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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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改版履歴

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 （周波数帯域：25kHz～483kHz） ・長延化 （下りPSD mask：-28.5dBm/Hz peak）

付属資料について

付属資料番号 （ページ）	サービス化	下り信号 使用帯域	上り信号		過去の技術開示資料 との関係
			使用帯域	ｼｪｲﾋﾟﾝｸﾞ	
1 （P5-P62）	済 （モアⅡ40M）	138k～3.75MHz	25k～138kHz	なし	1、2版からの変更なし
2 （P63-P128）	未定	25k～3.75MHz	25k～276kHz	なし	2版の更新
3 （P129-P197）	〃	25k～3.75MHz	25k～414Hz	あり	新規
4 （P198-P266）	〃	25k～3.75MHz	25k～483kHz	なし	新規
5 （P267-P332）	〃	25k～2.2MHz	25k～276kHz	なし	2版の更新
6 （P333-P401）	〃	25k～2.2MHz	25k～414kHz	あり	新規
7 （P402-P464）	〃	25k～1.1MHz （長延化方式を含む）	25k～276kHz	なし	新規

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 → increased number of subcarriers, NSC=1024 (used subcarriers up to 869)
- Increased bit loading, beyond 15 bits/bin
- Extended framing → 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.

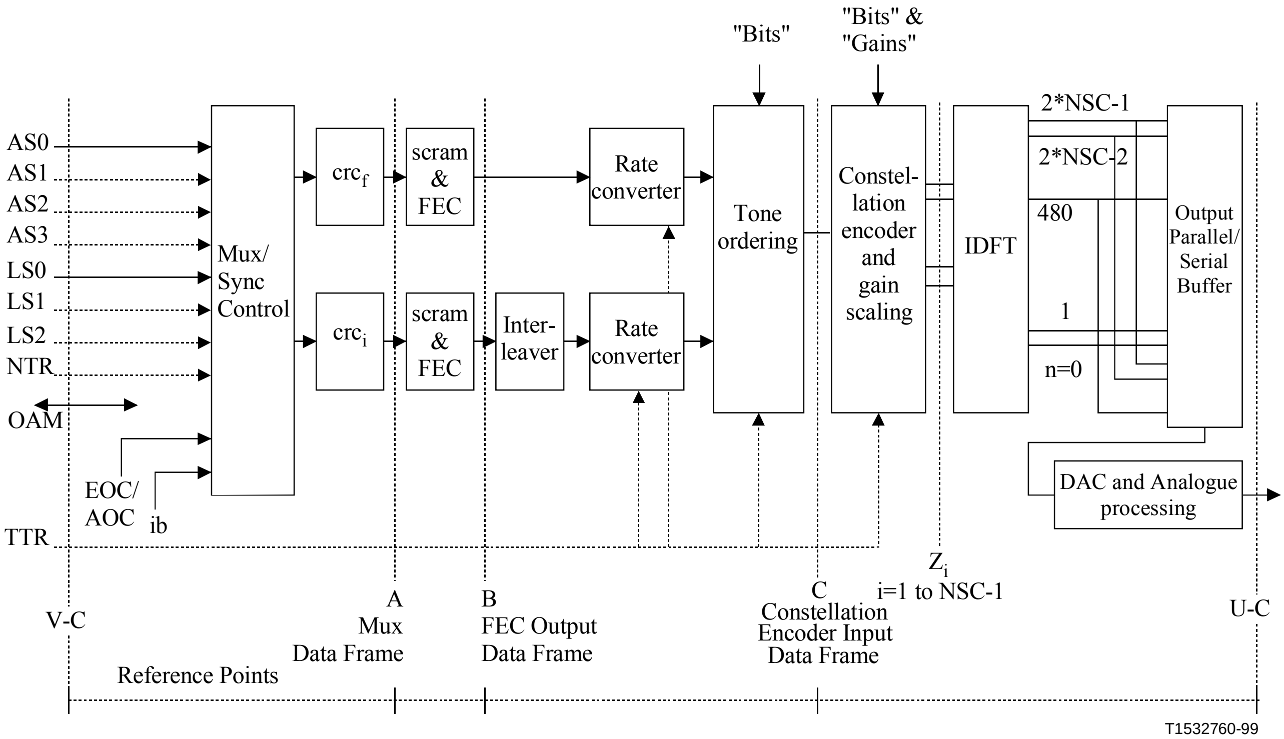
Q.2 Definitions

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	The Dual Bitmap method has dual bit rates under the FEXT and NEXT noise from TCM-ISDN
FEXT Bitmap	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	5 Superframes structure which synchronized TTR
$NEXT_C$ duration	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	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.
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

Q.3 Reference Models

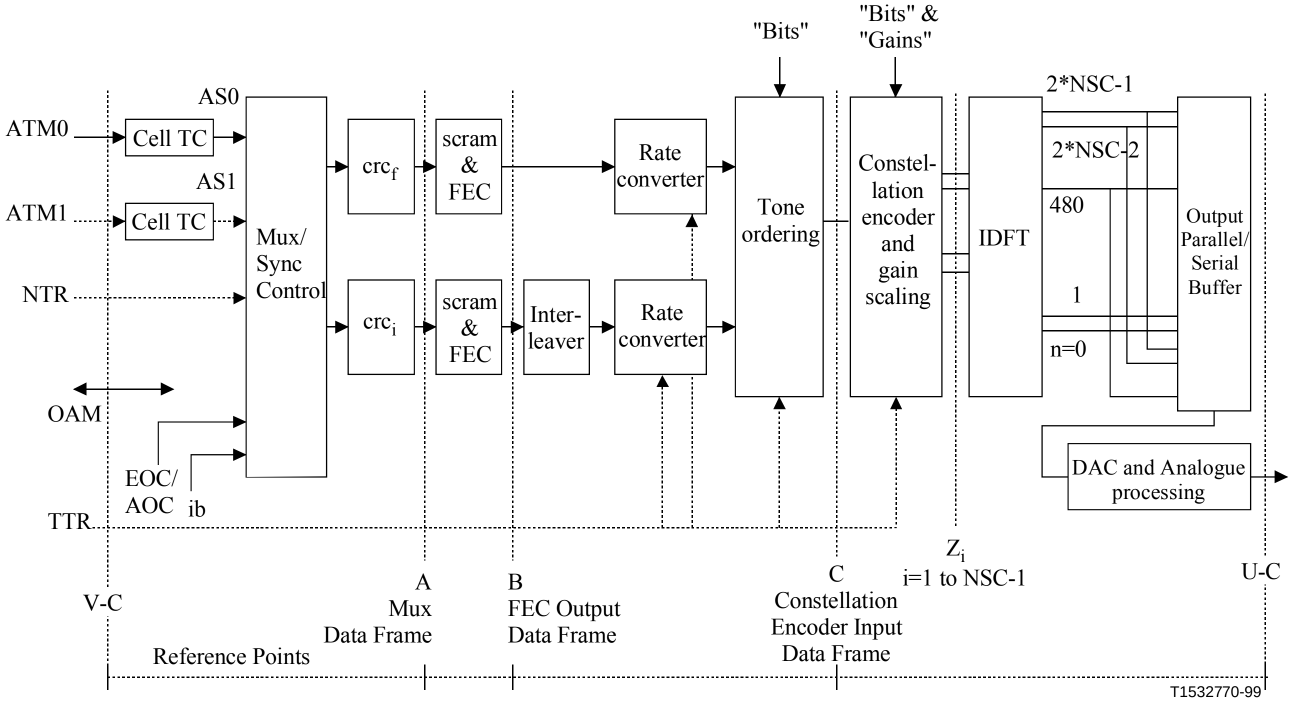
Q.3.1 ATU-C transmitter reference model (replaces figures in 5.1)

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

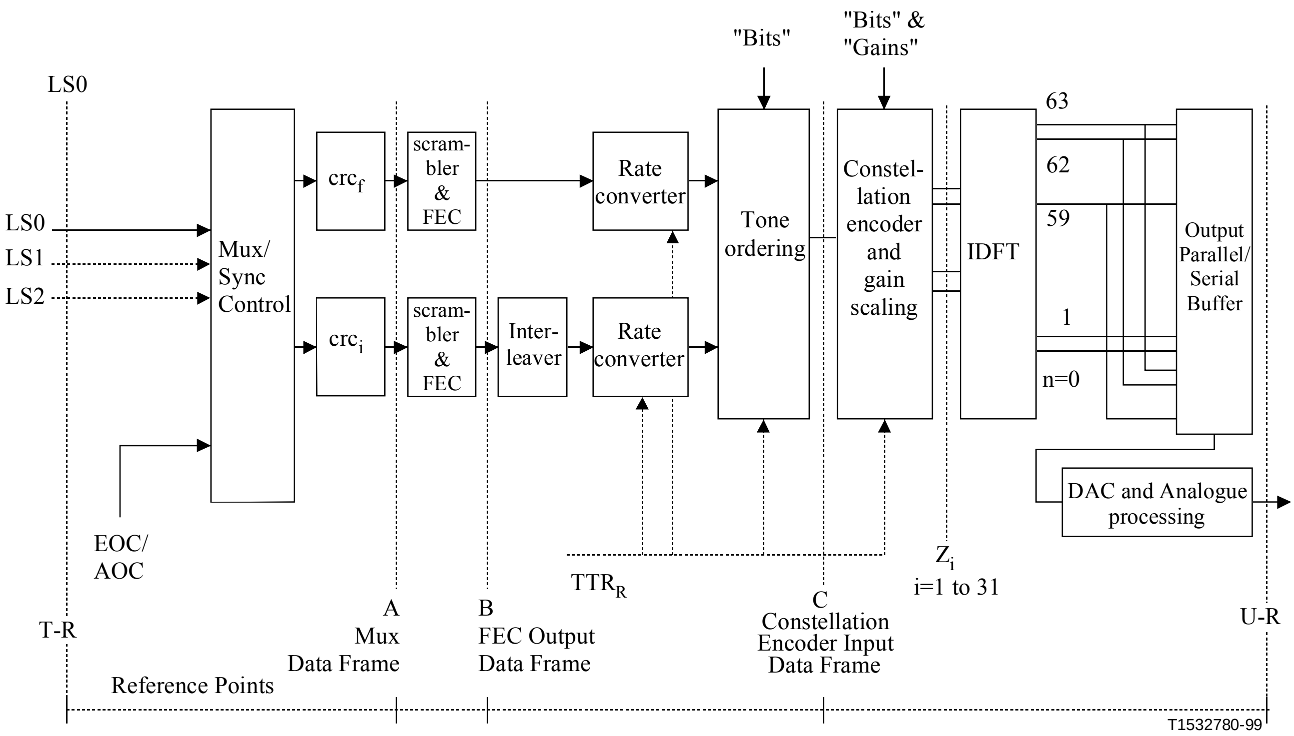


NOTE – The TTR may be generated in ATU-C without being provided from the TCM-ISDN clock.

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

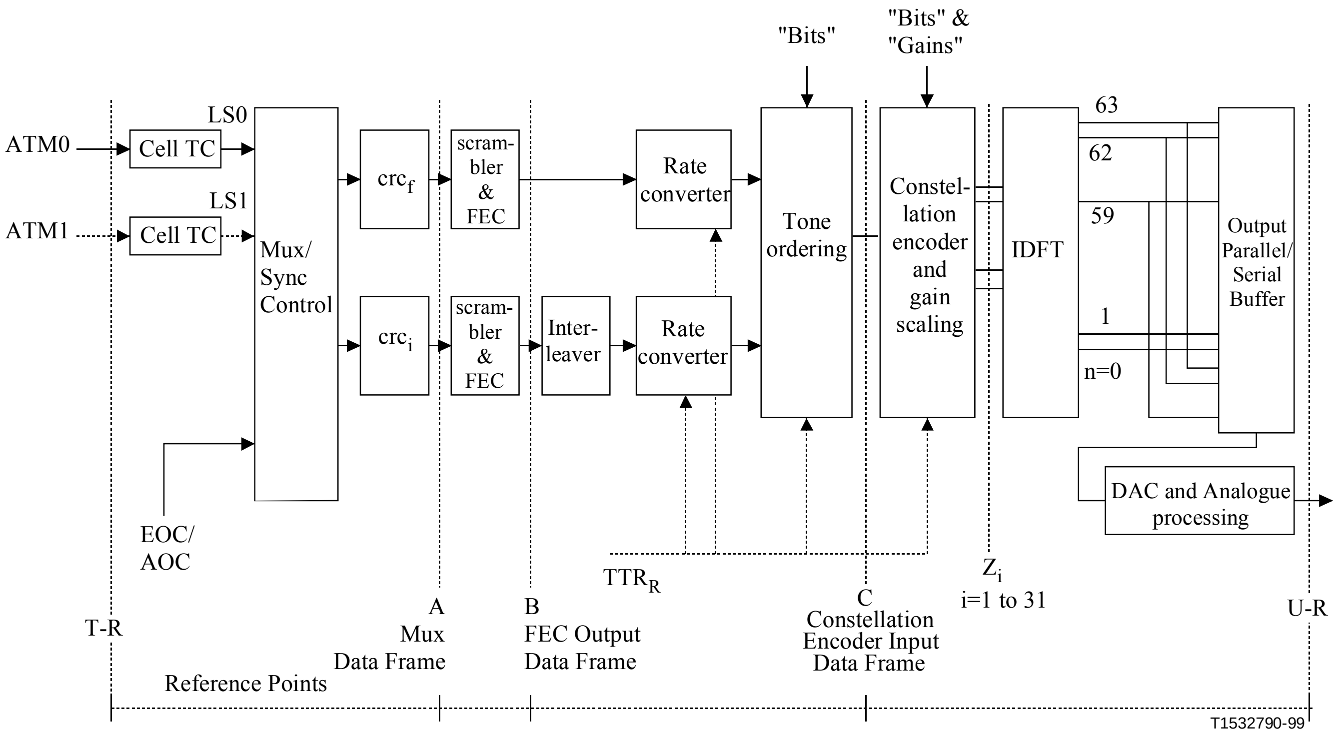
Q.3.2 ATU-R transmitter reference model (replaces figures in 5.2)

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



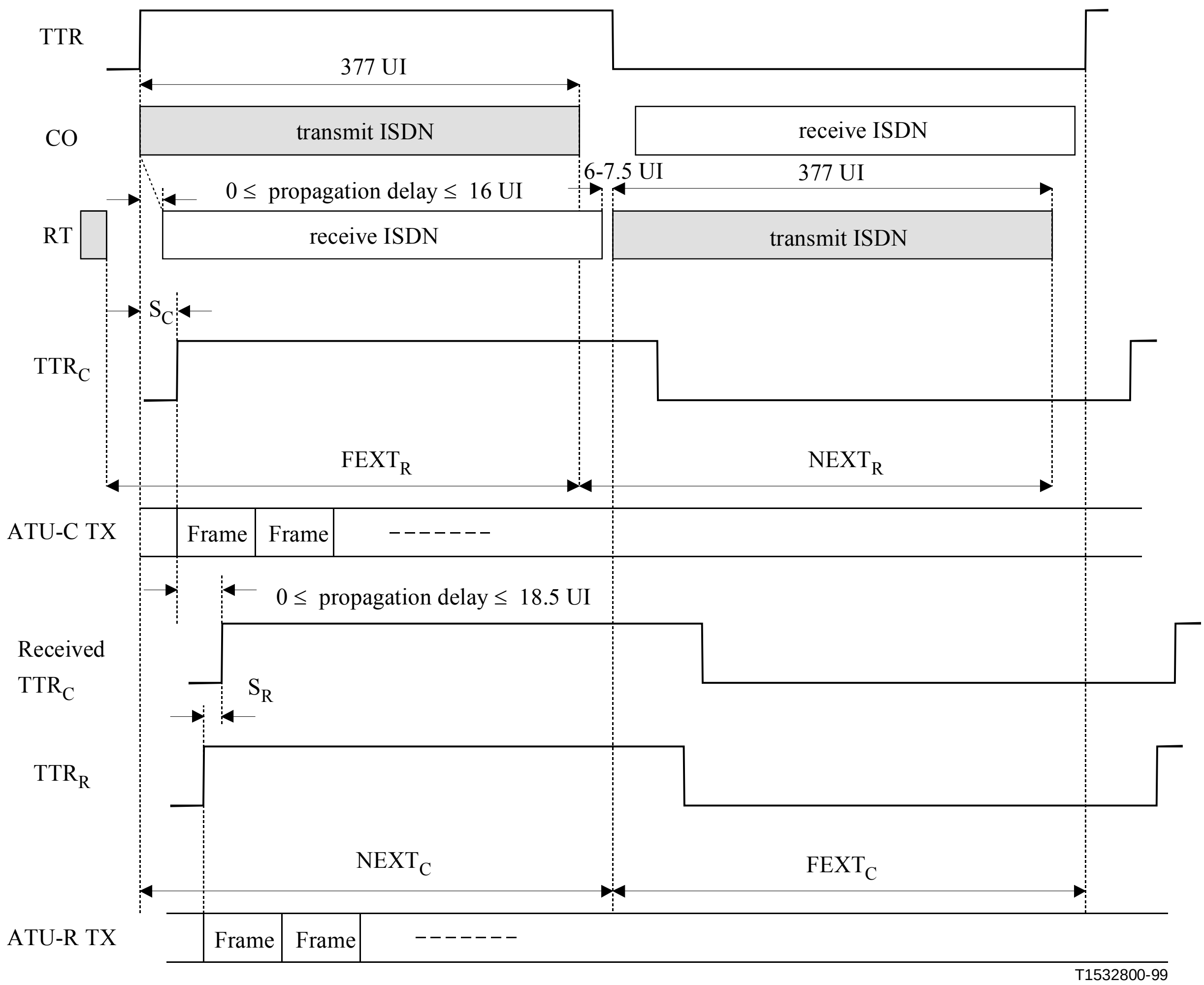
NOTE – The TTR$_R$ shall be generated in ATU-R from the received TTR$_C$ signal, and it is locked to 690 periods of upstream sampling clock (276 kHz).

Figure Q.4/G.992.1 – ATU-R transmitter reference model for ATM transport

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.



1 UI = 3.125 µs

$FEXT_R$ and **$NEXT_R$** are estimated by ATU-C

$FEXT_C$ and **$NEXT_C$** are estimated by ATU-R

TTR	TCM-ISDN timing reference
TTR_C	Timing reference used in ATU-C
Received TTR_C	Received TTR_C at ATU-R
TTR_R	Timing reference used in ATU-R
S_C	55 × 0.9058 µs: Offset from TTR to TTR_C
S_R	–42 × 0.9058 µs: Offset from received TTR_C to TTR_R

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.

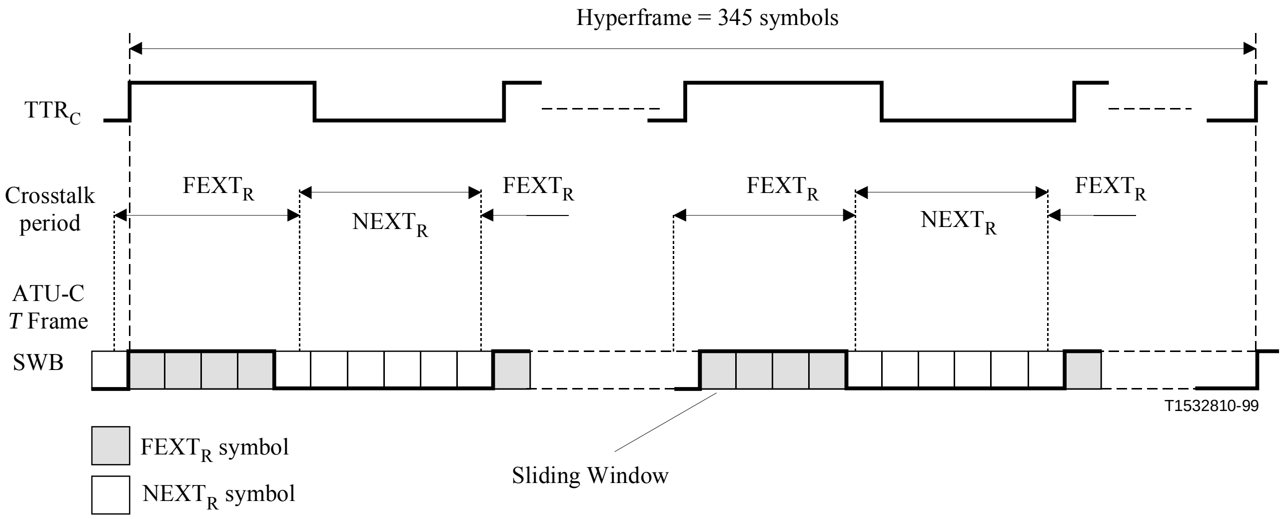


Figure Q.6/G.992.1 – Sliding window for downstream symbols

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

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.

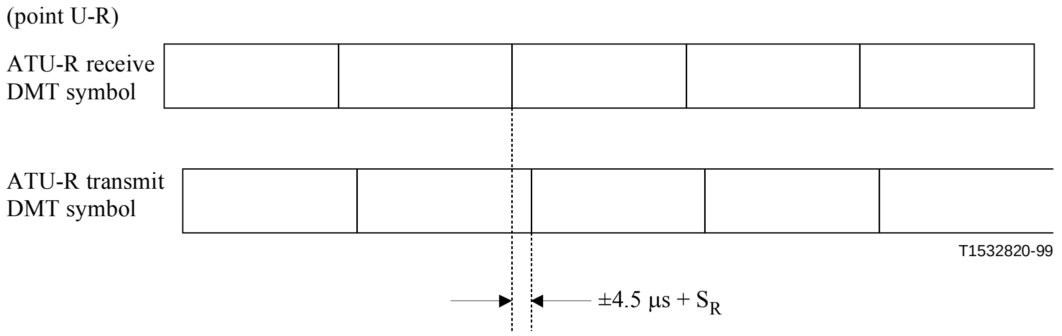


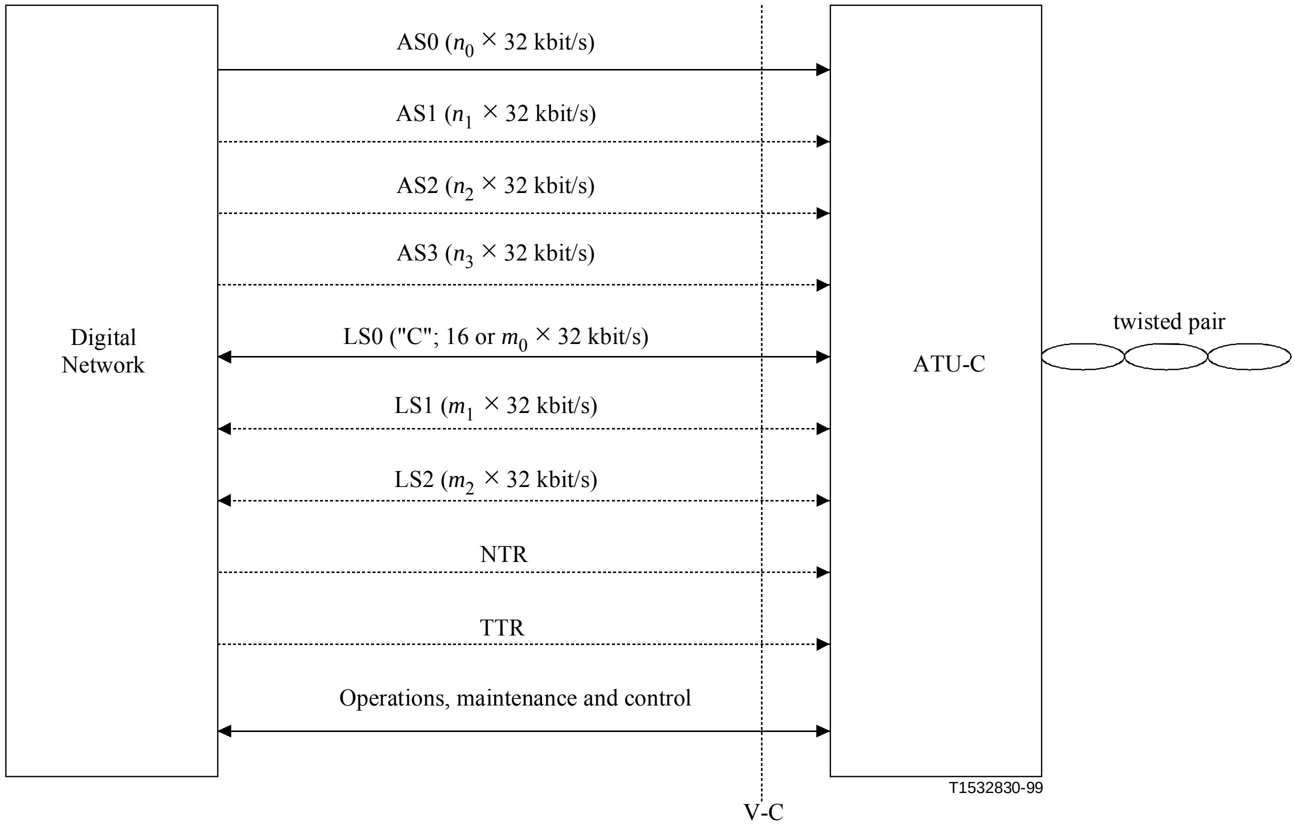
Figure Q.7/G.992.1 – Loop timing for ATU-R

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

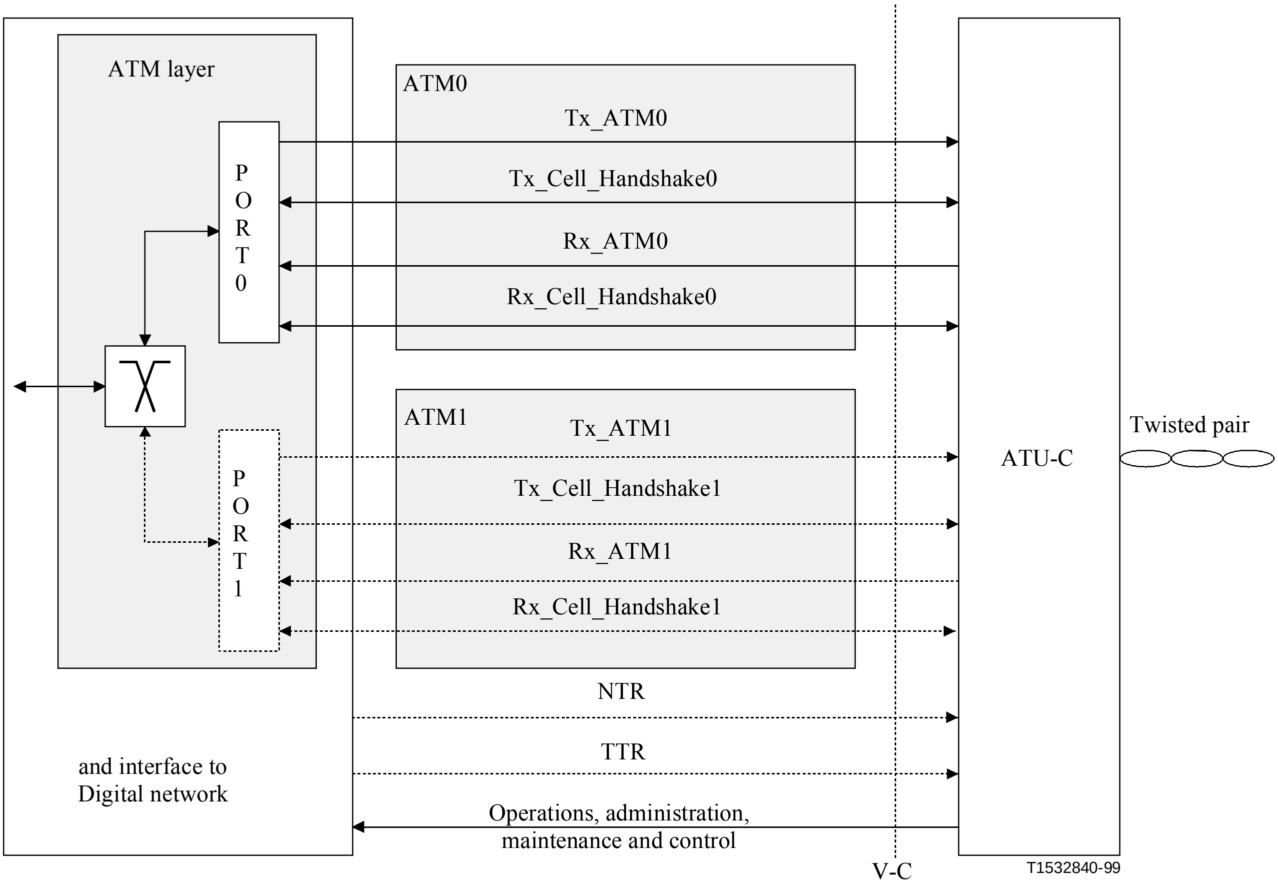
Q.4.1.2 Payload transfer delay (supplements 7.1.4)

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 $NEXT_R$ symbol in a $FEXT_R$ 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).

