 – The ATU-R shall transmit the FEXTC symbols, and shall not transmit the NEXTC symbols.

NOTE 4 – The ATU-R shall transmit both FEXTC symbols, when Bitmap-NC is enabled (Dual Bitmap mode). ATU-R shall

not transmit NEXTC symbols, when Bitmap-NC is disabled (FEXT Bitmap mode).

NOTE 5 – The ATU-C shall transmit both FEXTR and NEXTR symbols.

Figure C.22/G.992.1 – Timing diagram of the initialization sequence – Part 2

[Editor's note: updated Figure C.22 to parameterize the length of C-B&G and the maximum length of R-REVERB5.]

C.8 AOC On-line adaptation and reconfiguration (pertains to clause 11)

C.8.1.1 Bit swap request (replaces 11.2.3)

The receiver shall initiate a bit swap by sending a bit swap request to the transmitter via the AOC channel. This request tells the transmitter which subcarriers are to be modified. The format of the request is shown in Table C.8.

Message header	Message field 1-4		
{111111112}	Bitmap index	Command	Subchannel index
(8 bits)	(1 bit)	(7 bits)	(8 bits)

Table C.8/G.992.1 – Format of the bit swap request message

The request shall comprise nine bytes as follows:

- an AOC message header consisting of 8 binary ones;
- message fields 1-4, each of which consists of one-bit bitmap index, a seven-bit command followed by a related eight-bit subchannel index. One-bit bitmap index and valid seven-bit commands for the bit swap message shall be as shown in Table C.9. In Table C.9, the MSB for the bit swap request command represents the Bitmap index. For downstream data, Bitmap index equals 0 indicates Bitmap- F_R , and Bitmap index equals 1 indicates Bitmap- N_R . Similarly for upstream data, Bitmap index equals 0 indicates Bitmap- F_C , and 1 indicates Bitmap- N_C . The eight-bit subchannel index is counted from low to high frequencies with the lowest frequency subcarrier having the number zero. The subcarrier index zero shall not be used;
- the bit swap between FEXT_{C/R} symbols and NEXT_{C/R} symbols is not allowed.

Value (8 bit)	Interpretation		
y00000002	Do nothing		
y00000012	Increase the number of allocated bits by one		
y00000102	Decrease the number of allocated bits by one		
y00000112	Increase the transmitted power by 1 dB		
y00001002	Increase the transmitted power by 2 dB		
y00001012	Increase the transmitted power by 3 dB		
y00001102	Reduce the transmitted power by 1 dB		
y00001112	Reduce the transmitted power by 2 dB		
y0001xxx2	Reserved for vendor discretionary commands		
NOTE – y is "0" for FEXT _{C/R} symbols, and "1" for NEXT _{C/R} symbols of the Sliding Window.			

Table C.9/G.992.1 – Bit swap request command

The bit swap request message (i.e. header and message fields) shall be transmitted five consecutive times.

To avoid g_i divergence between ATU-C and ATU-R after several bit swaps, for a g_i update of Δ dB the new g_i value should be given by:

$$g_i' = (1/512) \times round(512 \times g_i \times 10 \exp(\Delta/20))$$
 (C.11-1)

C.8.1.2 Extended bit swap request (supplements 11.2.4)

The format of the extended bit swap request is shown in Table C.10.

Message header	Message field 1-6		
{11111100 ₂ }	Bitmap index	Command	Subchannel index
(8 bits)	(1 bit)	(7 bits)	(8 bits)

Table C.10/G.992.1 – Format of the bit swap request message

In the same manner as the bit swap request, each of the massage fields of the extended bit swap request consists of one-bit bitmap index, a seven-bit command followed by a related eight-bit subchannel index.

C.8.1.3 Bit swap acknowledge (supplements 11.2.5)

The bit swap superframe counter number shall only indicate the last superframe (SPF#4) of a hyperframe. The new bit and/or transmit power table(s) shall then take effect starting from the first frame (frame 0) of SPF#0 of a hyperframe.

If the bit swap superframe counter number contained in the received bit swap acknowledge message does not indicate SPF#4, then the new table(s) shall take effect starting from frame 0 of SPF#0 of the next hyperframe.