For $N_{dmt} = 0, 1, ..., 344$

$S = 272 \times N_{dmt} \bmod 2760$

if { (S + 271 < a) 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.

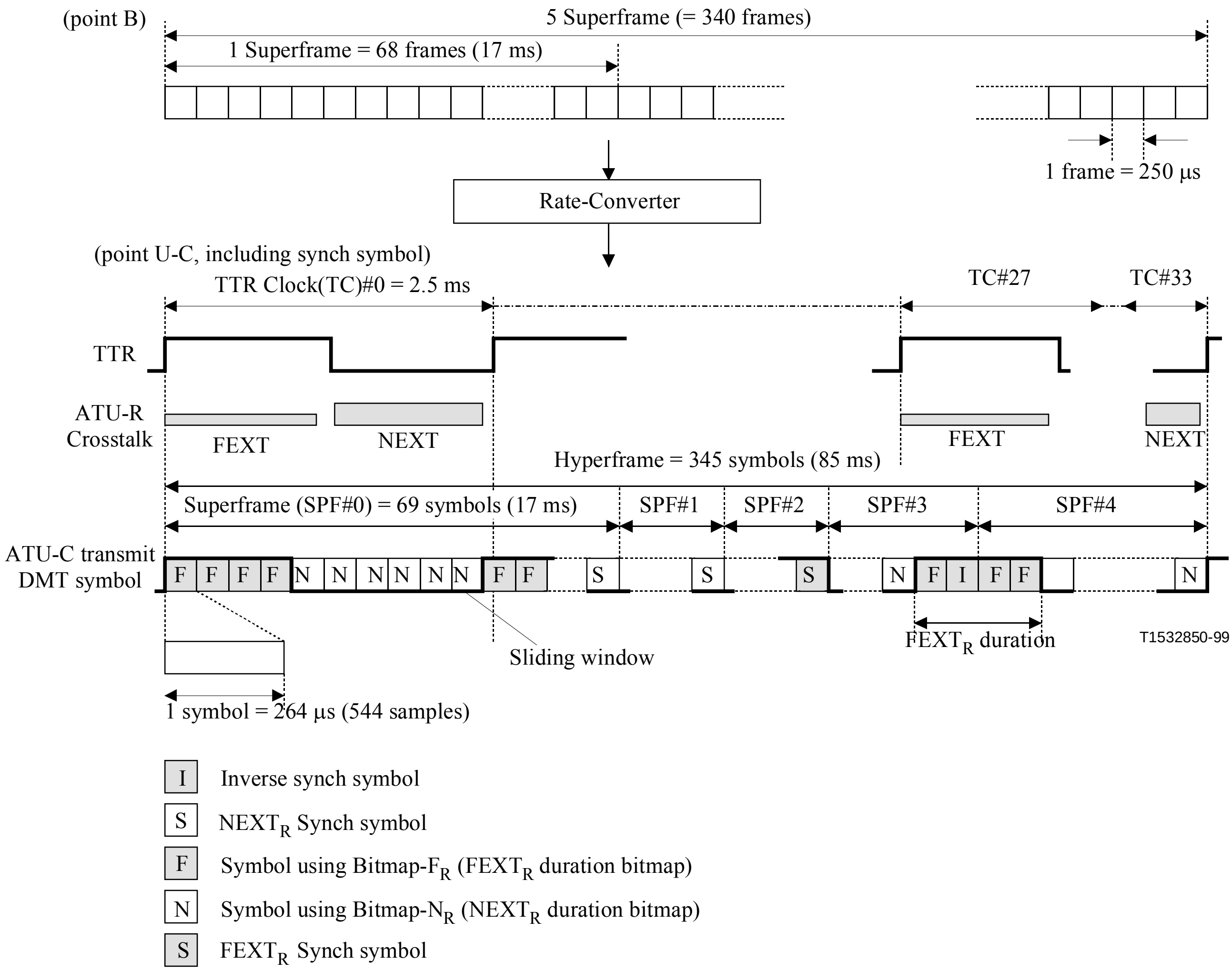


Figure Q.10/G.992.1 – Hyperframe structure for downstream

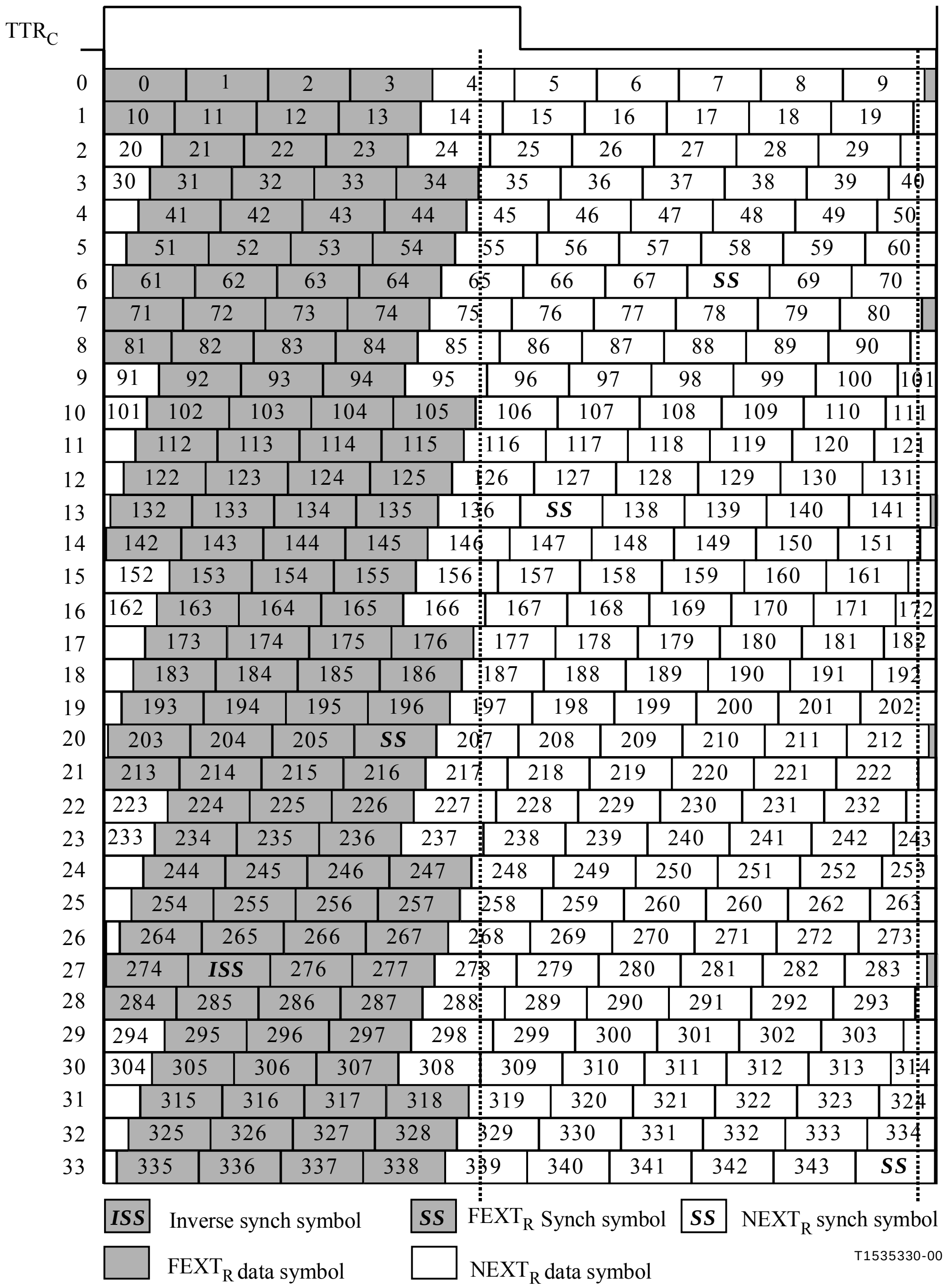


Figure Q.11/G.992.1 – Symbol pattern in a hyperframe with cyclic prefix – Downstream

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.

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

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

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 $t_{Rf} \le n_{R\max}$:

$$n_{Rf} = t_{Rf}$$
$$n_{Ri} = n_R - n_{Rf}$$
$$f_{Rf} = t_{Rf}$$
$$f_{Ri} = f_R - f_{Rf}$$

If $t_{Rf} > n_{R\max}$:

$$n_{Rf} = n_{R\max}$$
$$n_{Ri} = 0$$
$$f_{Rf} = \begin{cases} f_{Rf4} = \left\lceil \dfrac{t_{Rf} \times 10 - n_{Rf} \times 6}{4} \right\rceil \\ f_{Rf3} = \left\lceil \dfrac{t_{Rf} \times 10 - n_{Rf} \times 7}{3} \right\rceil \end{cases}$$
$$f_{Ri} = \begin{cases} f_{Ri4} = f_R = f_{Rf4} \\ f_{Ri3} = f_R - f_{Rf3} \end{cases}$$

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 for synch symbols.
f_{Rf4}	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.
n_R	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 $t_{Rf} \le n_{R\max}$:

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

If $t_{Rf} > n_{R\max}$:

$$dummy_{Rf\,4} = (f_{Rf} \times 4 + n_{Rf} \times 6) - t_{Rf} \times 10$$
$$dummy_{Rf\,3} = (f_{Rf} \times 3 + n_{Rf} \times 7) - t_{Rf} \times 10$$
$$dummy_{Ri} = (f_{Ri4} \times 96 + f_{Ri3} \times 30) - t_{Ri} \times 340$$

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:

$$dummy_{SRf} = f_{Rf\,3} - f_{Rf\,4}$$

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.

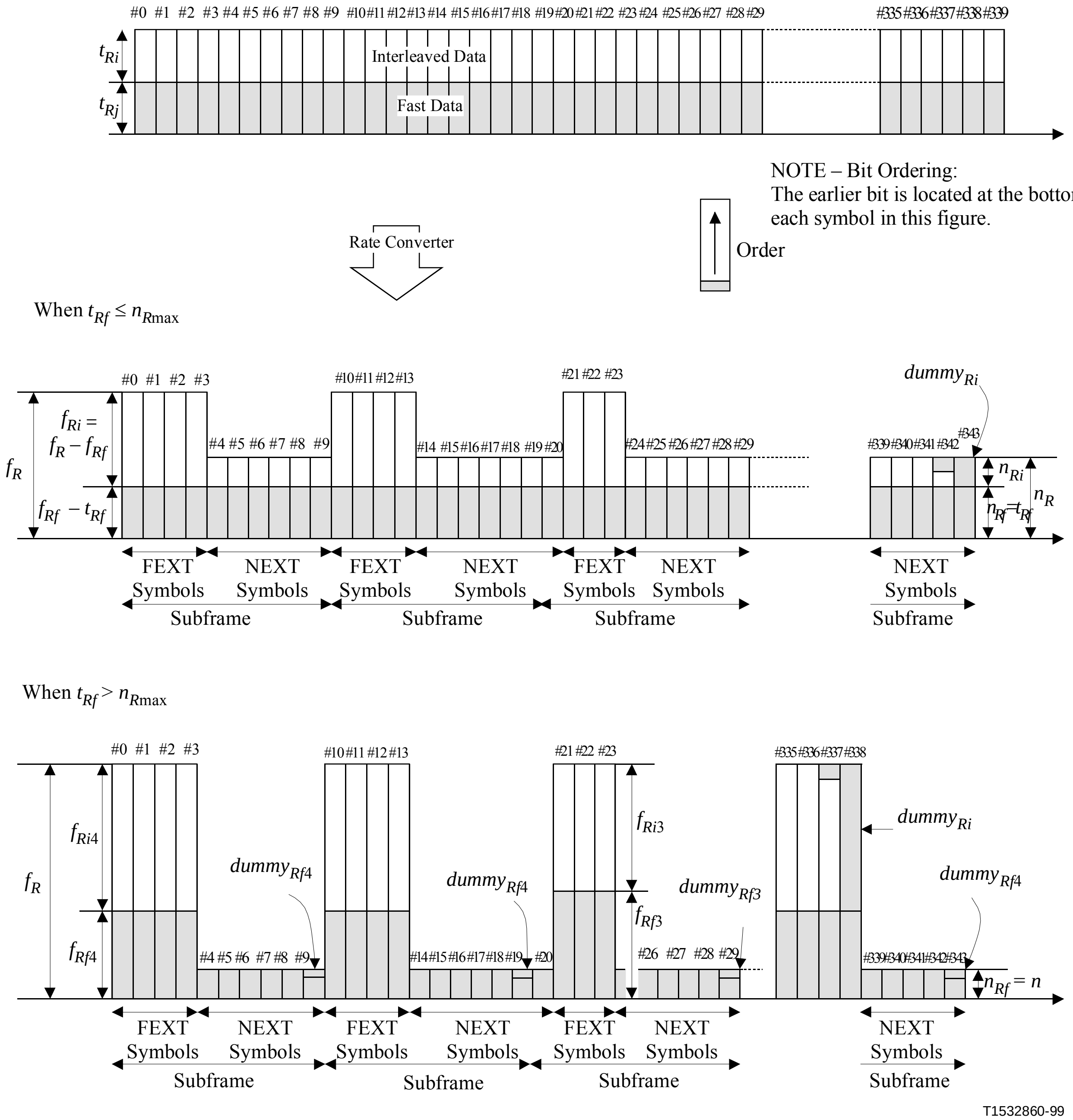


Figure Q.12/G.992.1 – Bit distribution for Rate Converter under Dual latency and Dual Bitmap mode

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:

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

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 = 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, Δf = 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.

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

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,

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

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.

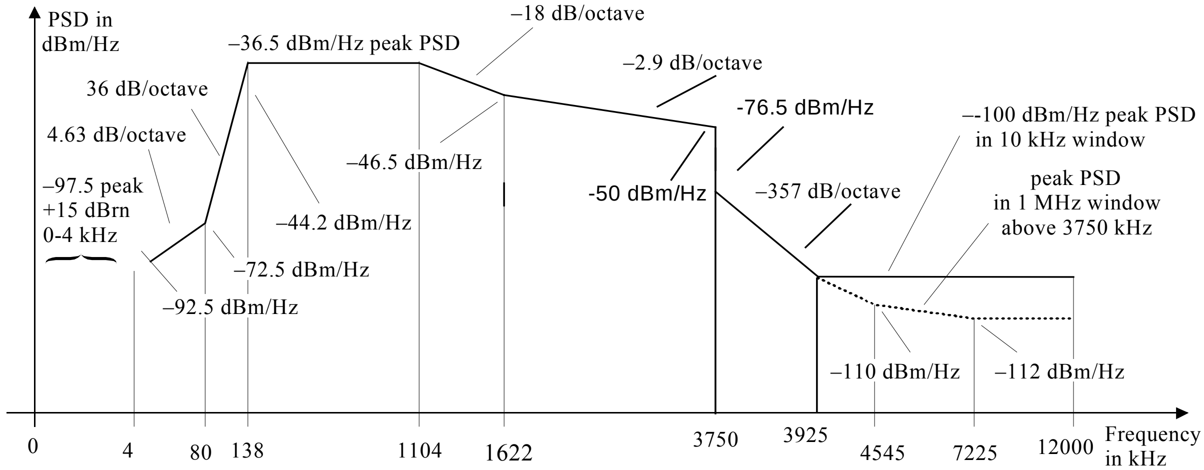
The cyclic prefix shall be used for all symbols beginning with the C-RATES1 segment of the initialization sequence, as defined in 10.6.2.

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.



Frequency band f (kHz)	**Equation for line (dBm/Hz)**
0 < f < 4	-97.5
4 < f < 80	-92.5 + 4.63*log2(f/4)
80 < f < 138	-72.5 + 36*log2(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 ≤ 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:

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

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.

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

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)

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 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 $n \geq 1$, 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.

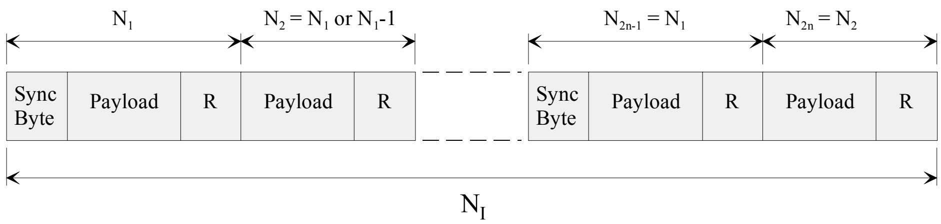


Figure Q.14 – Data frame for S = 1/2n mode

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.

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

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]

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).

For N_{dmt} = 0, 1, …, 344

    $S = 272 \times N_{dmt} \bmod 2760$

    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.

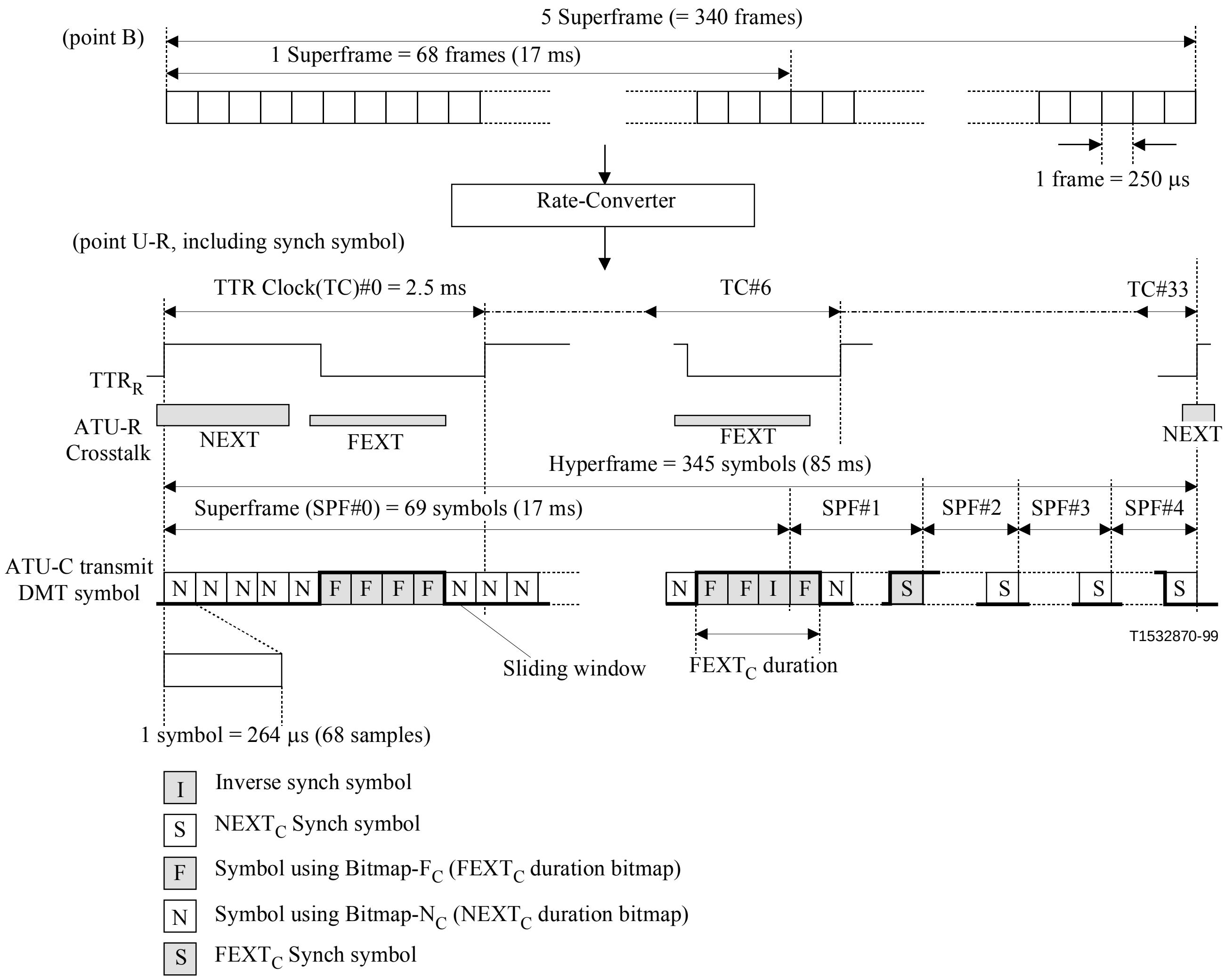


Figure Q.15/G.992.1 – Hyperframe structure for upstream

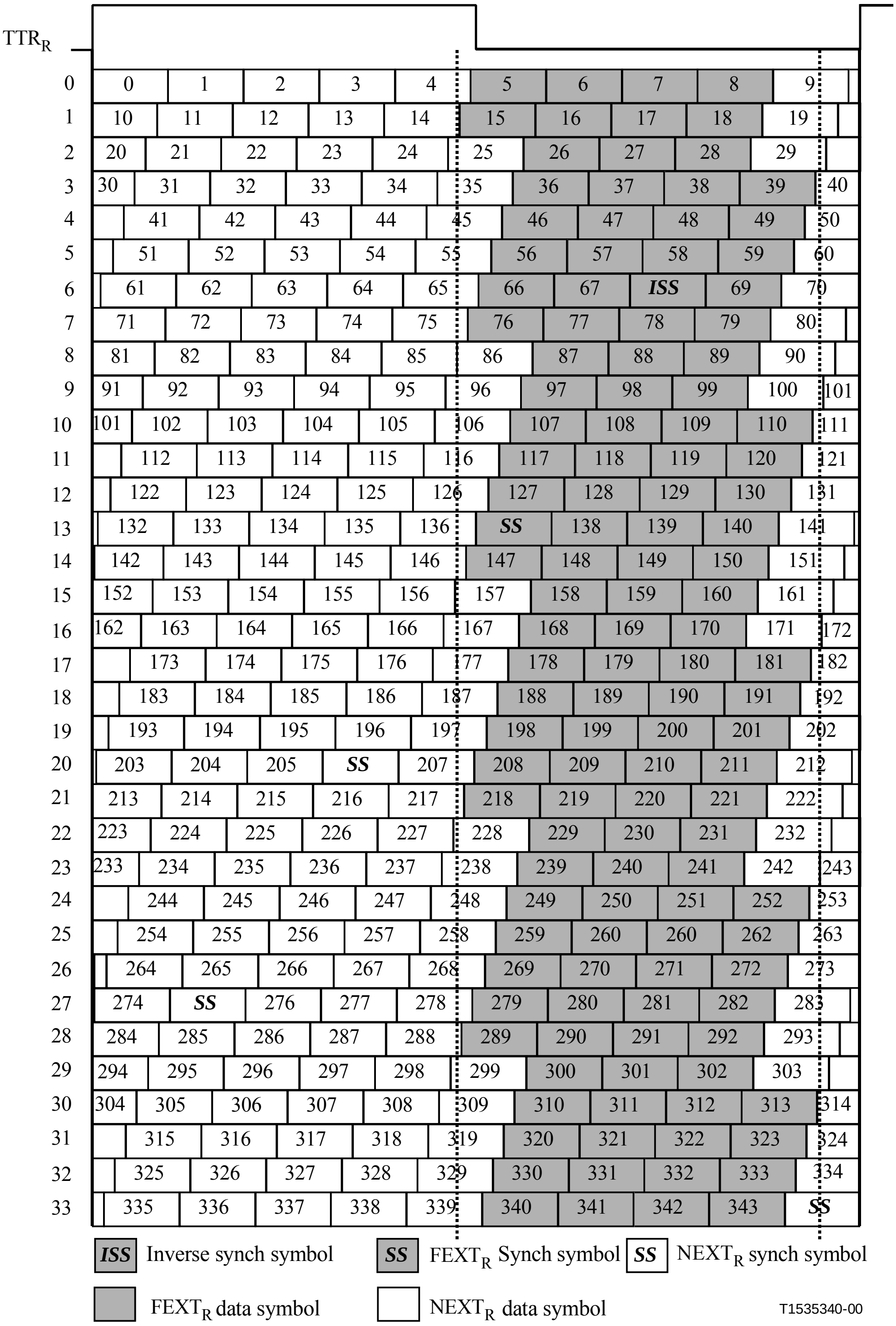


Figure Q.16/G.992.1 – Symbol pattern in a hyperframe with cyclic prefix – Upstream

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.

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

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

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 $t_{Cf} \le n_{C\max}$:

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

If $t_{Cf} > n_{C\max}$:

$$n_{Cf} = n_{C\max}$$
$$n_{Ci} = 0$$
$$f_{Cf} = \begin{cases} f_{Cf4} = \left\lceil \dfrac{t_{Cf} \times 10 - n_{Cf} \times 6}{4} \right\rceil \\ f_{Cf3} = \left\lceil \dfrac{t_{Cf} \times 10 - n_{Cf} \times 7}{3} \right\rceil \end{cases}$$
$$f_{Ci} = \begin{cases} f_{Ci4} = f_C - f_{C4} \\ f_{Ci3} = f_C - f_{Cf3} \end{cases}$$

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 for synch symbols.
f_{Cf4}	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.
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 $t_{Cf} \le n_{C\max}$:

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

If $t_{Cf} > n_{C\max}$:

$$dummy_{Cf4} = \left(f_{Cf} \times 4 + n_{Cf} \times 6\right) - t_{Cf} \times 10$$
$$dummy_{Cf3} = \left(f_{Cf} \times 3 + n_{Cf} \times 7\right) - t_{Cf} \times 10$$
$$dummy_{Ci} = \left(f_{Ci4} \times 96 + f_{Ci3} \times 30\right) - t_{Ci} \times 340$$

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 $+10\log(g_{sync}^2)$ 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.

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-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, …344

S = 256 x 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 Q.18).

For N_{dmt} = 0, 1, …, 344,

S = 256 x 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 x 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 Q.16).

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

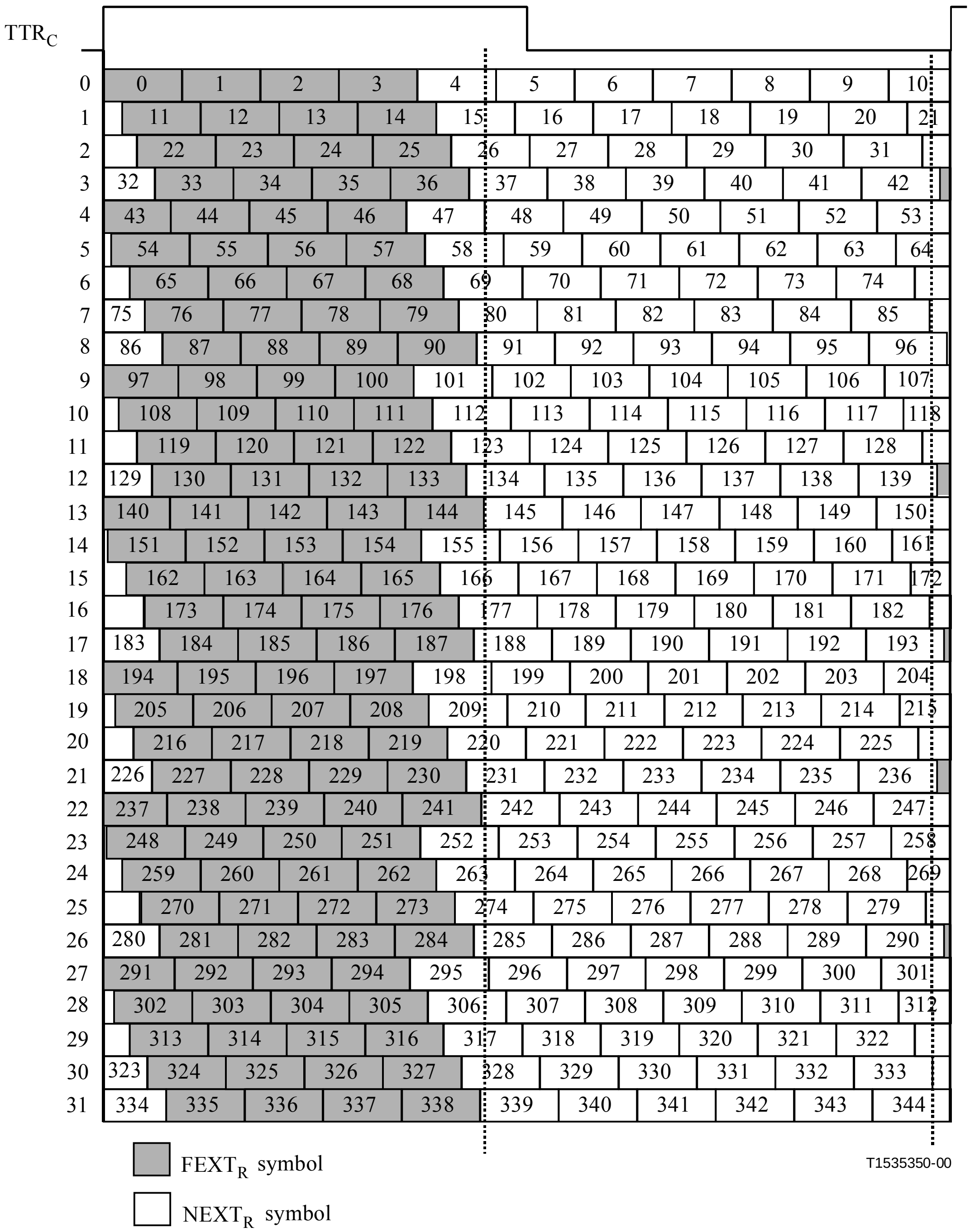


Figure Q.17/G.992.1 – Symbol pattern in a hyperframe without cyclic prefix – Downstream

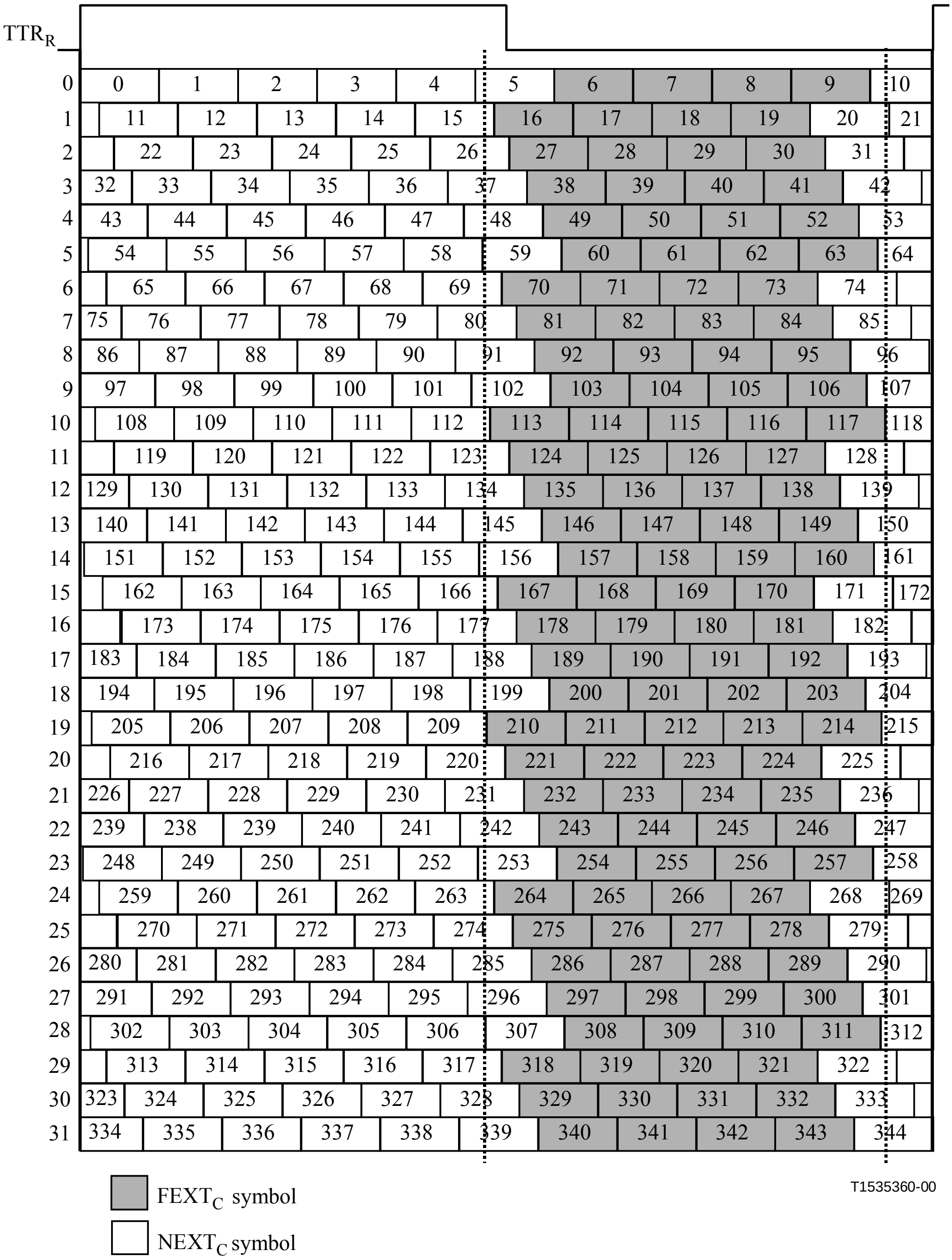


Figure Q.18/G.992.1 – Symbol pattern in a hyperframe without cyclic prefix – Upstream

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-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 §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.

Table Q.5 – Non-standard information field – NPar(1) coding

Bits 8	7	6	5	4	3	2	1	**NPar(1)s**
x	x	x	x	x	x	x	1	Reserved for future use
x	x	x	x	x	x	1	x	Reserved for future use
x	x	x	x	x	1	x	x	Reserved for future use
x	x	x	x	1	x	x	x	Reserved for future use
x	x	x	1	x	x	x	x	Reserved for future use
x	x	1	x	x	x	x	x	Reserved for future use
x	1	x	x	x	x	x	x	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	x	x	x	x	x	x	1	G.992.1 Annex Q
x	x	x	x	x	x	1	x	Reserved for future use
x	x	x	x	x	1	x	x	Reserved for future use
x	x	x	x	1	x	x	x	Reserved for future use
x	x	x	1	x	x	x	x	Reserved for future use
x	x	1	x	x	x	x	x	Reserved for future use
x	1	x	x	x	x	x	x	Reserved for future use
x	0	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

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

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	x	x	x	x	x	x	1	Additional inband spectral shaping
x	x	x	x	x	x	1	x	Reserved for future use
x	x	x	x	x	1	x	x	Reserved for future use
x	x	x	x	1	x	x	x	Reserved for future use
x	x	x	1	x	x	x	x	Reserved for future use
x	x	1	x	x	x	x	x	Reserved for future use
x	x	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	x					x	x	NOMINAL_PSD_lowband (bits 8 & 7)
x	x	x	x	x	x			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**
x	x	x	x	x	x	x	x	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
x	x					x	x	PSD level at 1622 kHz (bits 8 & 7)
x	x	x	x	x	x			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	x	x	x	x	x	x	x	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

Bits 8	7	6	5	4	3	2	1	G.992.1 Annex Q Npar(3)s Octet 5
x	x					x	x	PSD level at 3750 kHz (bits 8 & 7)
x	x	x	x	x	x			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
x	x	x	x	x	x	x	x	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 NPar(2) bit definitions for Annex Q

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.
$n_{C\text{-PILOT1}}=64$	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 64.
$n_{C\text{-PILOT1}}=128$	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 128.
$n_{C\text{-PILOT1}}=256$	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 definitions for Annex Q

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.
$n_{C\text{-PILOT1}}=64$	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 64 (Note 1).
$n_{C\text{-PILOT1}}=128$	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 128 (Note 1).
$n_{C\text{-PILOT1}}=256$	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.
Note 1: One and only 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.

Table Q.9/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.
$n_{C\text{-}PILOT1}=64$	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 64.
$n_{C\text{-}PILOT1}=128$	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 128.
$n_{C\text{-}PILOT1}=256$	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.

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.

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.
$n_{C\text{-}PILOT1}$=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).
$n_{C\text{-}PILOT1}$=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).
$n_{C\text{-}PILOT1}$=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 only one pilot tone bit shall be set in an MS message.	

Q.7.3.2.3 MP messages (new)

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 proposing G.992.1 Annex Q.
$n_{C\text{-PILOT1}}$=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).
$n_{C\text{-PILOT1}}$=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).
$n_{C\text{-PILOT1}}$=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 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.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 $f_{\text{C-PILOT1}}$ 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:

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

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.

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.

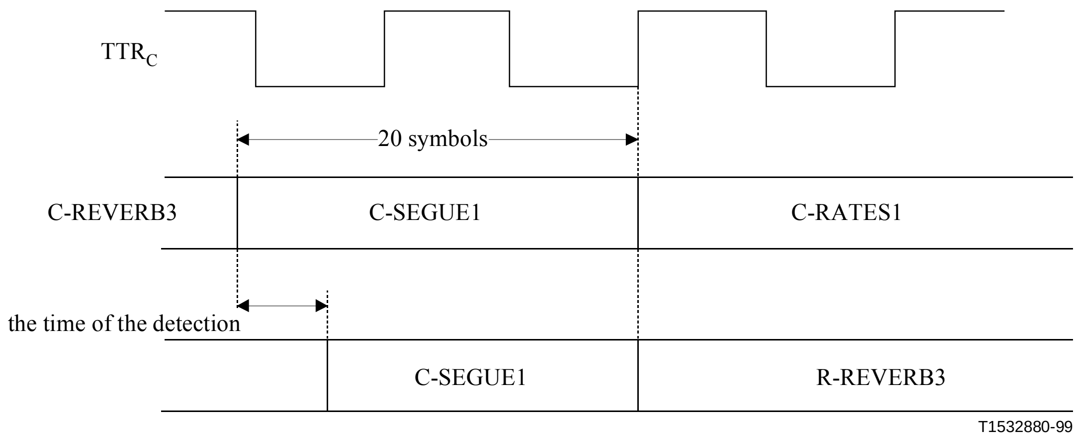


Figure Q.20/G.992.1 – Timing diagram from C-SEGUE1 to C-RATES1

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*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 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:

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

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
    $S = 272 \times N_{dmt} \bmod 2760$
    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 $FEXT_R$.

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.

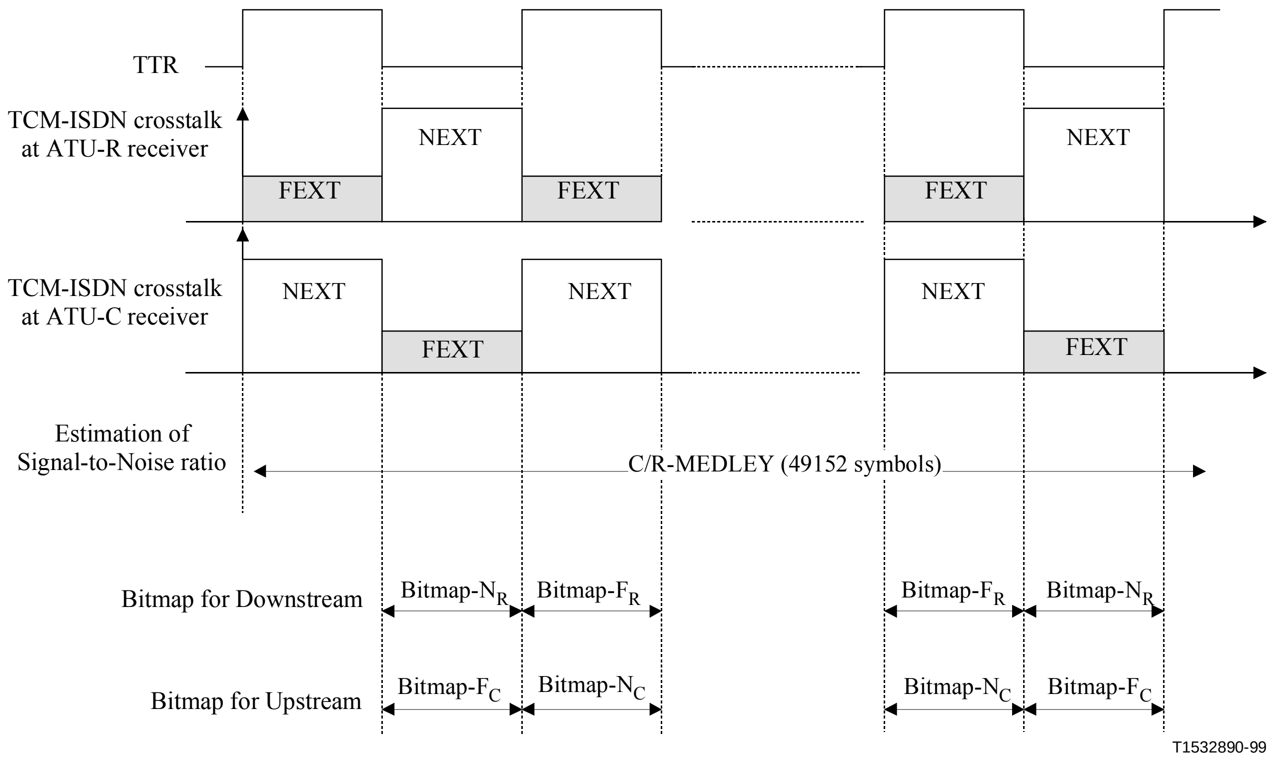


Figure Q.21/G.992.1 – Estimation of periodic Signal-to-Noise Ratio

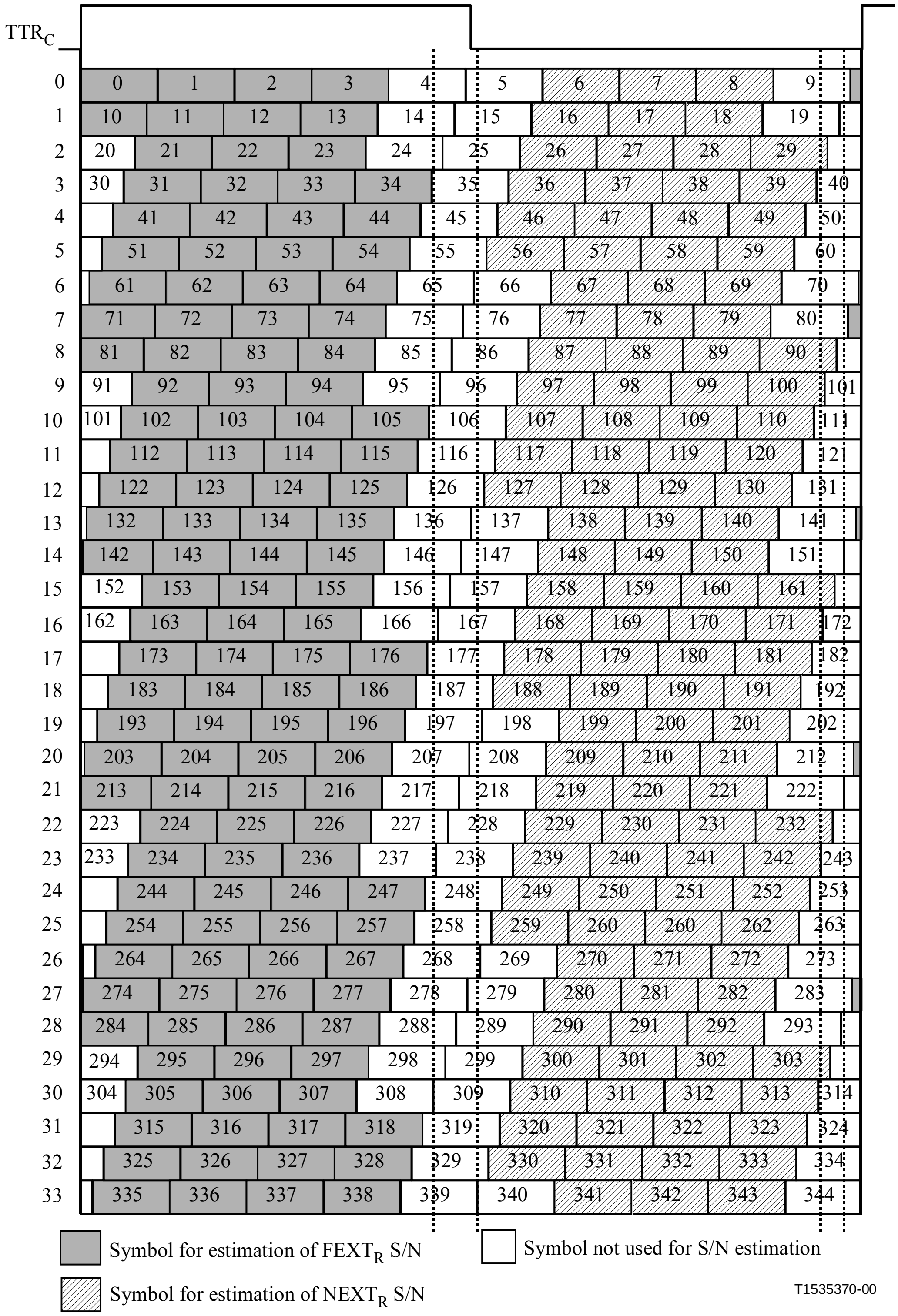


Figure Q.22/G.992.1 – Symbol pattern in a hyperframe for S/N estimation – Downstream

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., $RS_I = R_I/(n*S)$.

Q.7.6.4 C-MSG1 (supplements 10.6.4)

Table Q.12/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; binary coded 0-15 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 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

$S = 272 \times N_{dmt} \bmod 2760$

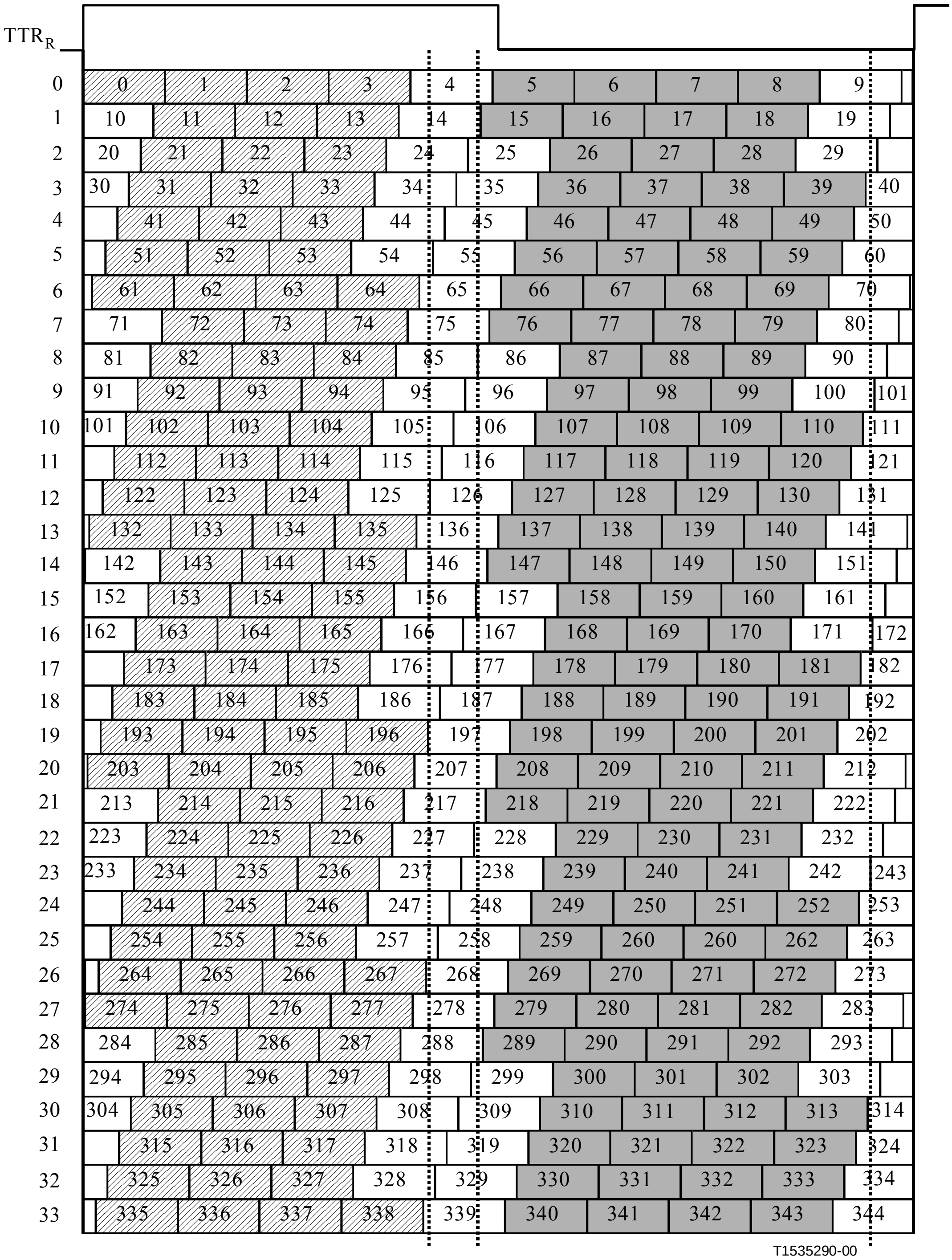
if { (S > b) and (S + 271 < c) } then symbol for estimation of $FEXT_C$ SNR

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 $FEXT_C$.

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.



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)

Table Q.13/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 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 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 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)

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

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 x 126 + 88 x 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 $FEXT_C$ symbols. Similarly, b_i of Bitmap-N_C indicates the number of bits onto the $(i – 32)$ th upstream carrier in $NEXT_C$ symbols; g_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_is 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 (00000_2 and $00000000\ 000_2$, 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 (000.00110000_2 to 001.01010101_2).

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

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

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.

Q.7.9.4 C-RATES-RA (supplements 10.8.3)

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

	⟵ bits ⟶							
fields	7	6	5	4	3	2	1	0
RS_F	B_{10} (AS0)	0	value of RS_F MSB … LSB					
RS_I	B_8 (AS0)	B_9 (AS0)	value of RS_I MSB … LSB					
S	I_9	I_8	value of S MSB … LSB					
I	I_7	I_6	I_5	I_4	I_3	I_2	I_1	I_0
FS(LS2)	value of FS(LS2) *set to* $\{00000000_2\}$							

The RS_I field has been extended to include bit B_9 of B_I (AS0) in bit 6, and The RS_F field has been extended to include the most significant bit B_{10} 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.

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

Suffix(ces) of m_i (Note)	Parameter 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	$B_{fast\text{-}max}$
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 separate fields the least significant bits have the lowest subscripts.	

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 $B_{fast\text{-}max}$ (new)

$B_{fast\text{-}max}$ 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 $B_{fast\text{-}max}$ is t_f.

Q.7.10.2 R-MSG2 (supplements 10.9.8)

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

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 - 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".	

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

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.7.10.3 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_{64} and g_{NSC+64} shall be set to g_{sync}. When subcarrier 128 is reserved as the pilot tone, b_{128} and $b_{NSC+128}$, 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) 001.01000000_2 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 (00000_2 and $00000000\ 000_2$, 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 (000.00110000_2 to 001.01010101_2).

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

$$m = \{m_{(2*NSC-2)*16-1}, m_{(2*NSC-2)*16-2}, \ldots, m_1, m_0\} = \{g_{2*NSC-1}, b_{2*NSC-1}, \ldots, g_{NSC+1}, b_{NSC+1}, g_{NSC-1}, b_{NSC-1}, \ldots, g_1, b_1\}, \quad \text{(Q.10-3)}$$

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.

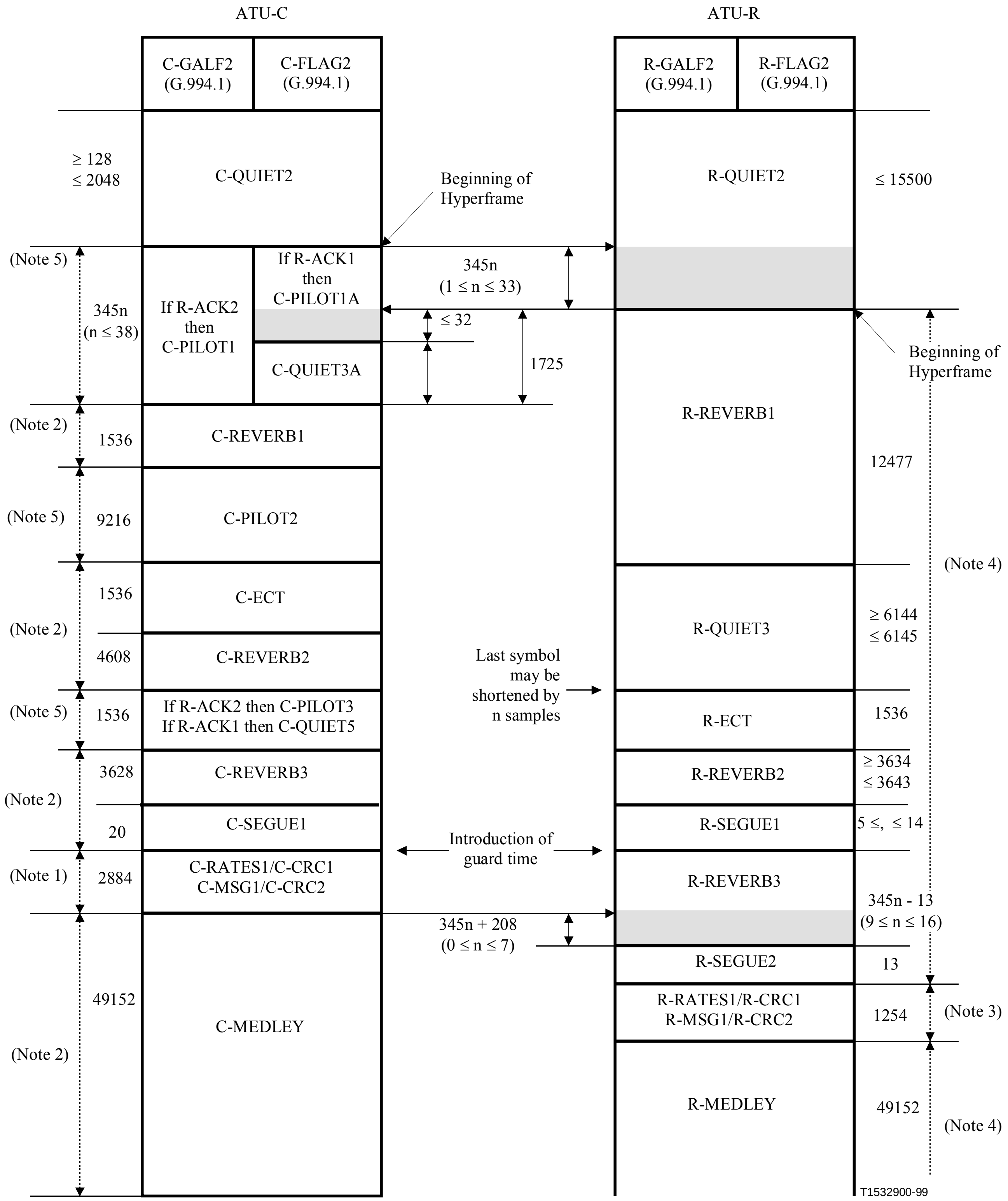
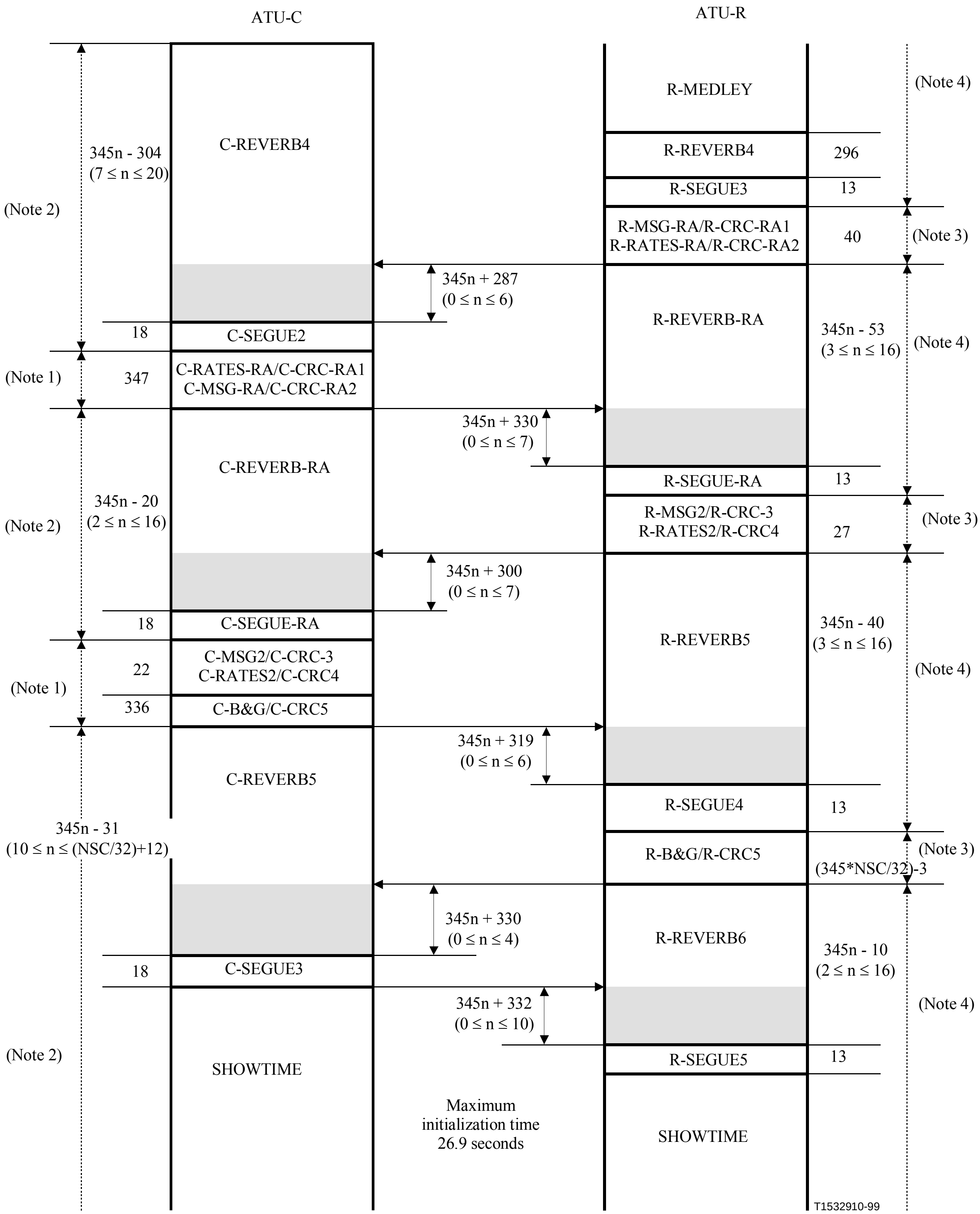


Figure Q.24/G.992.1 – Timing diagram of the initialization sequence – Part 1



NOTE 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.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.

Table Q.17/G.992.1 – Format of the bit swap request message

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

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 $FEXT_{C/R}$ symbols and $NEXT_{C/R}$ symbols is not allowed.

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

Value (8 bit)	Interpretation
$yzz00000_2$	Do nothing
$yzz00001_2$	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
$yzz00110_2$	Reduce the transmitted power by 1 dB
$yzz00111_2$	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	

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:

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

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.

Table Q.19/G.992.1 – Format of the bit swap request message

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)

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 → increased number of subcarriers, NSCus=64
- Increased bit loading, beyond 15 bits/bin
- Extended framing → 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 Q-EU also implements Annexes I and C.

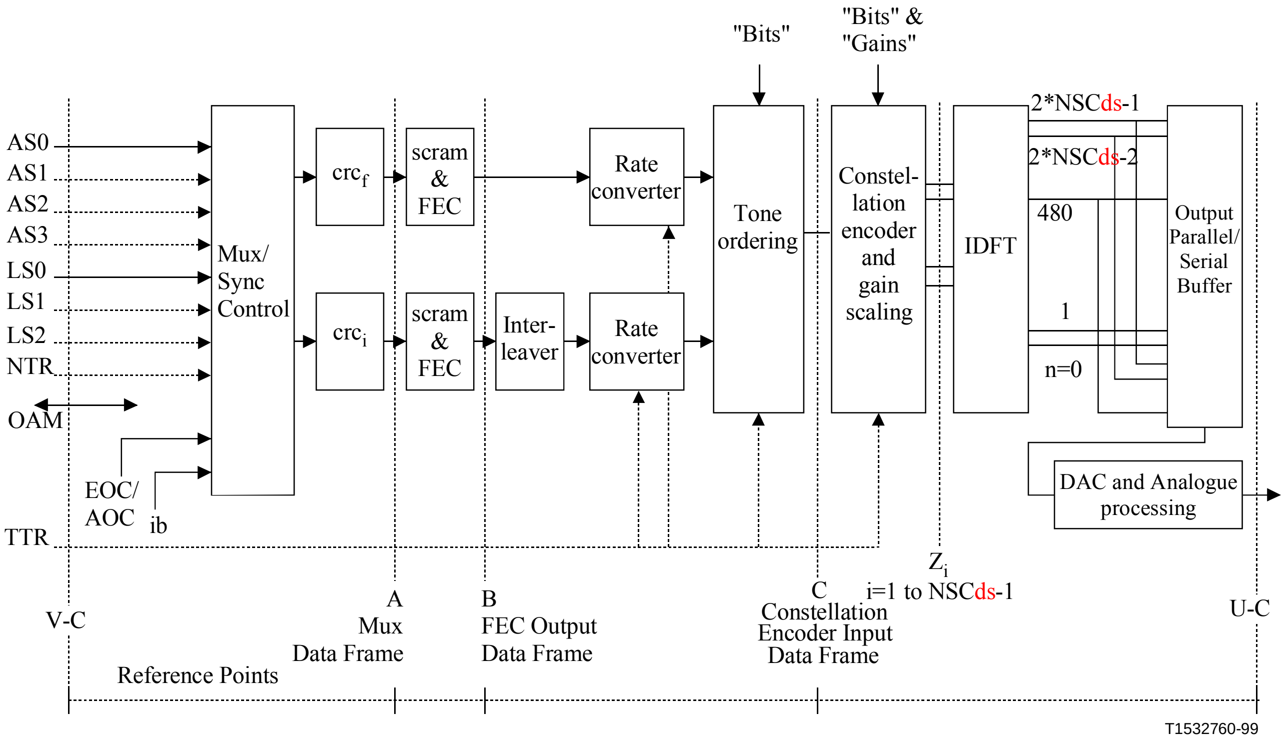
Q.2 Definitions

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 Bitmap	The Dual Bitmap method has dual bit rates under the FEXT and NEXT noise from TCM-ISDN
FEXT Bitmap	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	5 Superframes structure which synchronized TTR
$NEXT_C$ duration	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	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)

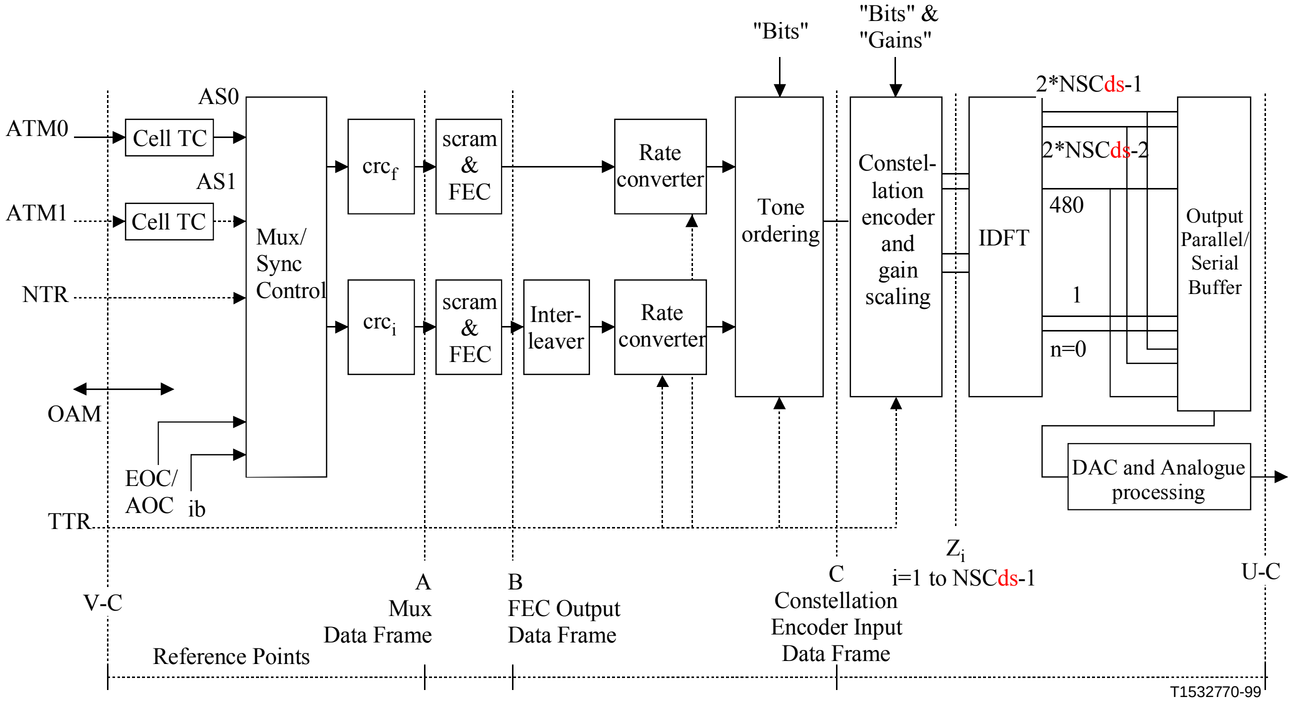
See Figure Q.1 and Figure Q.2.



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

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

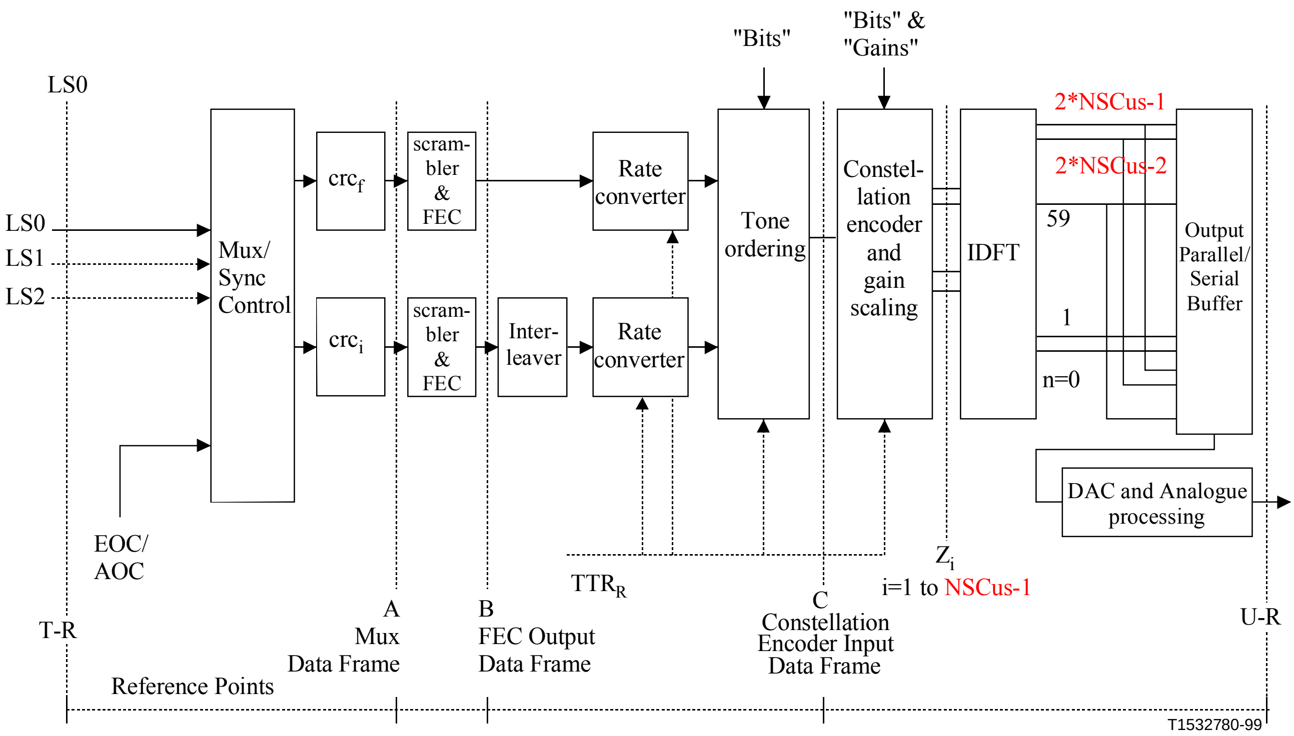


NOTE – The TTR may be generated in ATU-C without being provided from the TCM-ISDN clock.

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)

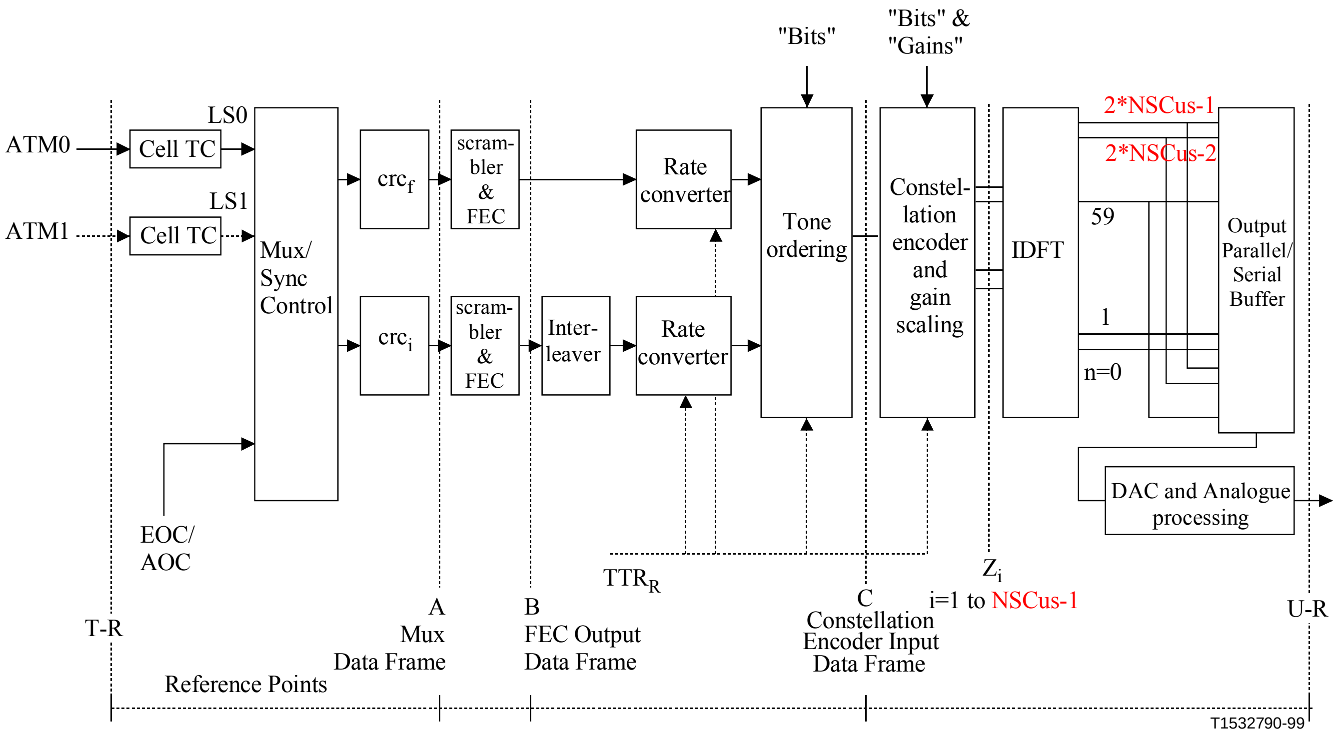
See Figure Q.3 and Figure Q.4.



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.



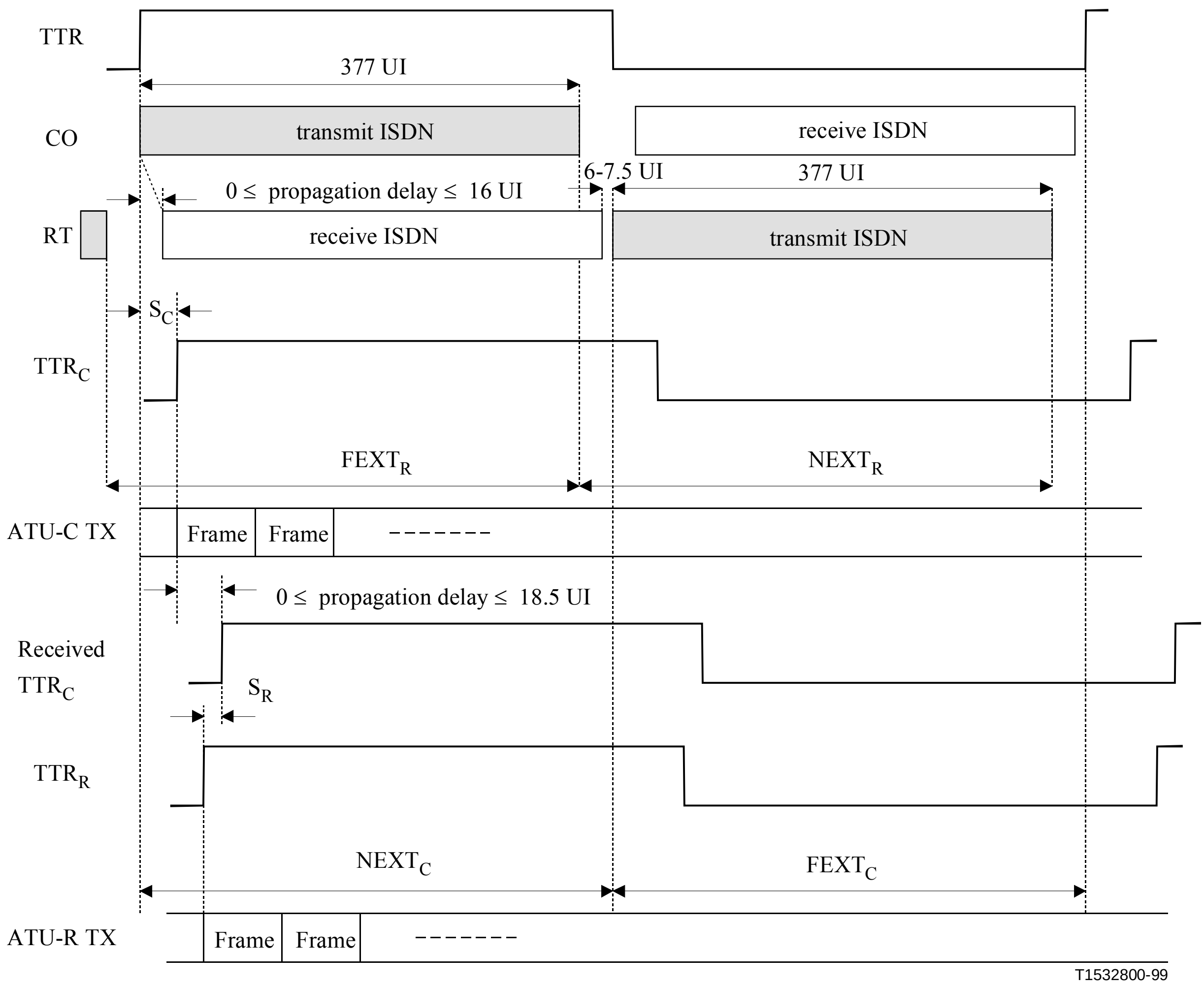
NOTE – The TTR_R shall be generated in ATU-R from the received TTR_C signal, and it is locked to 690 periods of upstream sampling clock (1.104 MHz).

Figure Q.4/G.992.1 – ATU-R transmitter reference model for ATM transport

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.



1 UI = 3.125 µs

$FEXT_R$ and **$NEXT_R$** are estimated by ATU-C

$FEXT_C$ and **$NEXT_C$** are estimated by ATU-R

TTR	TCM-ISDN timing reference
TTR_C	Timing reference used in ATU-C
Received TTR_C	Received TTR_C at ATU-R
TTR_R	Timing reference used in ATU-R
S_C	55 × 0.9058 µs: Offset from TTR to TTR_C
S_R	–42 × 0.9058 µs: Offset from received TTR_C to TTR_R

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.

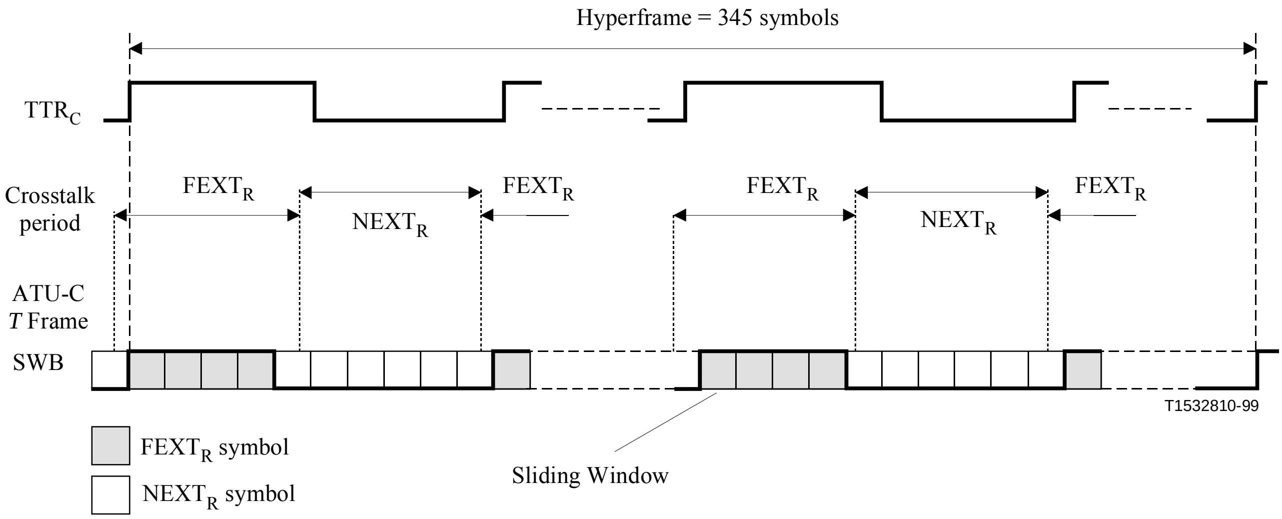


Figure Q.6/G.992.1 – Sliding window for downstream symbols

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

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.

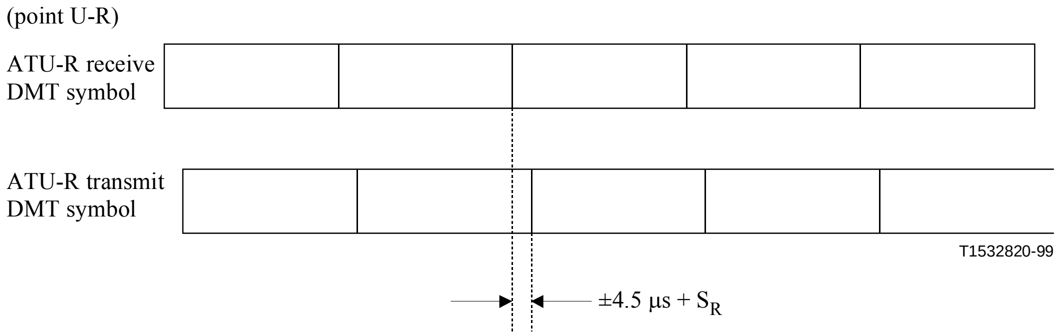


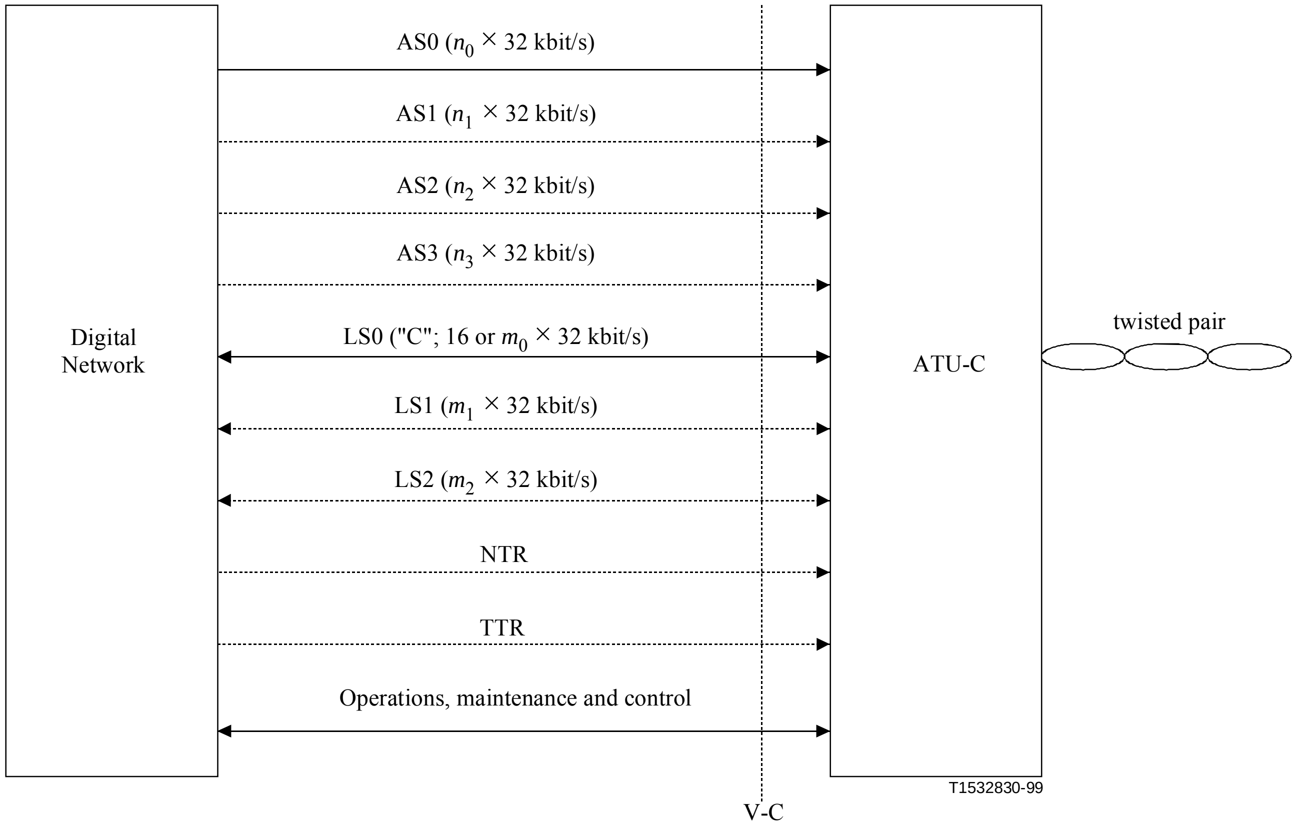
Figure Q.7/G.992.1 – Loop timing for ATU-R

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

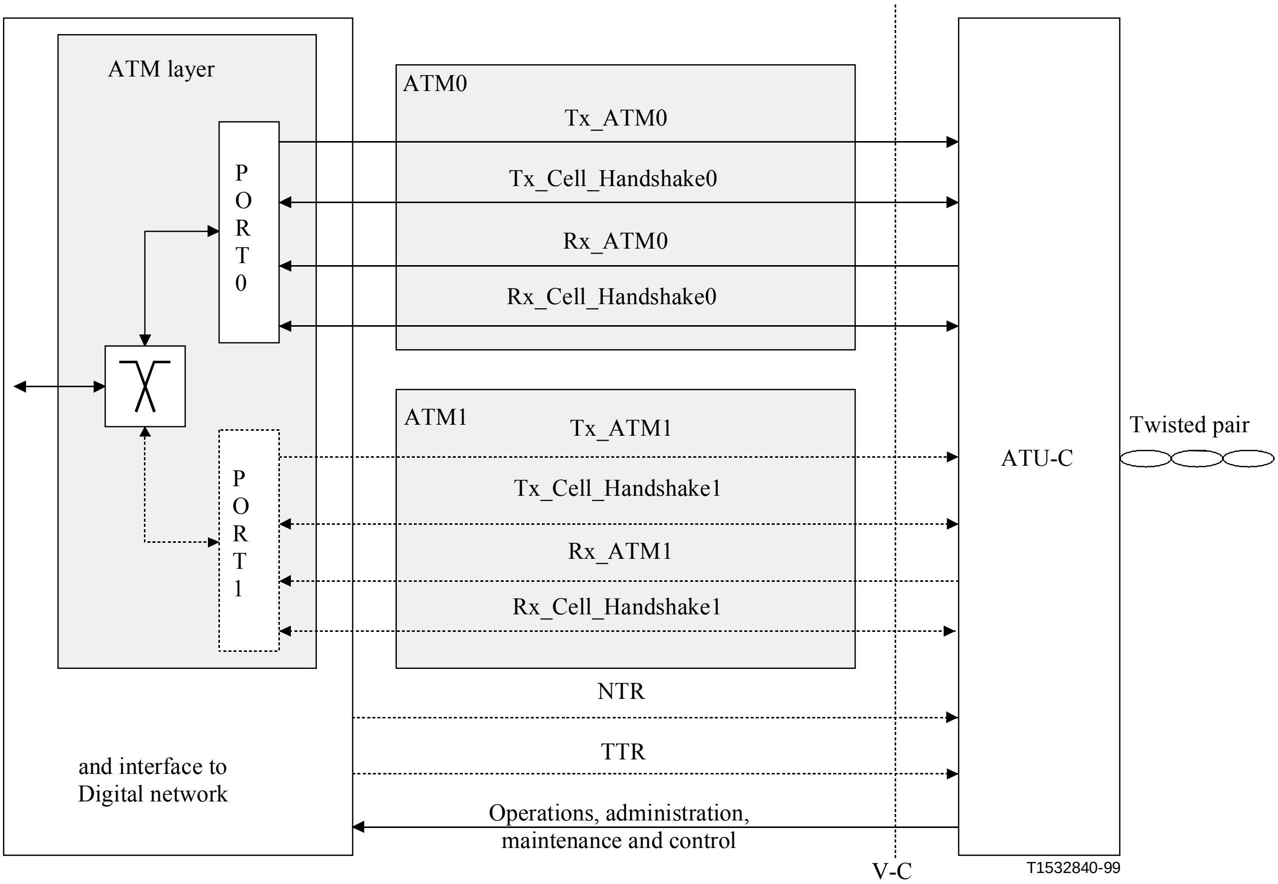
Q.4.1.2 Payload transfer delay (supplements 7.1.4)

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 $NEXT_R$ symbol in a $FEXT_R$ 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).

For $N_{dmt} = 0, 1, ..., 344$

$S = 272 \times N_{dmt} \bmod 2760$

if { (S + 271 < a) 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.

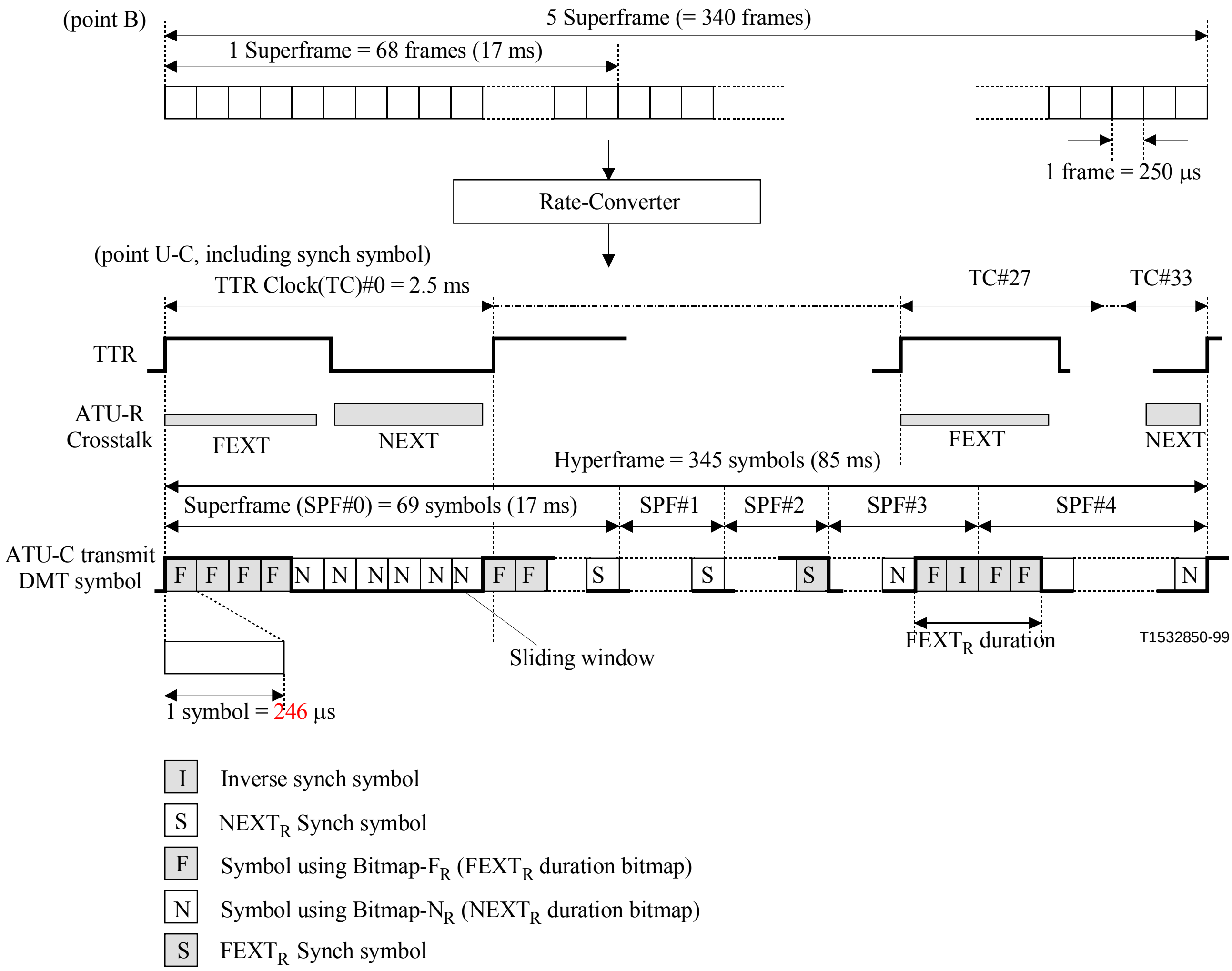


Figure Q.10/G.992.1 – Hyperframe structure for downstream

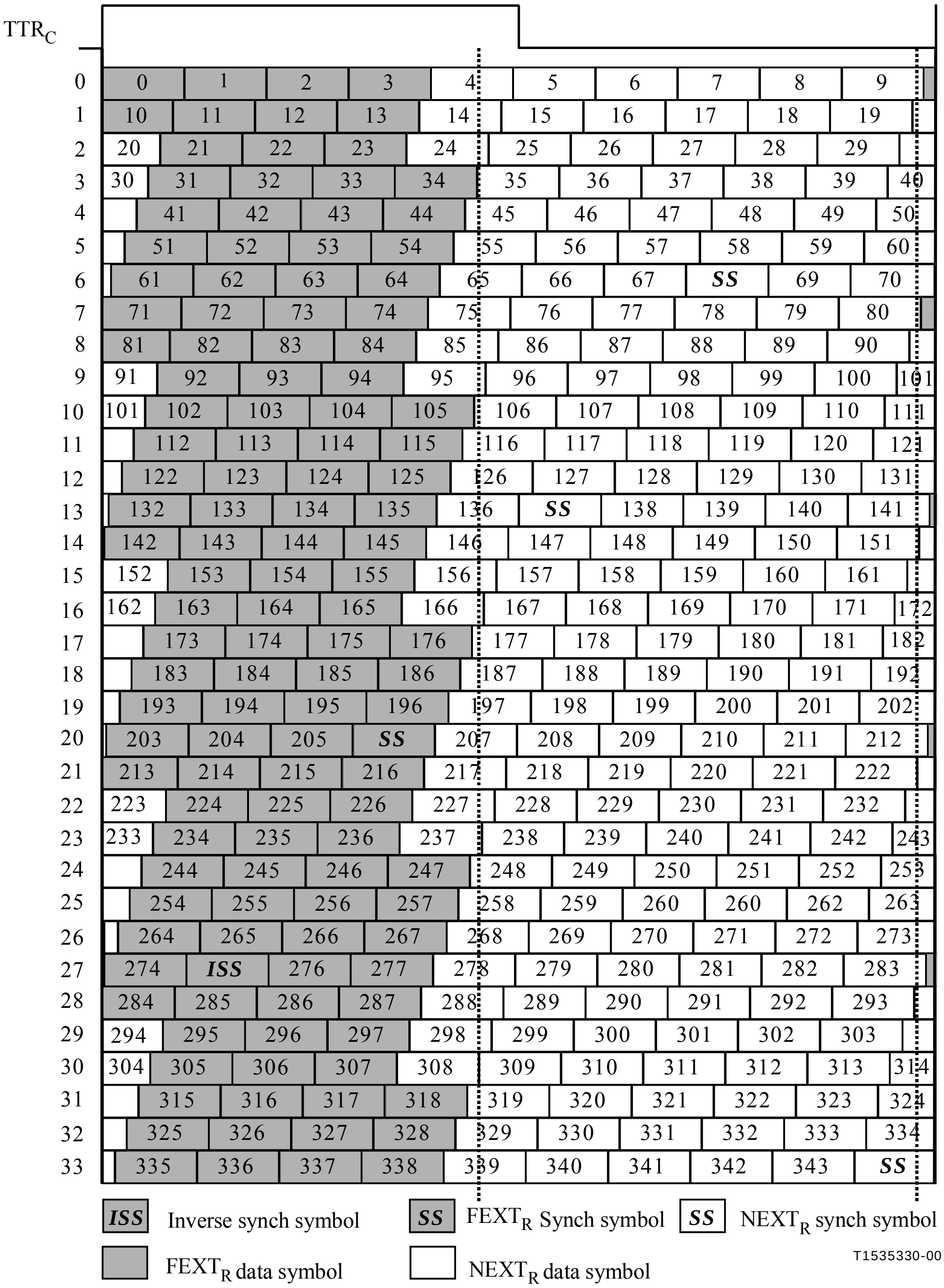


Figure Q.11/G.992.1 – Symbol pattern in a hyperframe with cyclic prefix – Downstream

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.

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

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

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 $t_{Rf} \le n_{R\max}$:

$$n_{Rf} = t_{Rf}$$
$$n_{Ri} = n_R - n_{Rf}$$
$$f_{Rf} = t_{Rf}$$
$$f_{Ri} = f_R - f_{Rf}$$

If $t_{Rf} > n_{R\max}$:

$$n_{Rf} = n_{R\max}$$
$$n_{Ri} = 0$$
$$f_{Rf} = \begin{cases} f_{Rf4} = \left\lceil \dfrac{t_{Rf} \times 10 - n_{Rf} \times 6}{4} \right\rceil \\ f_{Rf3} = \left\lceil \dfrac{t_{Rf} \times 10 - n_{Rf} \times 7}{3} \right\rceil \end{cases}$$
$$f_{Ri} = \begin{cases} f_{Ri4} = f_R = f_{Rf4} \\ f_{Ri3} = f_R - f_{Rf3} \end{cases}$$

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 for synch symbols.
f_{Rf4}	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.
n_R	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 $t_{Rf} \le n_{R\max}$:

$$dummy_{Rf} = 0$$

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

If $t_{Rf} > n_{R\max}$:

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

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

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

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.

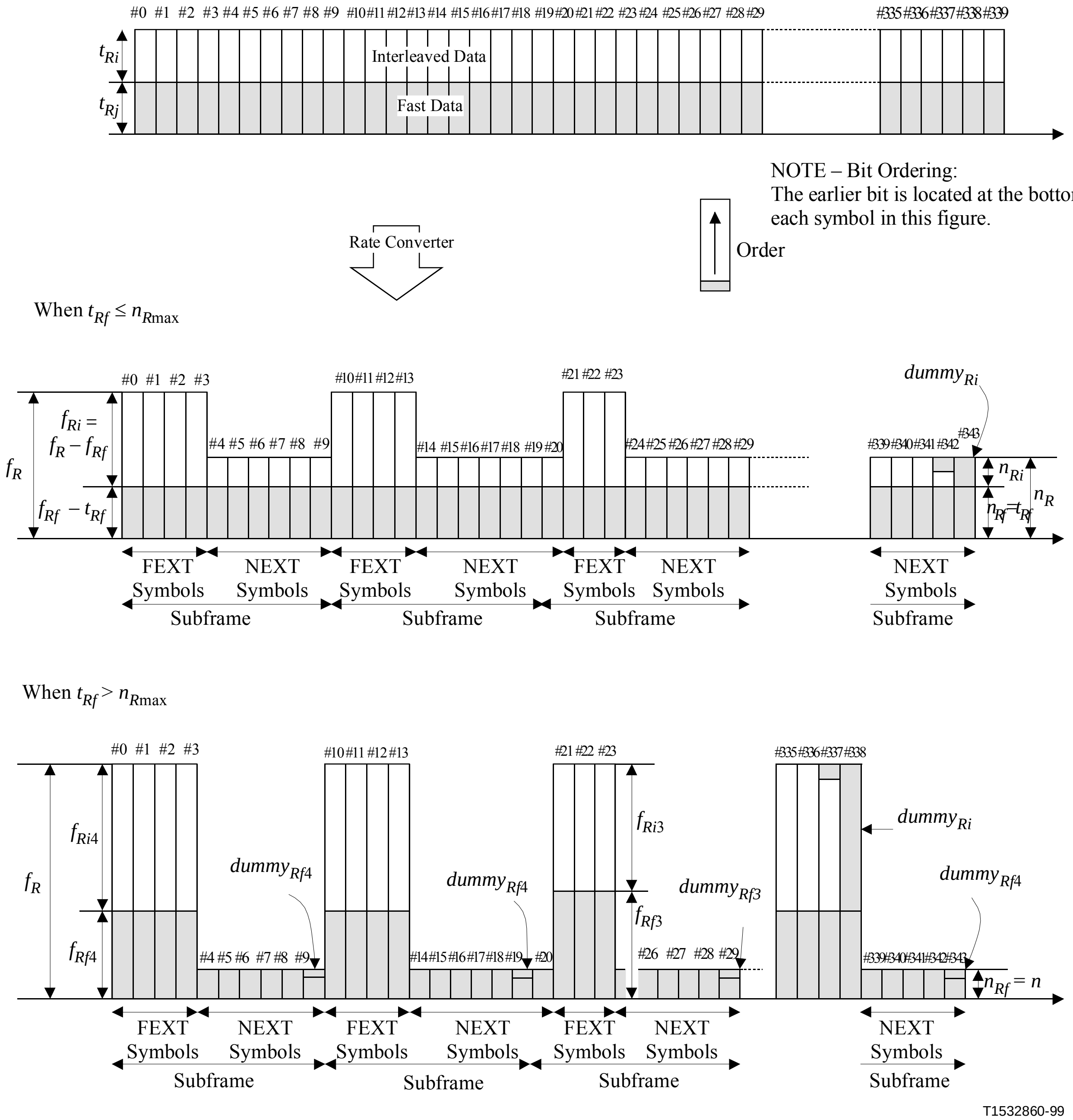


Figure Q.12/G.992.1 – Bit distribution for Rate Converter under Dual latency and Dual Bitmap mode

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:

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

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 = conj ($Z'_{2*NSCds-i}$) for i = NSCds+1 to 2*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, Δf = 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.

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

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,

$$(2 + 0.125)*\text{NSCds} \times 69 = (2 + 0.15625)*\text{NSCds} \times 68 \quad (7\text{-}24)$$

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

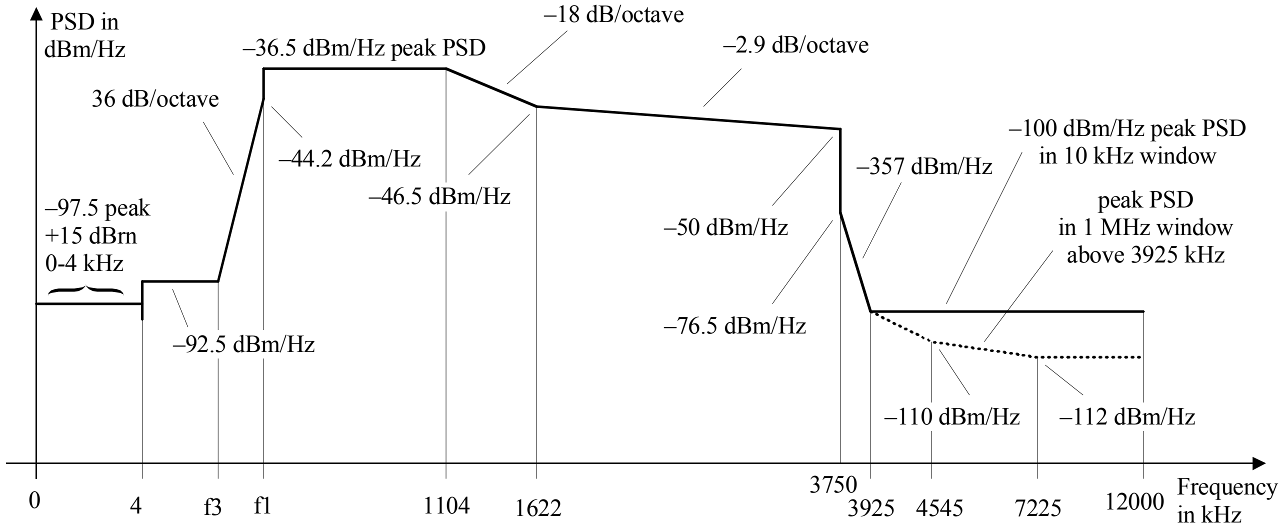
The cyclic prefix shall be used for all symbols beginning with the C-RATES1 segment of the initialization sequence, as defined in 10.6.2.

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*log2(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
f1	-44.2	10 kHz
f1	-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 ≤ 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.

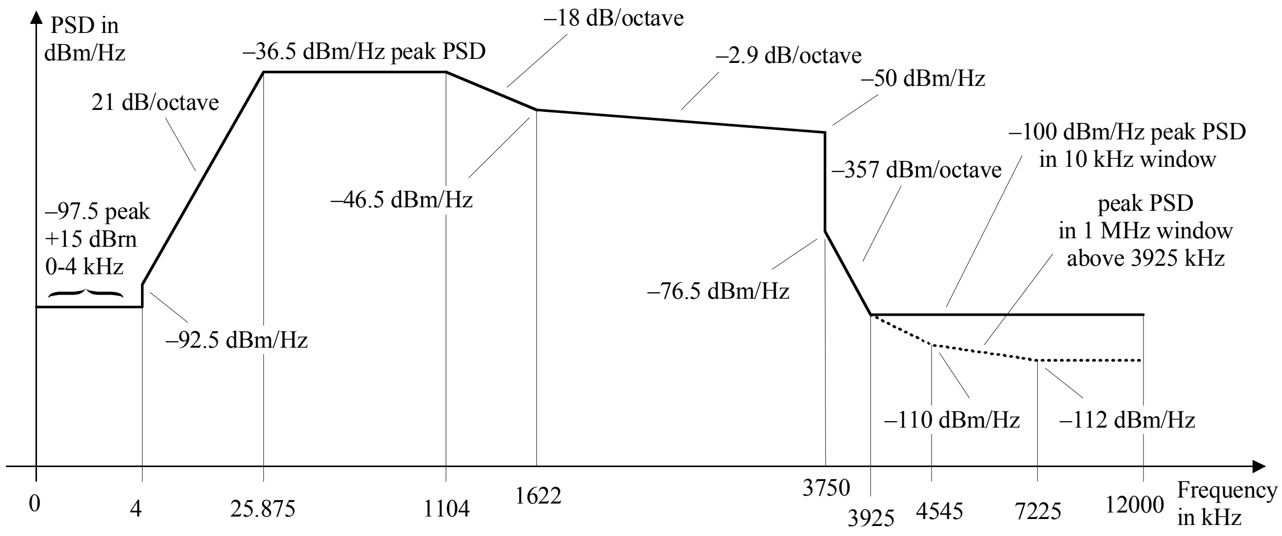
NOTE 6 – All PSD and power measurements shall be made at the U-C interface.

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*log2(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 ≤ 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:

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

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.

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

Tone Index	Log_ssv_i (dB)	Comments
n1	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.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

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	$\sum_{i=32}^{2*NSCds-1} ssv_i^2 * g_i^2 \leq \sum_{i=32}^{2*NSCds-1} ssv_i^2$

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 ≥ 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.

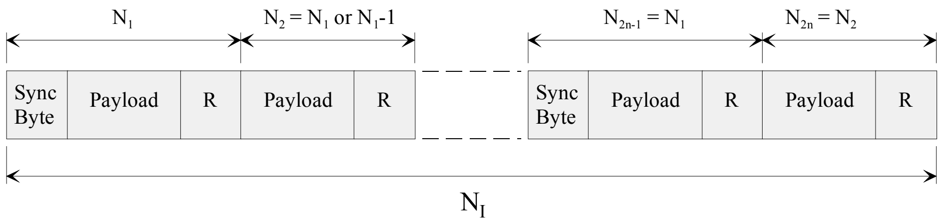


Figure Q.15 – Data frame for S = 1/2n mode

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.

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

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]

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

$S = 272 \times N_{dmt} \bmod 2760$

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.

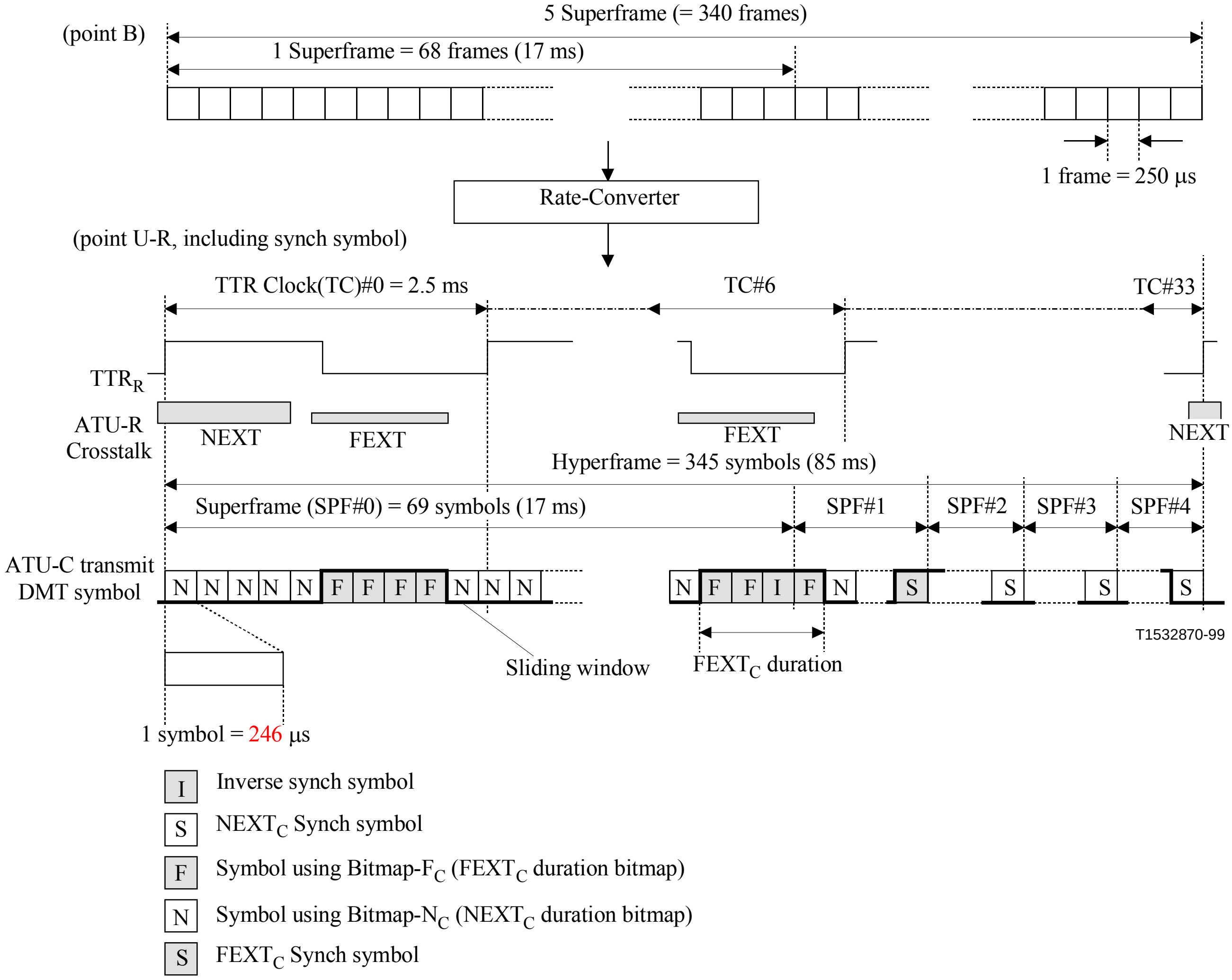


Figure Q.16/G.992.1 – Hyperframe structure for upstream

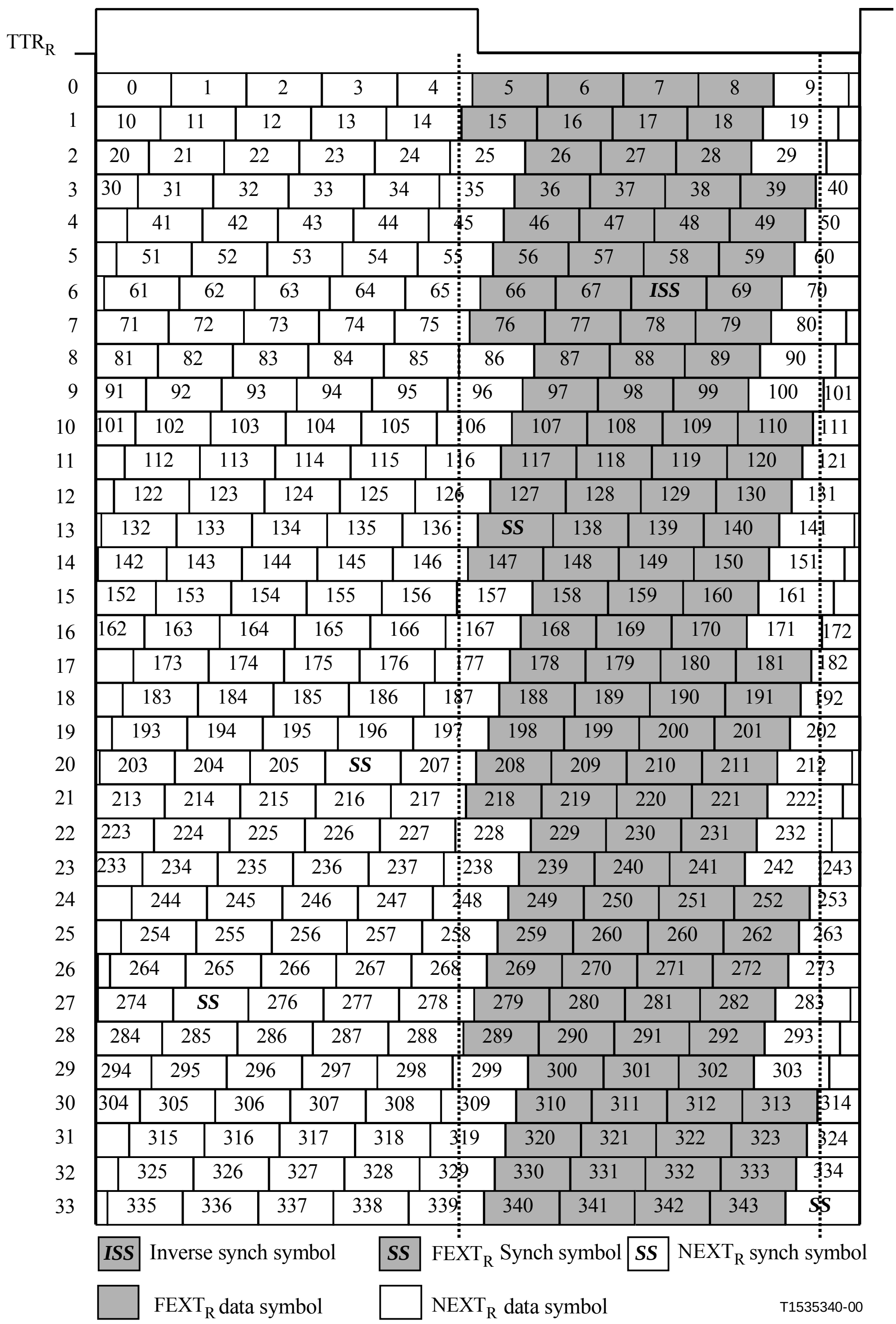


Figure Q.17/G.992.1 – Symbol pattern in a hyperframe with cyclic prefix – Upstream

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.

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

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

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 $t_{Cf} \leq n_{C\max}$:

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

If $t_{Cf} > n_{C\max}$:

$$n_{Cf} = n_{C\max}$$
$$n_{Ci} = 0$$
$$f_{Cf} = \begin{cases} f_{Cf4} = \left\lceil \dfrac{t_{Cf} \times 10 - n_{Cf} \times 6}{4} \right\rceil \\ f_{Cf3} = \left\lceil \dfrac{t_{Cf} \times 10 - n_{Cf} \times 7}{3} \right\rceil \end{cases}$$
$$f_{Ci} = \begin{cases} f_{Ci4} = f_C - f_{C4} \\ f_{Ci3} = f_C - f_{Cf3} \end{cases}$$

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 for synch symbols.
f_{Cf4}	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.
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 $t_{Cf} \le n_{C\max}$:

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

If $t_{Cf} > n_{C\max}$:

$$dummy_{Cf4} = (f_{Cf} \times 4 + n_{Cf} \times 6) - t_{Cf} \times 10$$
$$dummy_{Cf3} = (f_{Cf} \times 3 + n_{Cf} \times 7) - t_{Cf} \times 10$$
$$dummy_{Ci} = (f_{Ci4} \times 96 + f_{Ci3} \times 30) - t_{Ci} \times 340$$

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)

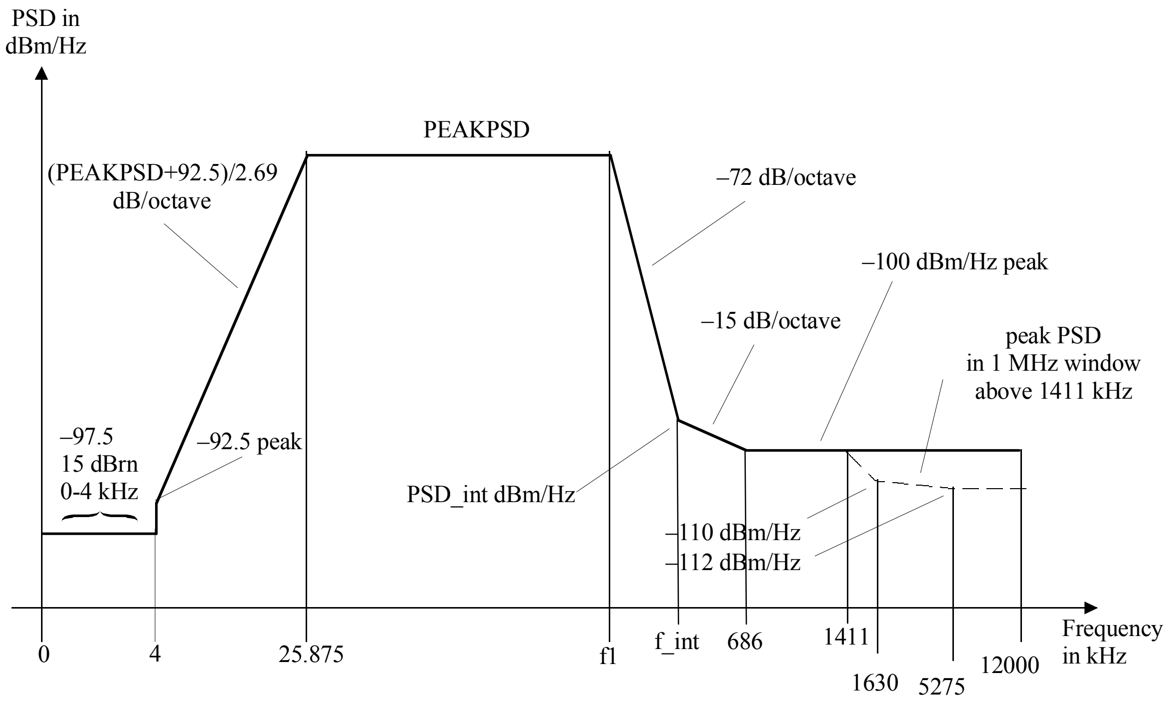
For Annex Q-EU, see A.2.2.

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:

Parameters in FEXT bitmap for mode 1, both bitmaps 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 ≤ 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-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, …344

$S = 256 \times N_{dmt} \bmod 2760$

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 Q.20).

For N_{dmt} = 0, 1, …, 344,

$S = 256 \times N_{dmt} \bmod 2760$

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

$S = 272 \times N_{dmt} \bmod 2760$

if { $(S + 271 \geq a)$ and $(S \leq a + b)$ } 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

$S = 272 \times N_{dmt} \bmod 2760$

if { (S > a) and (S + 271 < a + b) } then $FEXT_C$ symbols

else then $NEXT_C$ symbols

where a = 1315, b = 1293

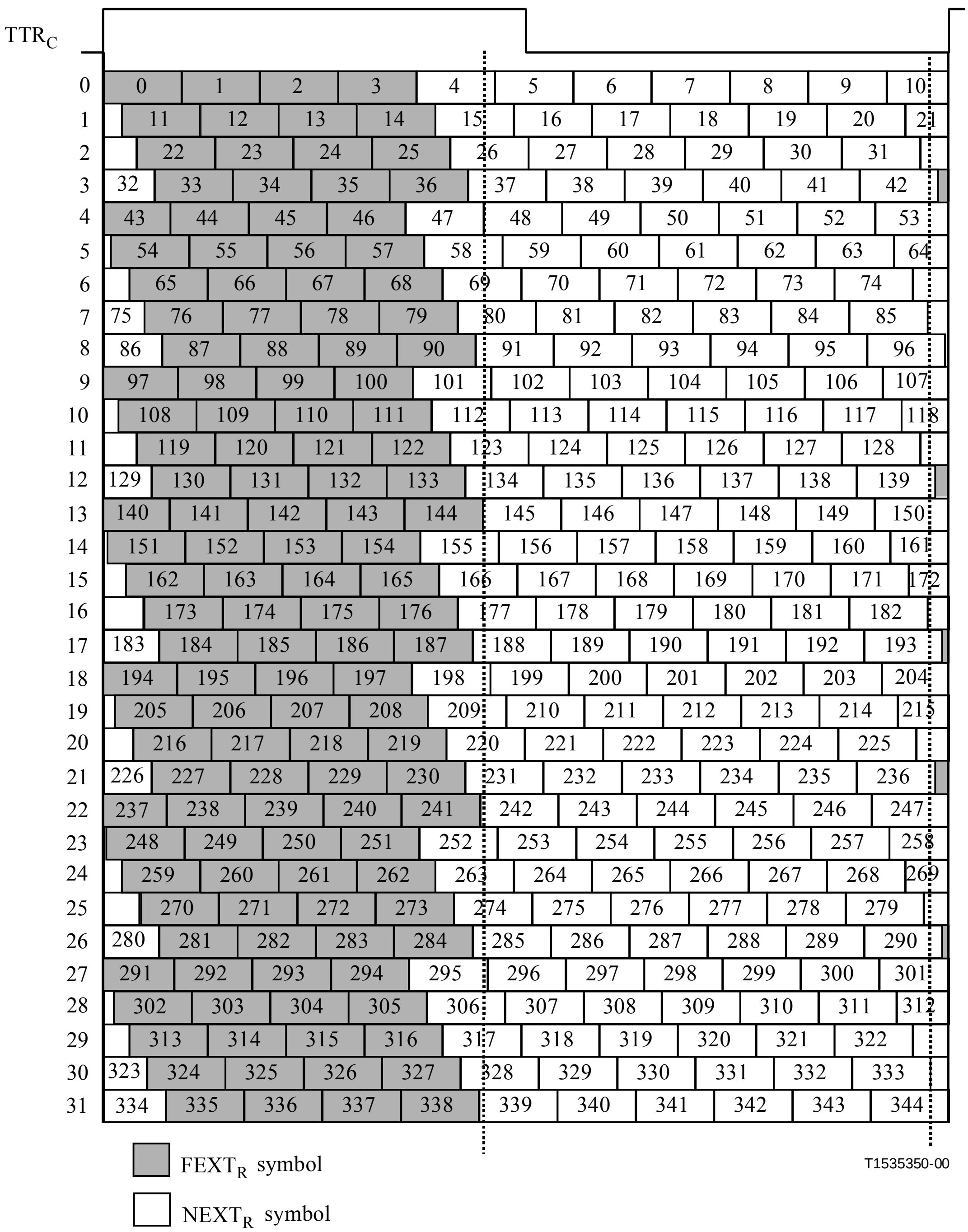


Figure Q.19/G.992.1 – Symbol pattern in a hyperframe without cyclic prefix – Downstream

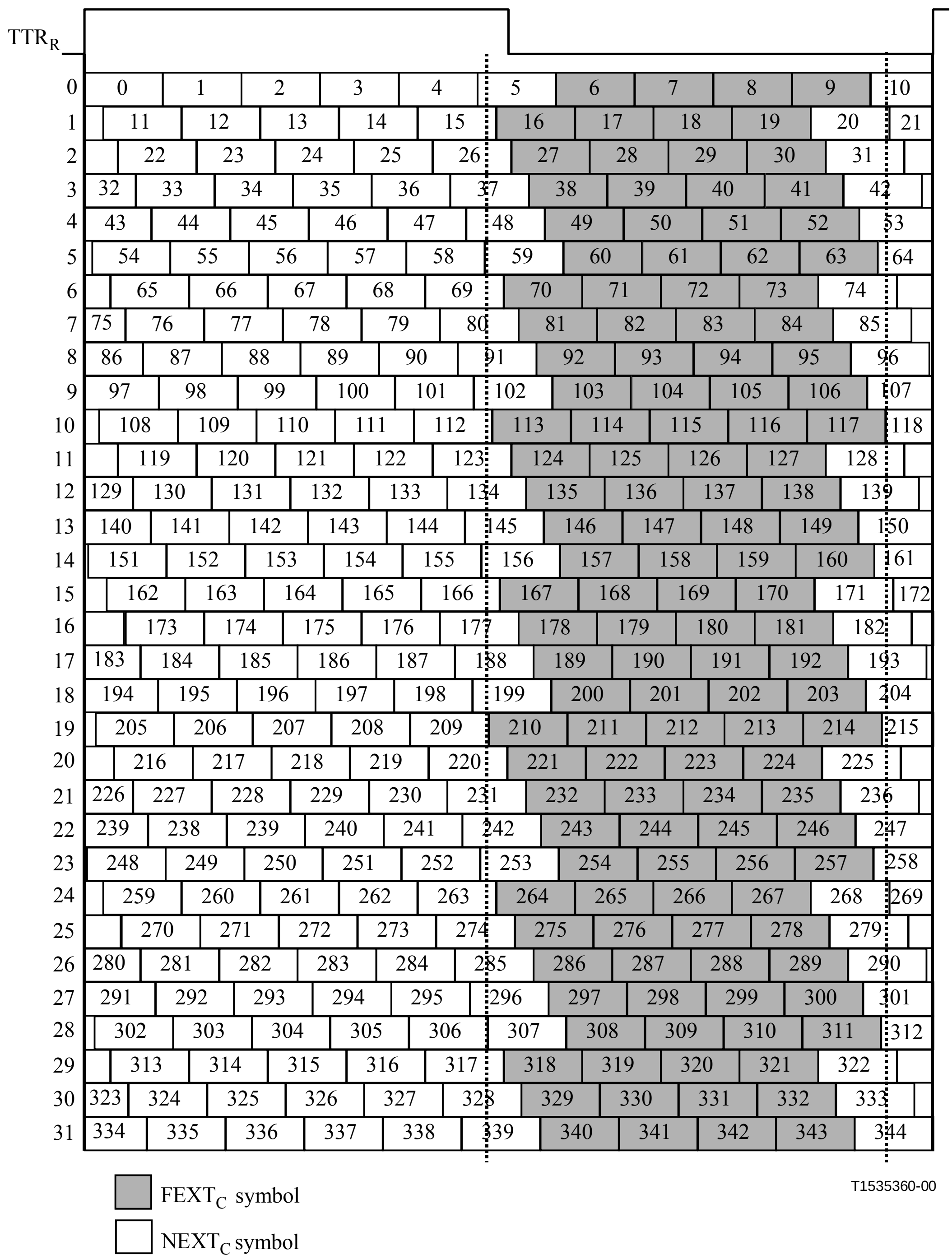


Figure Q.20/G.992.1 – Symbol pattern in a hyperframe without cyclic prefix – Upstream

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-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 §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".

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

Bits 8	7	6	5	4	3	2	1	**NPar(1)s**
x	x	x	x	x	x	x	1	Reserved for future use
x	x	x	x	x	x	1	x	Reserved for future use
x	x	x	x	x	1	x	x	Reserved for future use
x	x	x	x	1	x	x	x	Reserved for future use
x	x	x	1	x	x	x	x	Reserved for future use
x	x	1	x	x	x	x	x	Reserved for future use
x	1	x	x	x	x	x	x	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

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

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**
x	x	x	x	x	x	x	1	$n_{C\text{-}PILOT1} = 64$
x	x	x	x	x	x	1	x	$n_{C\text{-}PILOT1} = 128$
x	x	x	x	x	1	x	x	$n_{C\text{-}PILOT1} = 256$
x	x	x	x	1	x	x	x	Amateur radio notch – 1.8 MHz band
x	x	x	1	x	x	x	x	Amateur radio notch – 3.5 MHz band
x	x	1	x	x	x	x	x	$n_{C\text{-}PILOT1} = 96$
x	x	0	0	0	0	0	0	No parameters in this octet
Since A48 is the only TTR indication signal specified for Annex Q-EU, there is no need to include it in G.994.1.								

Table Q.7.1.1 – Non-standard information field – G.992.1 Annex Q NPar(2) coding – Octet 2

Bits 8	7	6	5	4	3	2	1	**G.992.1 Annex Q NPar(2)s – Octet 2**
x	x	x	x	x	x	x	1	R-ACK1
x	x	x	x	x	x	1	x	R-ACK2
x	x	x	x	x	1	x	x	Reserved for future use
x	x	x	x	1	x	x	x	Reserved for future use
x	x	x	1	x	x	x	x	Reserved for future use
x	x	1	x	x	x	x	x	G.997.1 – Clear EOC OAM
x	x	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.								

Table Q.7.2 – 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	x	x	x	x	x	x	1	Additional inband spectral shaping
x	x	x	x	x	x	1	x	Extended upstream
x	x	x	x	x	1	x	x	Reserved for future use
x	x	x	x	1	x	x	x	Reserved for future use
x	x	x	1	x	x	x	x	Reserved for future use
x	x	1	x	x	x	x	x	Reserved for future use
x	x	0	0	0	0	0	0	No parameters in this octet

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

Bits 8	7	6	5	4	3	2	1	G.992.1 Annex Q Additional inband spectral shaping Npar(3)s Octet 1
x	x					x	x	NOMINAL_PSD_lowband (bits 8 & 7)
x	x	x	x	x	x			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 8	7	6	5	4	3	2	1	G.992.1 Annex Q Additional inband spectral shaping Npar(3)s Octet 2
x	x	x	x	x	x	x	x	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					x	x	PSD level at 1622 kHz (bits 8 & 7)
x	x	x	x	x	x			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 8	7	6	5	4	3	2	1	G.992.1 Annex Q Additional inband spectral shaping Npar(3)s Octet 4
x	x	x	x	x	x	x	x	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	PSD level at 3750 kHz (bits 8 & 7)
x	x	x	x	x	x			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 8	7	6	5	4	3	2	1	G.992.1 Annex Q Additional inband spectral shaping Npar(3)s Octet 6
x	x	x	x	x	x	x	x	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	x	x	x	x	x	x	1	Mode 1 upstream mask
x	x	x	x	x	x	1	x	Mode 2 upstream mask
x	x	x	x	x	1	x	x	Optional upstream masks for non-overlapped spectrum
x	x	x	x	1	x	x	x	EU-64
x	x	x	1	x	x	x	x	EU-32
x	x	1	x	x	x	x	x	EU-36
x	x	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

Bits 8	7	6	5	4	3	2	1	G.992.1 Annex Q Extended upstream NPar(3)s Octet 2
x	x	x	x	x	x	x	1	EU-40
x	x	x	x	x	x	1	x	EU-44
x	x	x	x	x	1	x	x	EU-48
x	x	x	x	1	x	x	x	EU-52
x	x	x	1	x	x	x	x	EU-56
x	x	1	x	x	x	x	x	EU-60
x	x	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.

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

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.
$n_{C\text{-}PILOT1}$=64	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 64.
$n_{C\text{-}PILOT1}$=96	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 96.
$n_{C\text{-}PILOT1}$=128	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 128.
$n_{C\text{-}PILOT1}$=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.

Q.7.3.1.2 MS messages (supplements 10.2.2)

See Table Q.9.

Table Q.9/G.992.1 – ATU-C 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-C is selecting G.992.1 Annex Q, and possibly Annex Q-EU.
$n_{C\text{-PILOT1}}=64$	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 64 (Note 1).
$n_{C\text{-PILOT1}}=96$	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 96 (Note 1).
$n_{C\text{-PILOT1}}=128$	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 128 (Note 1).
$n_{C\text{-PILOT1}}=256$	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.
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.
$n_{C\text{-}PILOT1}=64$	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 64.
$n_{C\text{-}PILOT1}=96$	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 96.
$n_{C\text{-}PILOT1}=128$	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 128.
$n_{C\text{-}PILOT1}=256$	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.

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.
$n_{C\text{-}PILOT1}$=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).
$n_{C\text{-}PILOT1}$=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).
$n_{C\text{-}PILOT1}$=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).
$n_{C\text{-}PILOT1}$=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 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 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
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.
$n_{C\text{-}PILOT1}=64$	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the pilot tone on subcarrier 64 (Note 1).
$n_{C\text{-}PILOT1}=96$	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is proposing the pilot tone on subcarrier 96 (Note 1).
$n_{C\text{-}PILOT1}=128$	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the pilot tone on subcarrier 128 (Note 1).
$n_{C\text{-}PILOT1}=256$	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.
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 $f_{\text{C-PILOT1}}$ defined as:

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

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 kHz ($n_{\text{C-PILOT1}}$ = 64).
5. $f_{\text{C-PILOT1}}$ = 414 kHz ($n_{\text{C-PILOT1}}$ = 96).
6. $f_{\text{C-PILOT1}}$ = 552 kHz ($n_{\text{C-PILOT1}}$ = 128).
7. $f_{\text{C-PILOT1}}$ = 1104 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:

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.

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.

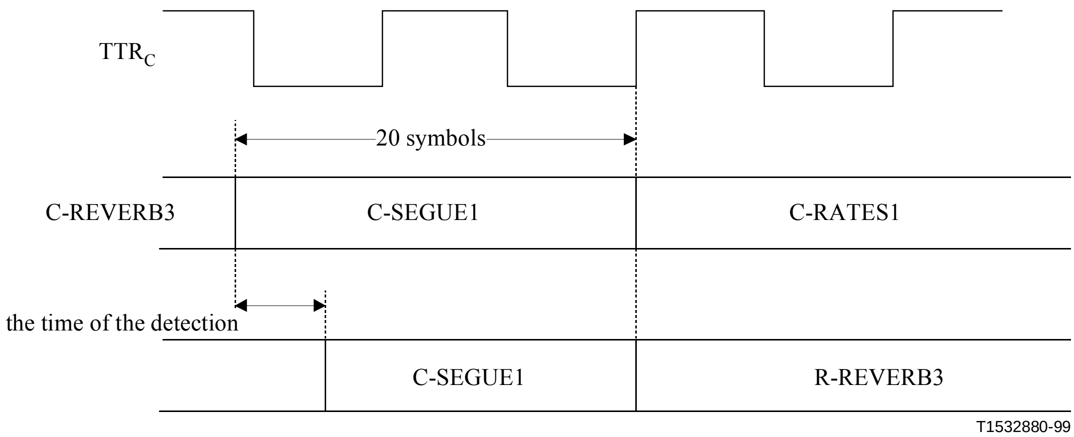


Figure Q.22/G.992.1 – Timing diagram from C-SEGUE1 to C-RATES1

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:

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

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:

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

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:

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

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 2^{14}-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

$S = 272 \times N_{dmt} \bmod 2760$

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).

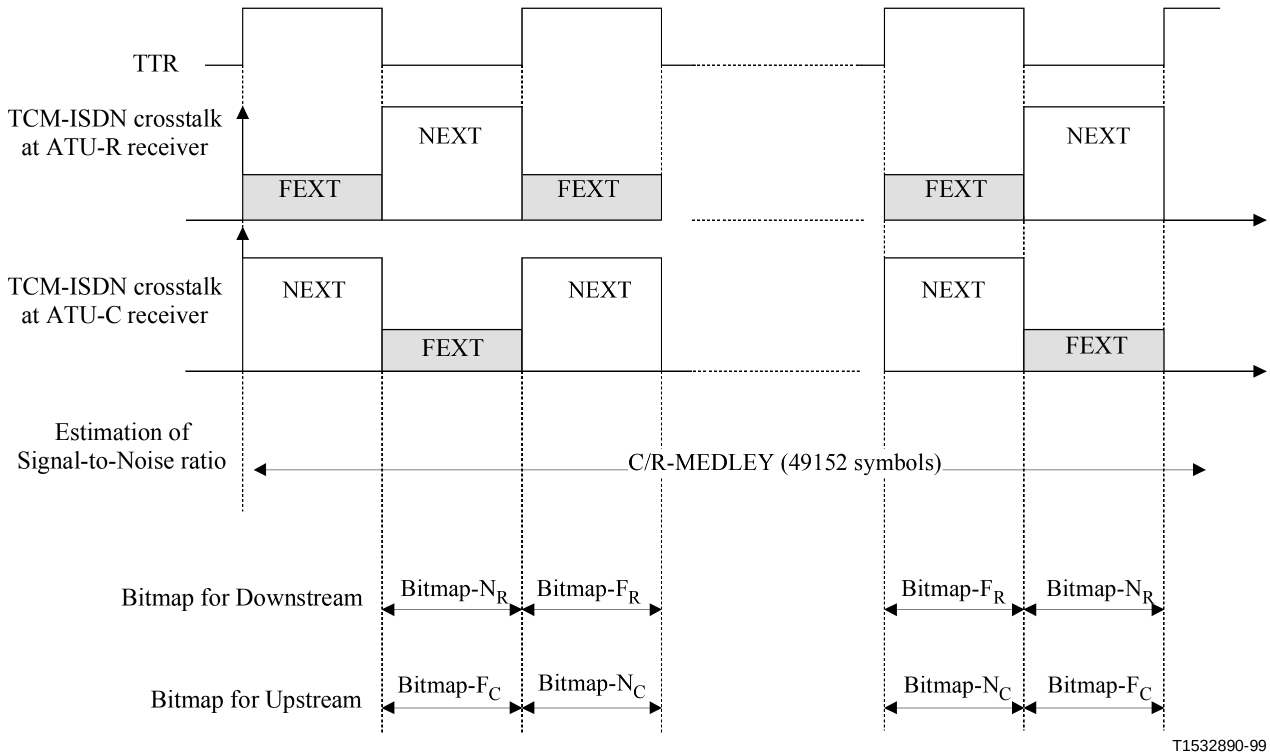


Figure Q.23/G.992.1 – Estimation of periodic Signal-to-Noise Ratio

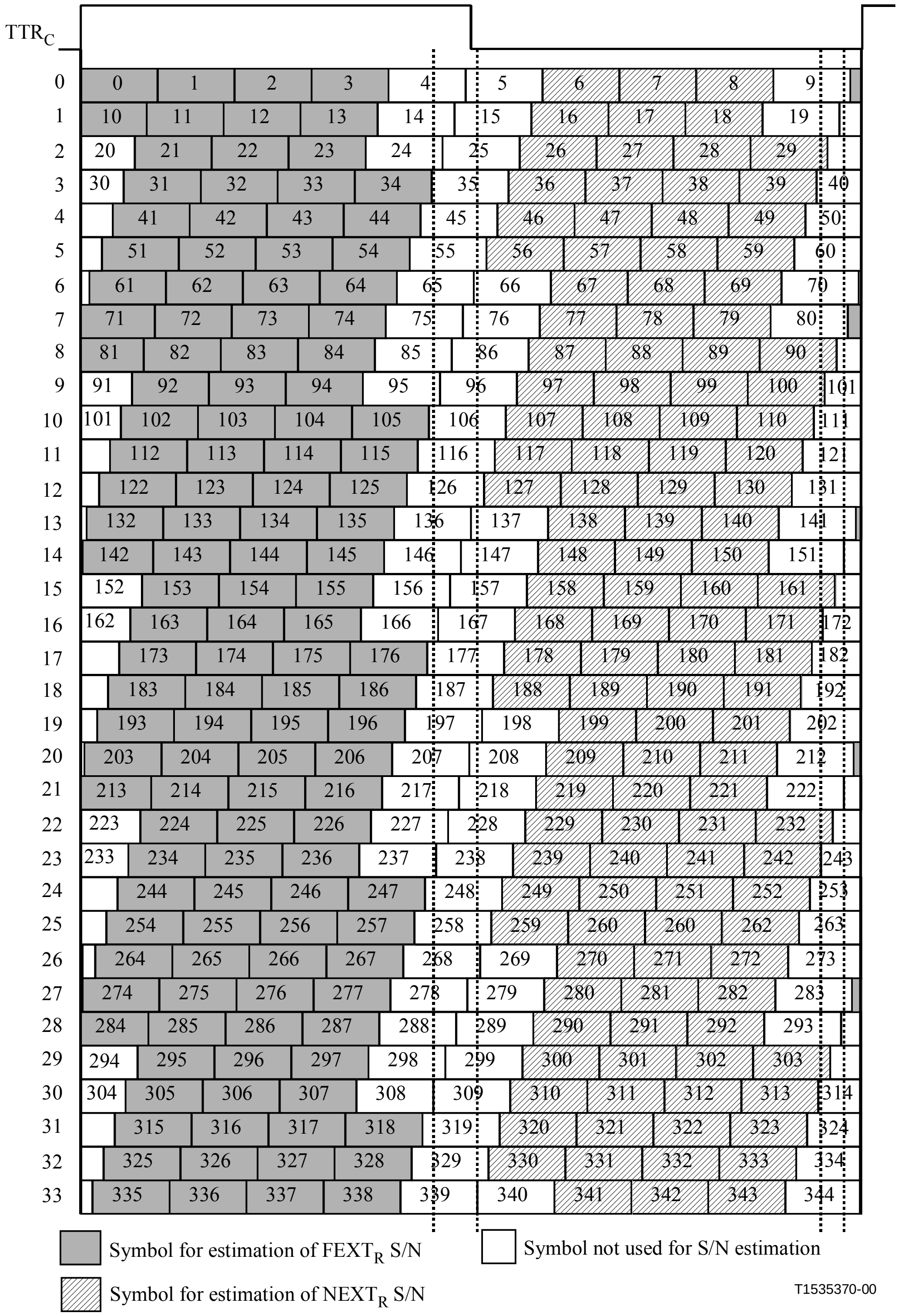


Figure Q.24/G.992.1 – Symbol pattern in a hyperframe for S/N estimation – Downstream

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., $RS_I = R_I/(n*S)$.

Q.7.6.4 C-MSG1 (supplements 10.6.4)

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; binary coded 0-15 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 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:

$$d_n = 1 \text{ for } n = 1 \text{ to } 23 \text{ and } d_n = d_{n-18} \oplus d_{n-23} \text{ for } n > 23.$$

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

$S = 272 \times N_{dmt} \bmod 2760$

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).

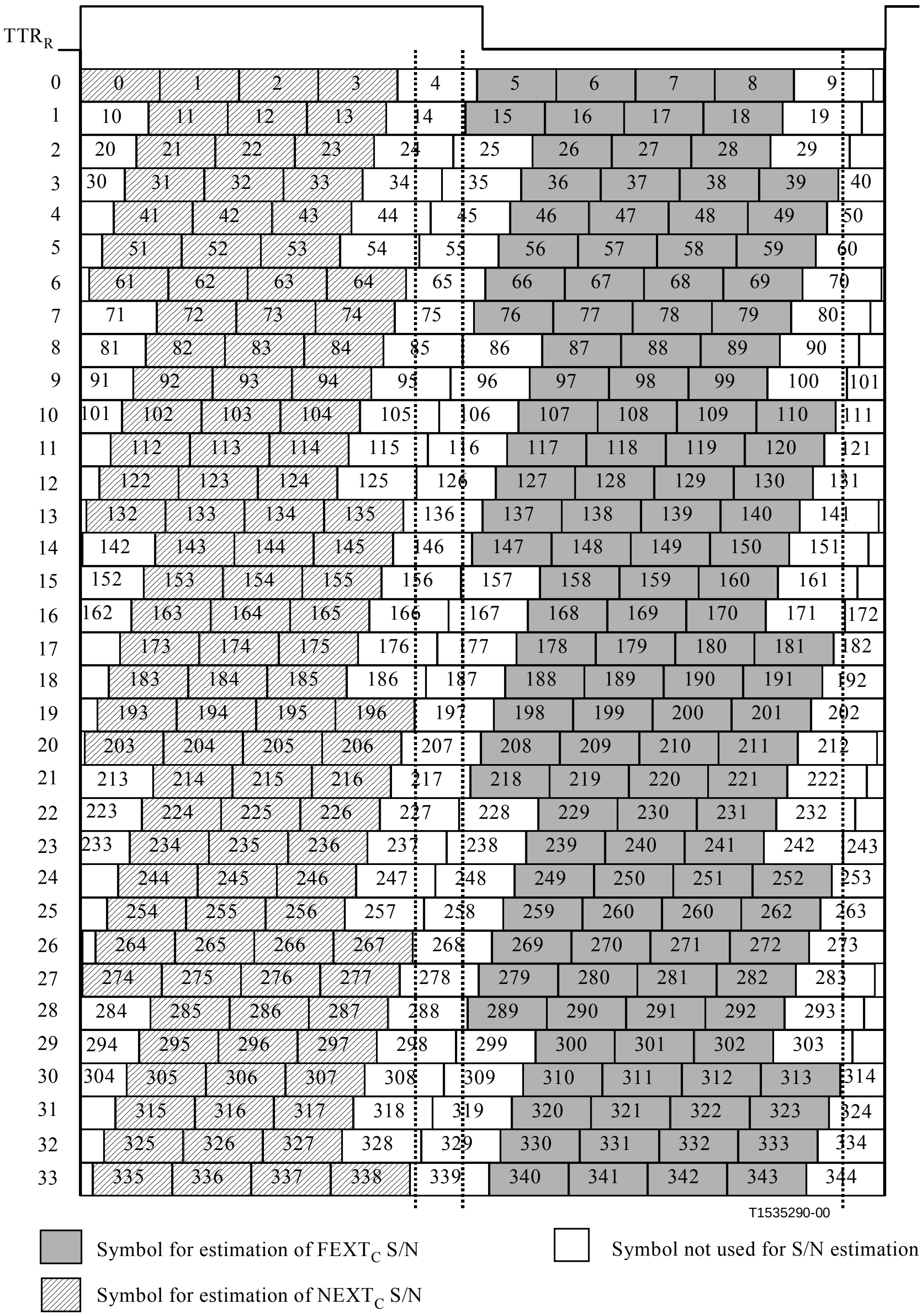


Figure Q.25/G.992.1 – Symbol pattern in a hyperframe for S/N estimation – Upstream

Q.7.8.4 R-MSG1 (supplements 10.7.6)

Table Q.14/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 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 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 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.

Table Q.15/G.992.1 – Assignment of 32 bits of C-MSG2

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".	

For NSCus=32,

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

Otherwise,

$n_{1C\text{-}MSG2} = 139$
$n_{2C\text{-}MSG2} = 187$

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 x 126 + 88 x 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), $\{m_{10}, ..., m_0\} = 00001111111_2$].

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_is 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 (00000_2 and $00000000\ 000_2$, 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 (000.00110000_2 to 001.01010101_2).

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:

$$m = \{m_{32*(NSCu-1)-1}, m_{32(NSCu-1)-2}, \ldots, m_1, m_0\} = \{ g_{2*NSCu-1}, b_{2*NSCu-1}, \ldots, g_{NSCu+1}, b_{NSCu+1}, g_{NSCu-1}, b_{NSCu-1}, \ldots, g_1, b_1\}, \qquad (C.10-2)$$

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.

Q.7.9.4 C-RATES-RA (supplements 10.8.3)

Table Q.16/G.992.1 – RRSI fields of C-RATES-RA

	← bits →							
fields	7	6	5	4	3	2	1	0
RS_F	B_{10} (AS0)	0	value of RS_F MSB … LSB					
RS_I	B_8 (AS0)	B_9 (AS0)	value of RS_I MSB … LSB					
S	I_9	I_8	value of S MSB … LSB					
I	I_7	I_6	I_5	I_4	I_3	I_2	I_1	I_0
FS(LS2)	value of FS(LS2) *set to* $\{00000000_2\}$							

The RS_I field has been extended to include bit B_9 of B_I (AS0) in bit 6, and The RS_F field has been extended to include the most significant bit B_{10} 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.

Table Q.17/G.992.1 – Assignment of 80 bits of R-MSG-RA (Annex Q-EU)

Suffix(ces) of m_i (Note)	Parameter 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 separate fields the least significant bits have the lowest subscripts.	

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 $B_{fast-max}$ is t_f.

Q.7.10.2 R-MSG2 (supplements 10.9.8)

Table Q.18/G.992.1 – Assignment of 32 bits of R-MSG2

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 - 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".	

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

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 96 is reserved as the pilot tone, b_{96} and $b_{NSCds+96}$, shall be set to 0, g_{96} and $g_{NSCds+96}$ 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 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) 001.01000000_2 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 (00000_2 and $00000000\ 000_2$, 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 (000.00110000_2 to 001.01010101_2).

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

$$m = \{m_{(2*NSCds-2)*16-1}, m_{(2*NSCds-2)*16-2}, \ldots, m_1, m_0\} = \{ g_{2*NSCds-1}, b_{2*NSCds-1}, \ldots, g_{NSCds+1}, b_{NSCds+1}, g_{NSCds-1}, b_{NSCds-1}, \ldots, g_1, b_1\}, \quad \text{(Q.10-3)}$$

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.

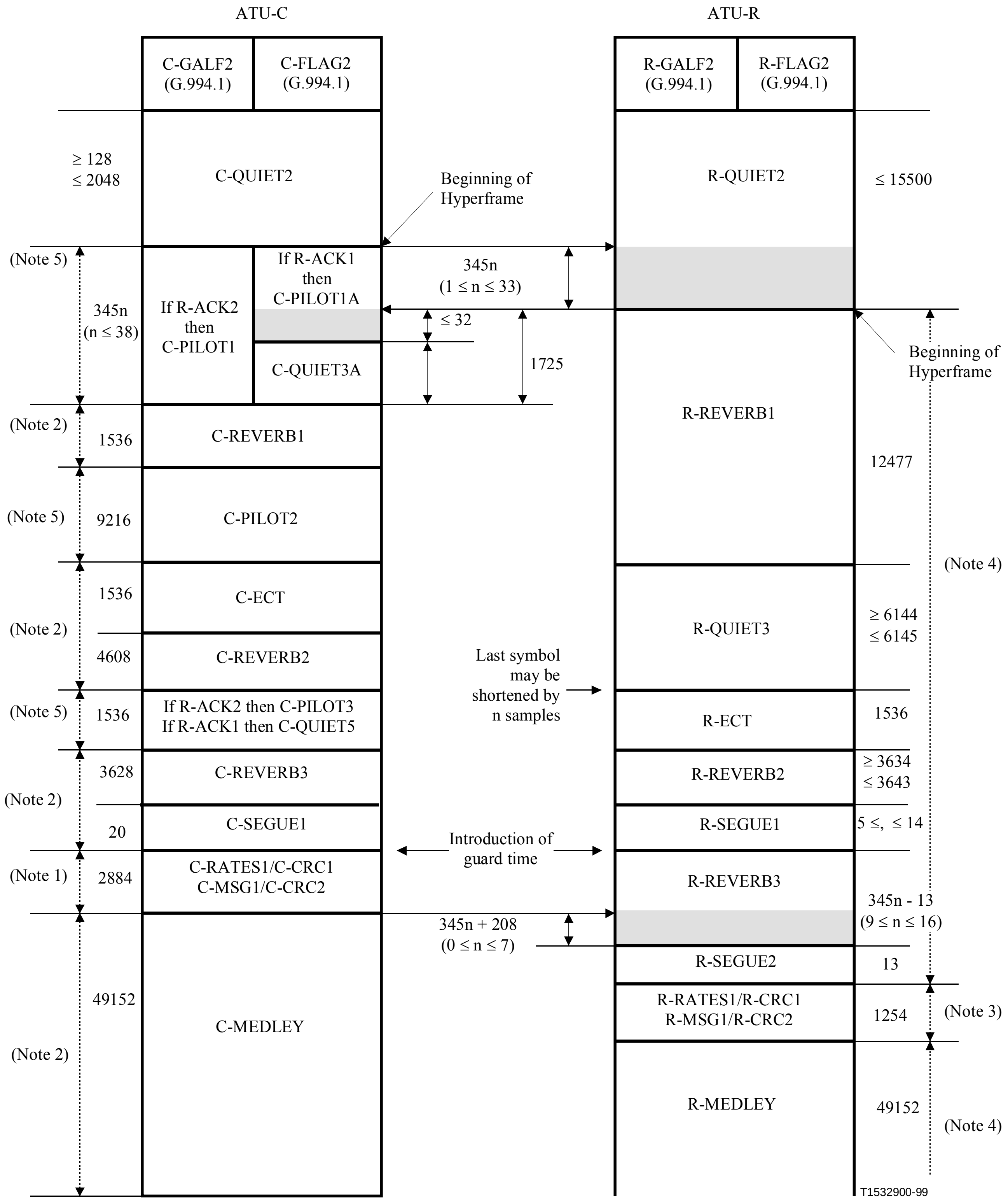
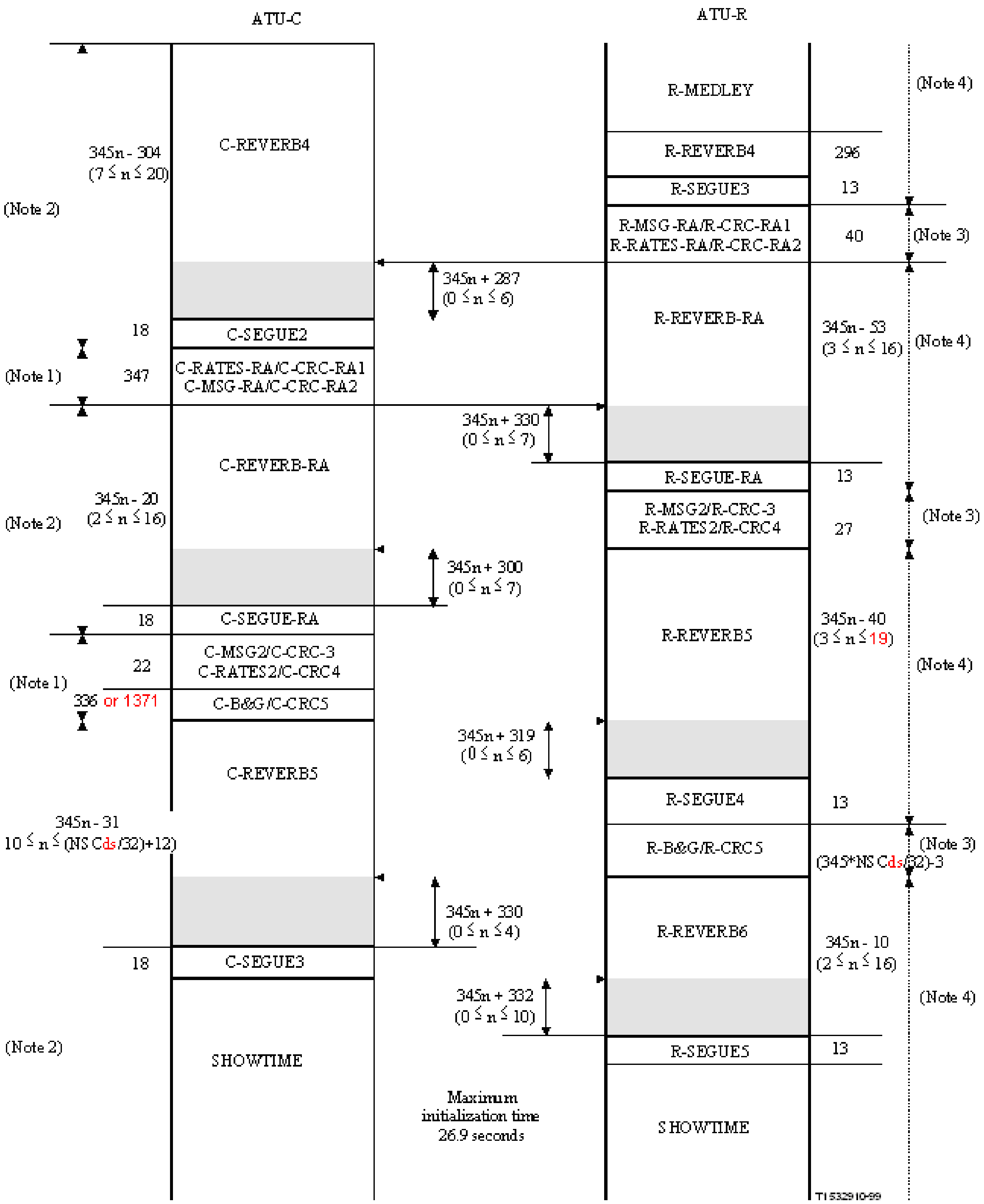


Figure Q.26/G.992.1 – Timing diagram of the initialization sequence – Part 1



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.

Table Q.19/G.992.1 – Format of the bit swap request message

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

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.

Table Q.20/G.992.1 – Bit swap request command

Value (8 bit)	Interpretation
$yzz00000_2$	Do nothing
$yzz00001_2$	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
$yzz00110_2$	Reduce the transmitted power by 1 dB
$yzz00111_2$	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	

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:

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

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.

Table Q.21/G.992.1 – Format of the bit swap request message

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)

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 → increased number of subcarriers, NSCus=96
- Increased bit loading, beyond 15 bits/bin
- Extended framing → 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 also implements Annexes I and C.

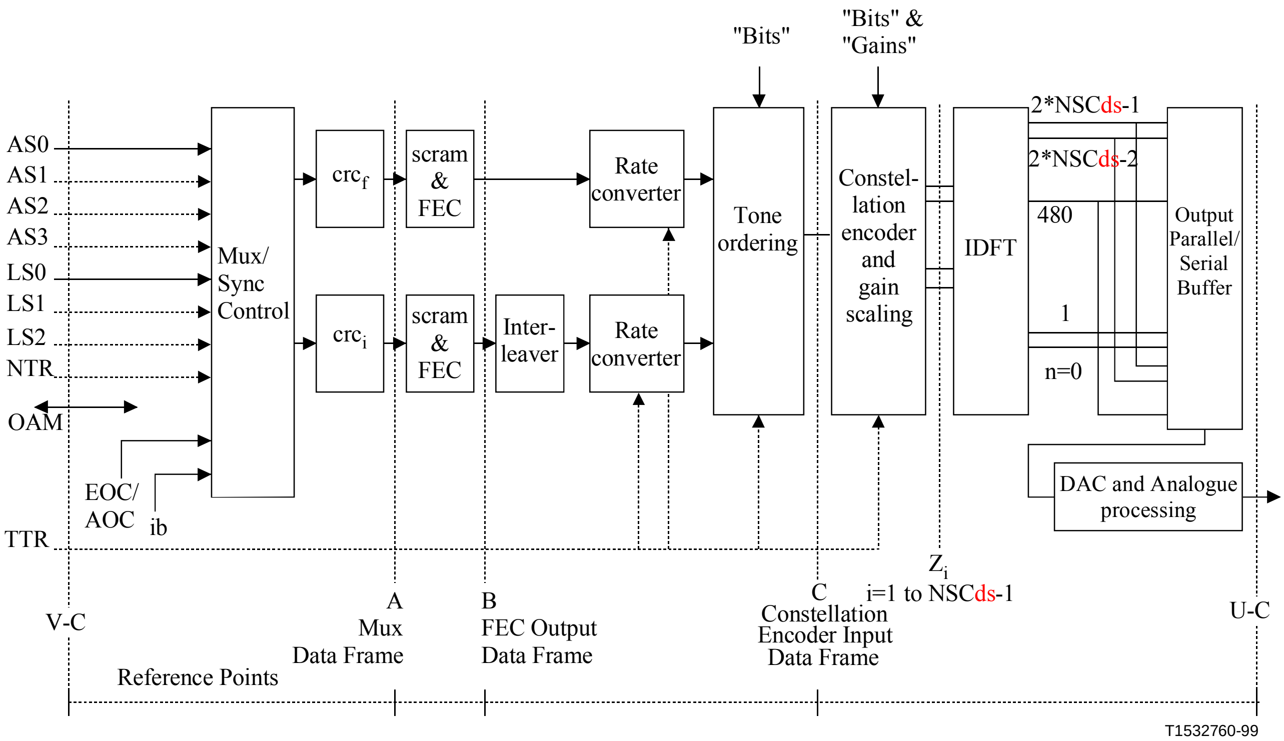
Q.2 Definitions

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 Bitmap	The Dual Bitmap method has dual bit rates under the FEXT and NEXT noise from TCM-ISDN
FEXT Bitmap	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	5 Superframes structure which synchronized TTR
$NEXT_C$ duration	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	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)

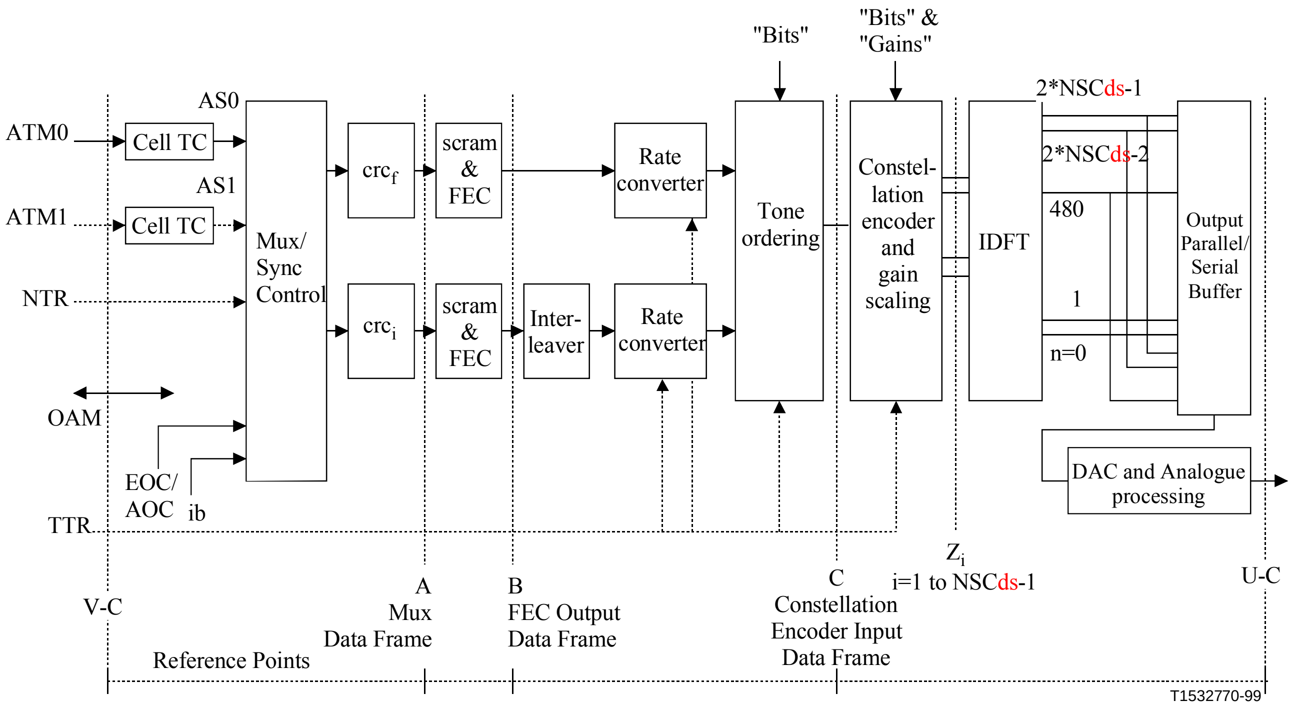
See Figure Q.1 and Figure Q.2.



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

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

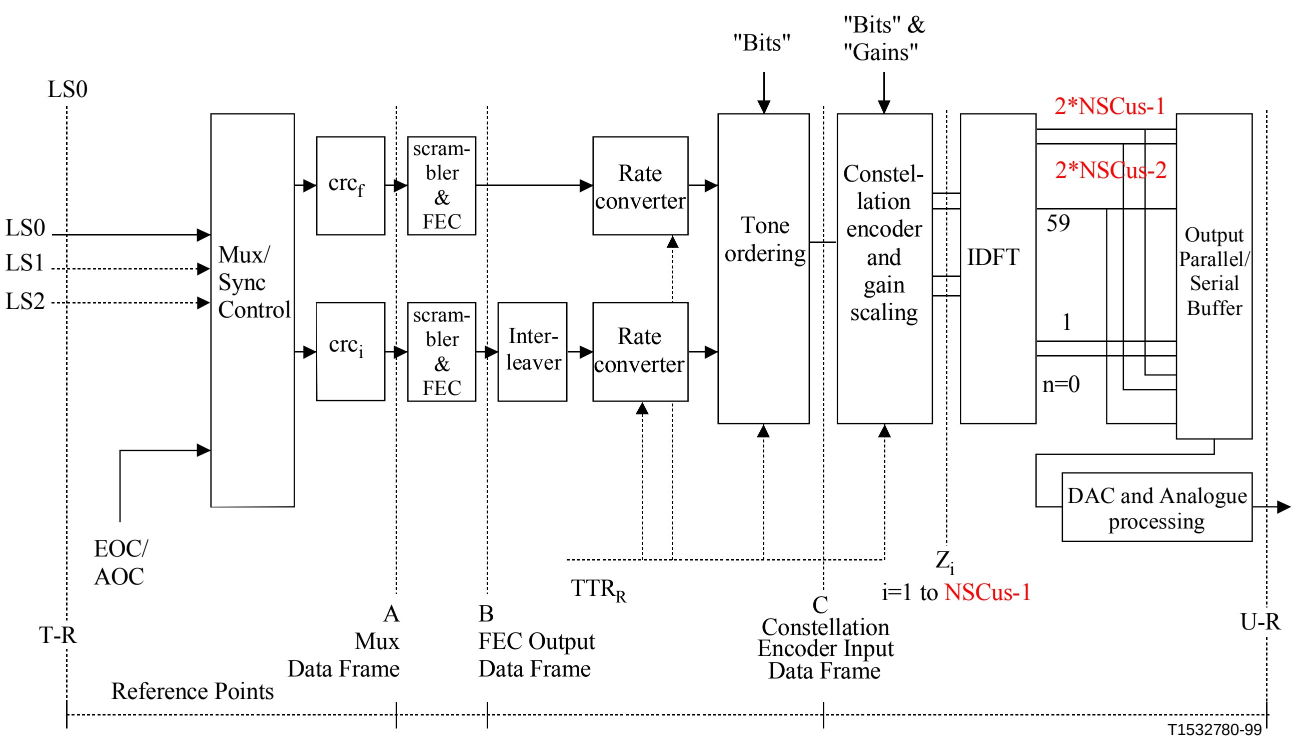


NOTE – The TTR may be generated in ATU-C without being provided from the TCM-ISDN clock.

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)

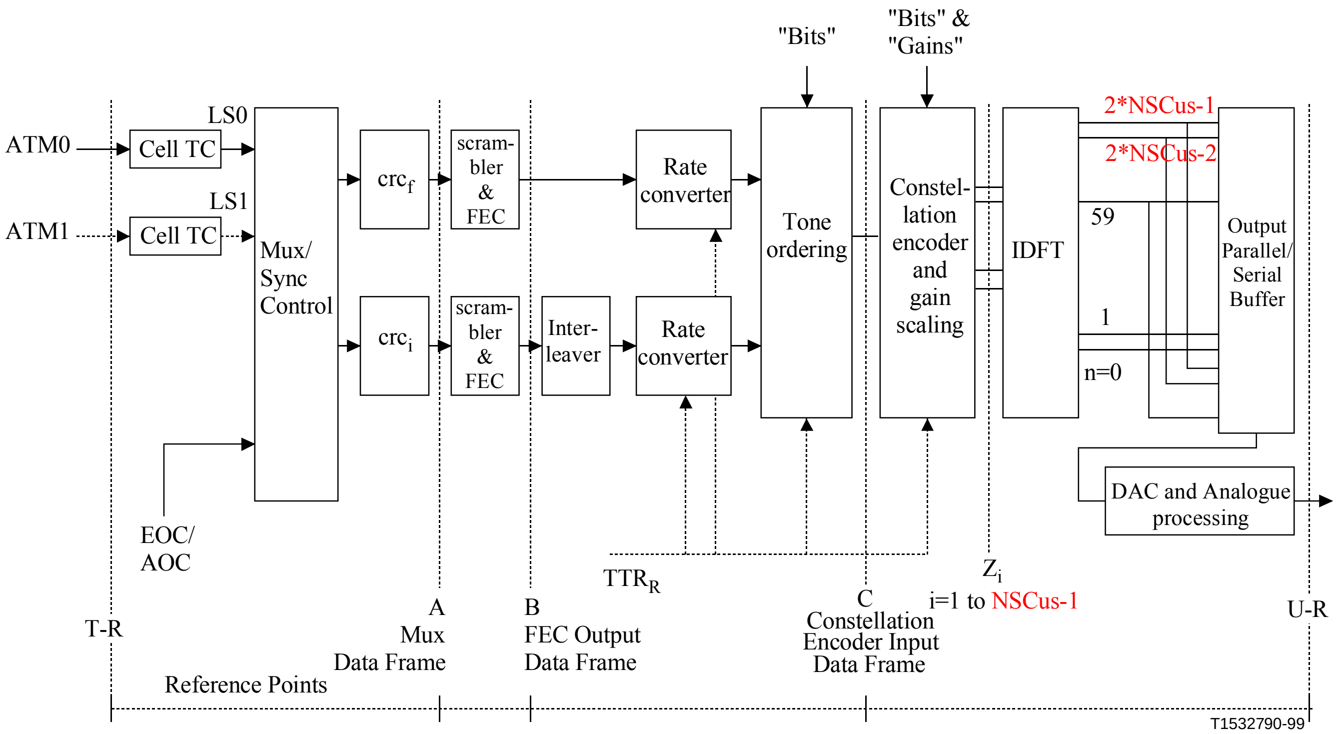
See Figure Q.3 and Figure Q.4.



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.



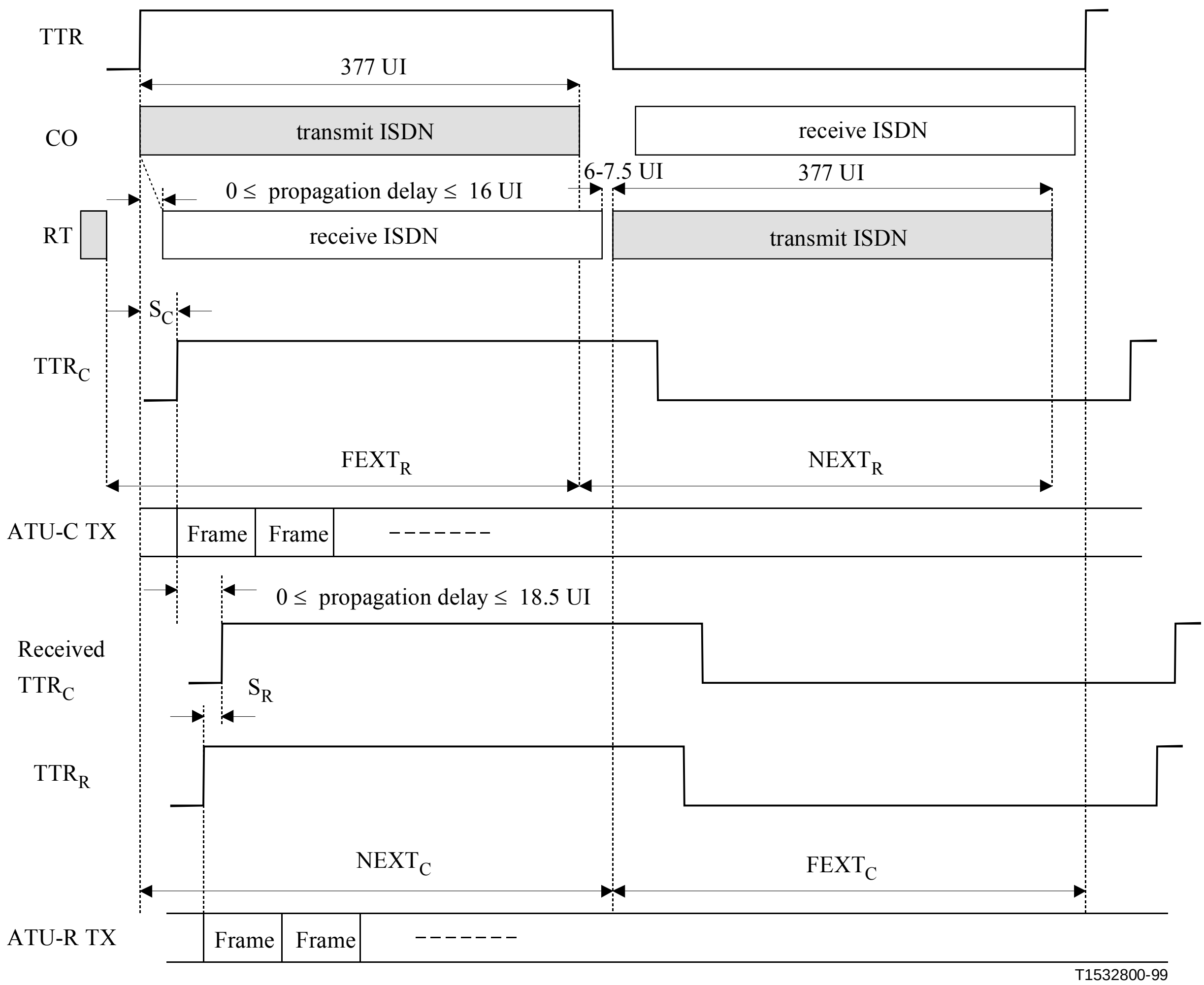
NOTE – The TTR_R shall be generated in ATU-R from the received TTR_C signal, and it is locked to 690 periods of upstream sampling clock (1.104 MHz).

Figure Q.4/G.992.1 – ATU-R transmitter reference model for ATM transport

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.



1 UI = 3.125 µs

$FEXT_R$ and **$NEXT_R$** are estimated by ATU-C

$FEXT_C$ and **$NEXT_C$** are estimated by ATU-R

TTR	TCM-ISDN timing reference
TTR_C	Timing reference used in ATU-C
Received TTR_C	Received TTR_C at ATU-R
TTR_R	Timing reference used in ATU-R
S_C	55 × 0.9058 µs: Offset from TTR to TTR_C
S_R	–42 × 0.9058 µs: Offset from received TTR_C to TTR_R

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.

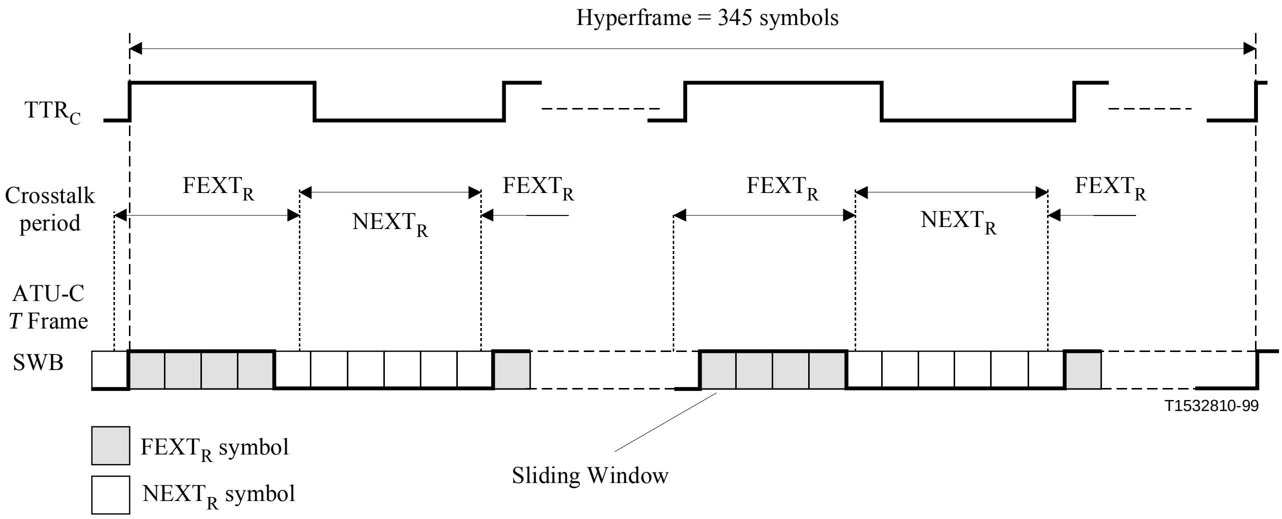


Figure Q.6/G.992.1 – Sliding window for downstream symbols

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

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.

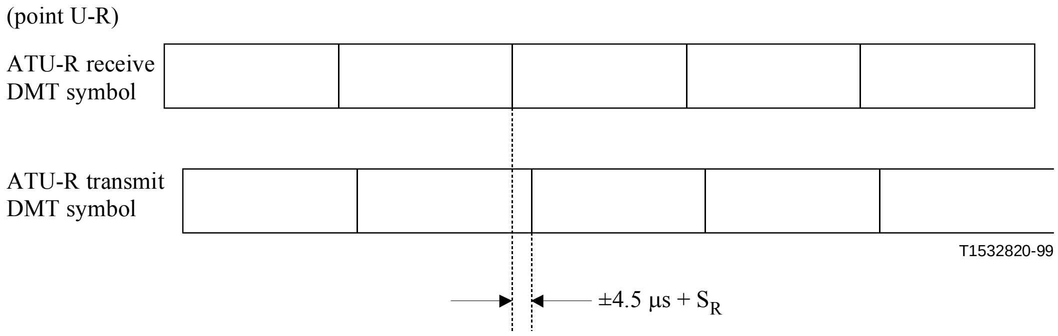


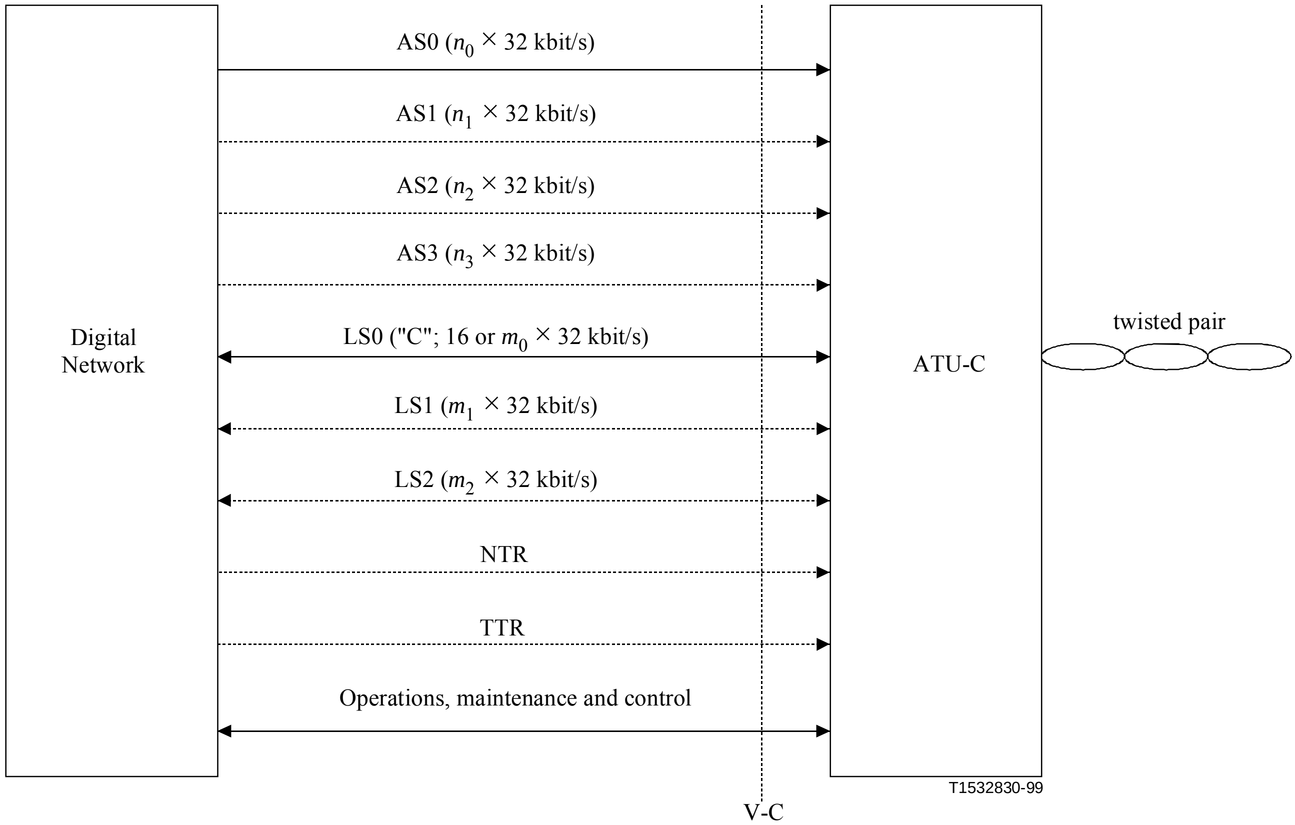
Figure Q.7/G.992.1 – Loop timing for ATU-R

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

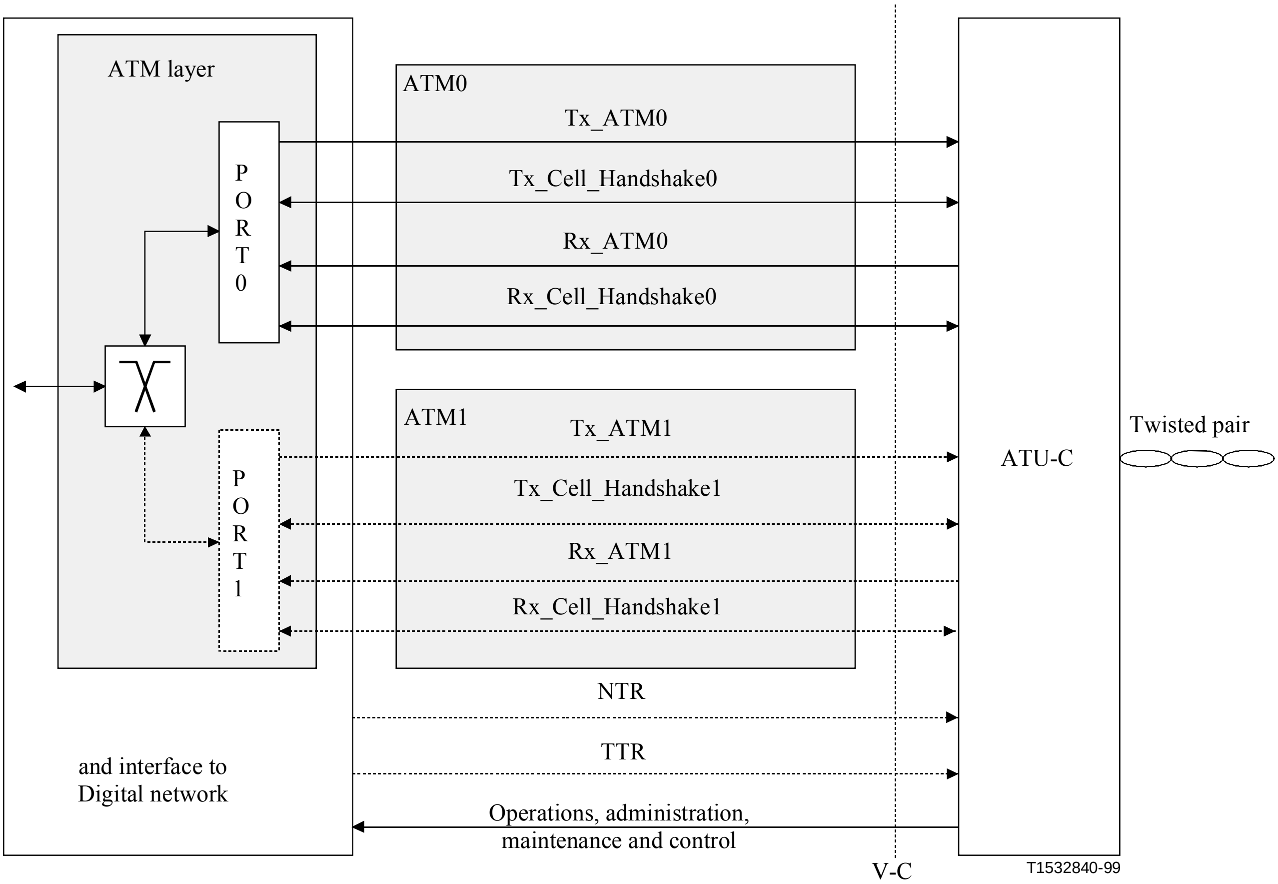
Q.4.1.2 Payload transfer delay (supplements 7.1.4)

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 $NEXT_R$ symbol in a $FEXT_R$ 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).

For N_{dmt} = 0, 1, ..., 344
    $S = 272 \times N_{dmt} \bmod 2760$
    if { (S + 271 < a) 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.

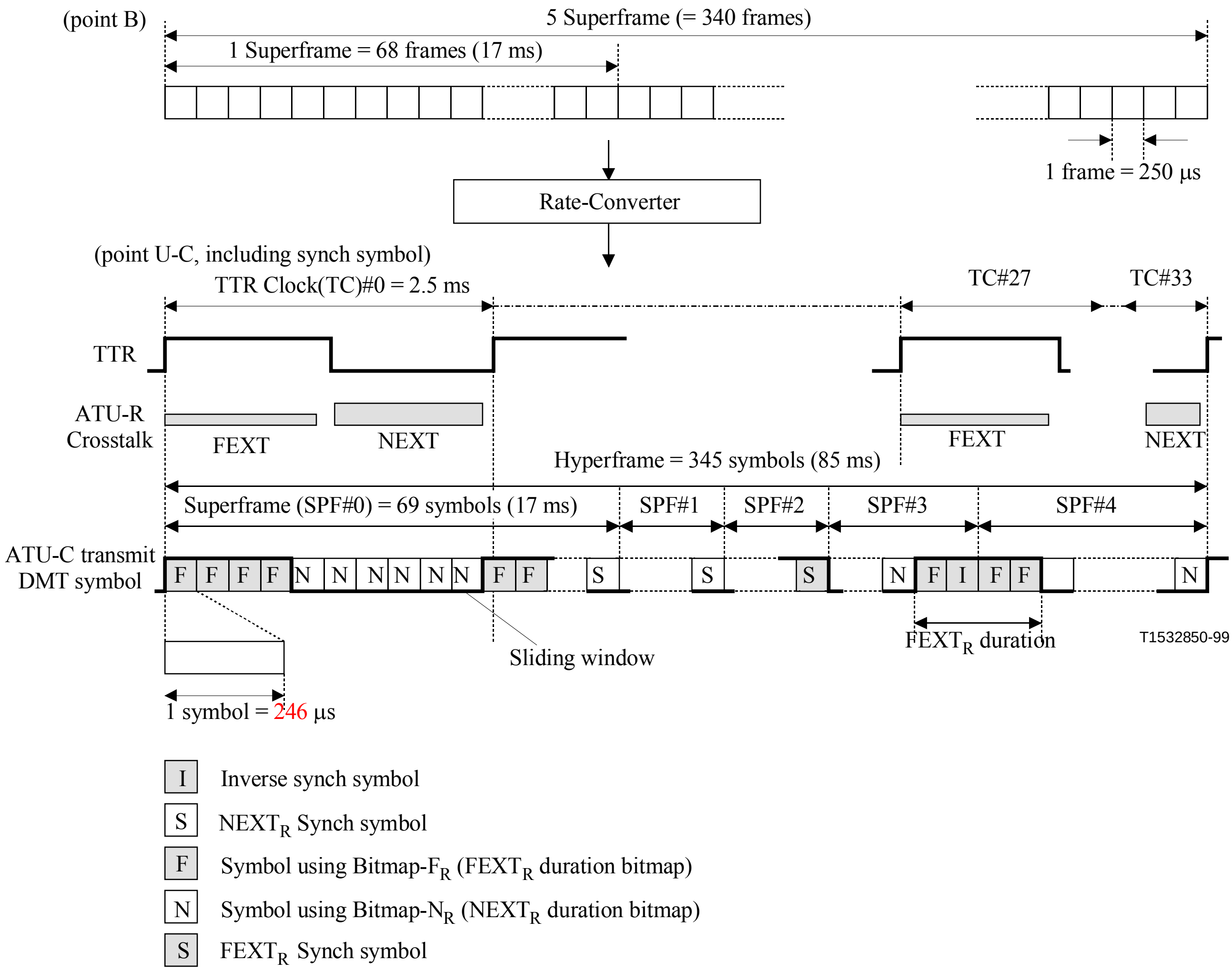


Figure Q.10/G.992.1 – Hyperframe structure for downstream

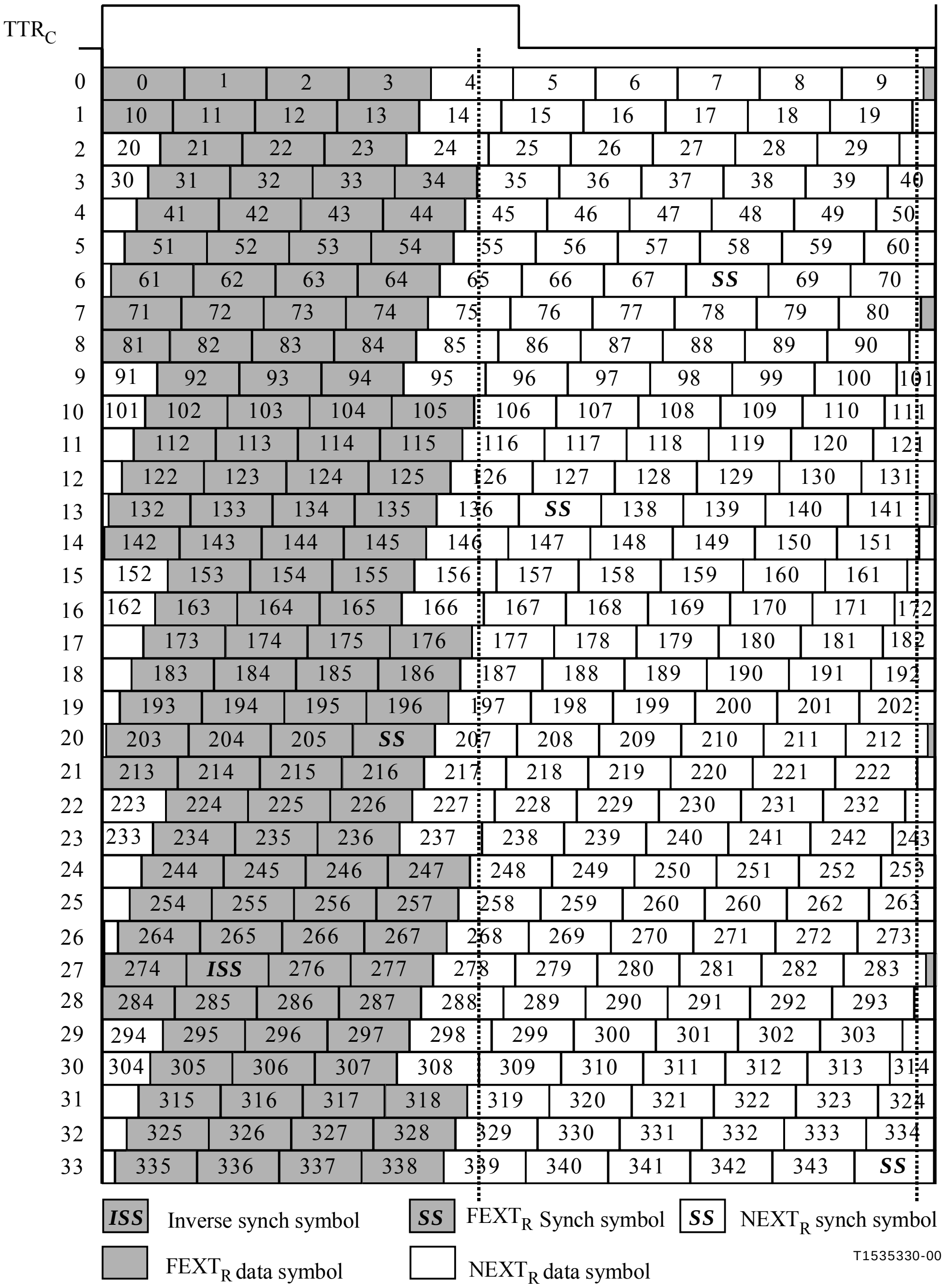


Figure Q.11/G.992.1 – Symbol pattern in a hyperframe with cyclic prefix – Downstream

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.

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

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

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 $t_{Rf} \le n_{R\max}$:

$$n_{Rf} = t_{Rf}$$
$$n_{Ri} = n_R - n_{Rf}$$
$$f_{Rf} = t_{Rf}$$
$$f_{Ri} = f_R - f_{Rf}$$

If $t_{Rf} > n_{R\max}$:

$$n_{Rf} = n_{R\max}$$
$$n_{Ri} = 0$$
$$f_{Rf} = \begin{cases} f_{Rf4} = \left\lceil \dfrac{t_{Rf} \times 10 - n_{Rf} \times 6}{4} \right\rceil \\ f_{Rf3} = \left\lceil \dfrac{t_{Rf} \times 10 - n_{Rf} \times 7}{3} \right\rceil \end{cases}$$
$$f_{Ri} = \begin{cases} f_{Ri4} = f_R = f_{Rf4} \\ f_{Ri3} = f_R - f_{Rf3} \end{cases}$$

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 for synch symbols.
f_{Rf4}	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.
n_R	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 $t_{Rf} \le n_{R\max}$:

$$dummy_{Rf} = 0$$

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

If $t_{Rf} > n_{R\max}$:

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

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

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

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:

$$dummy_{SRf} = f_{Rf\,3} - f_{Rf\,4}$$

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.

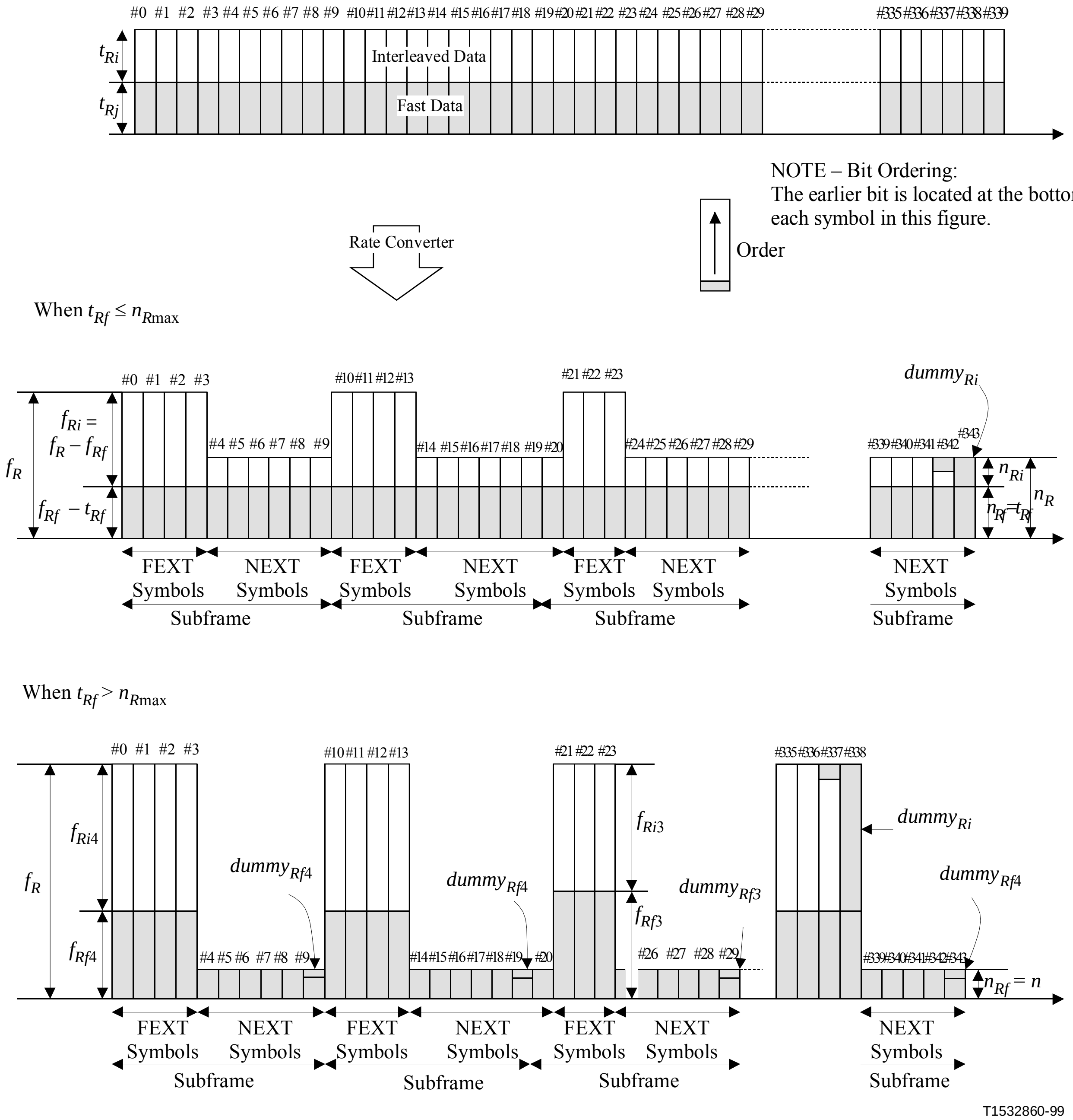


Figure Q.12/G.992.1 – Bit distribution for Rate Converter under Dual latency and Dual Bitmap mode

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:

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

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 = conj ($Z'_{2*NSCds-i}$) for i = NSCds+1 to 2*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, Δf = 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.

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

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,

$$(2 + 0.125)\text{*NSCds} \times 69 = (2 + 0.15625)\text{*NSCds} \times 68 \quad (7\text{-}24)$$

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

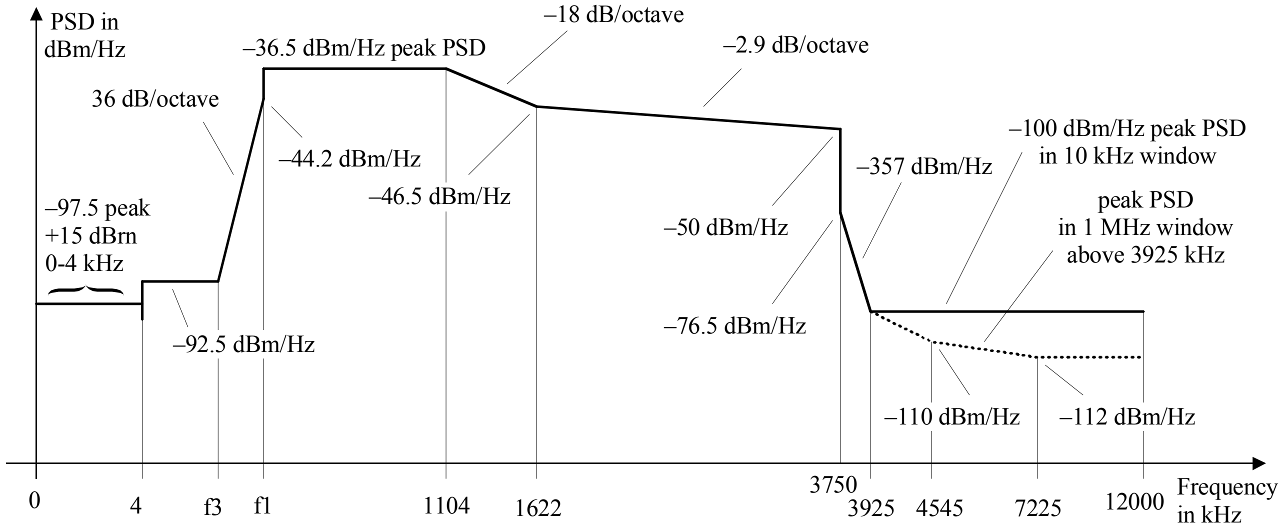
The cyclic prefix shall be used for all symbols beginning with the C-RATES1 segment of the initialization sequence, as defined in 10.6.2.

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*log2(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
f1	-44.2	10 kHz
f1	-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
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 ≤ 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.

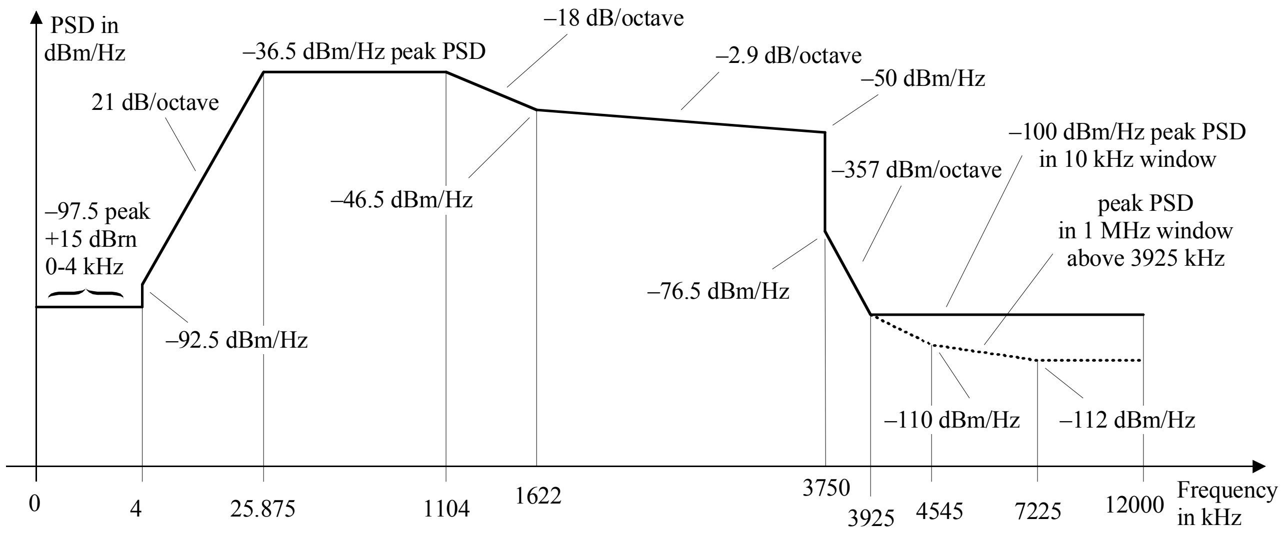
NOTE 6 – All PSD and power measurements shall be made at the U-C interface.

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*log2(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 ≤ 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:

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

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.

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

Tone Index	Log_ssv$_i$ (dB)	Comments
n1	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.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

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	$\sum_{i=32}^{2*NSCds-1} ssv_i^2 * g_i^2 \le \sum_{i=32}^{2*NSCds-1} ssv_i^2$

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 ≥ 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.

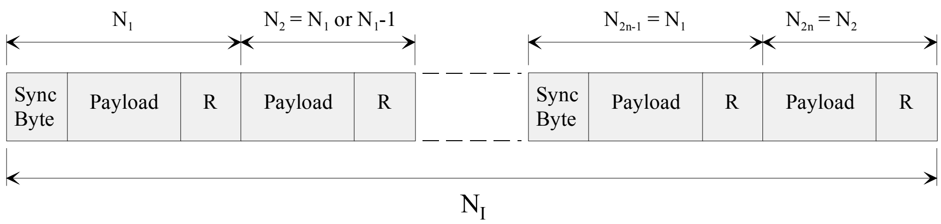


Figure Q.15 – Data frame for S = 1/2n mode

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.

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

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]

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

  $S = 272 \times N_{dmt} \bmod 2760$

  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.

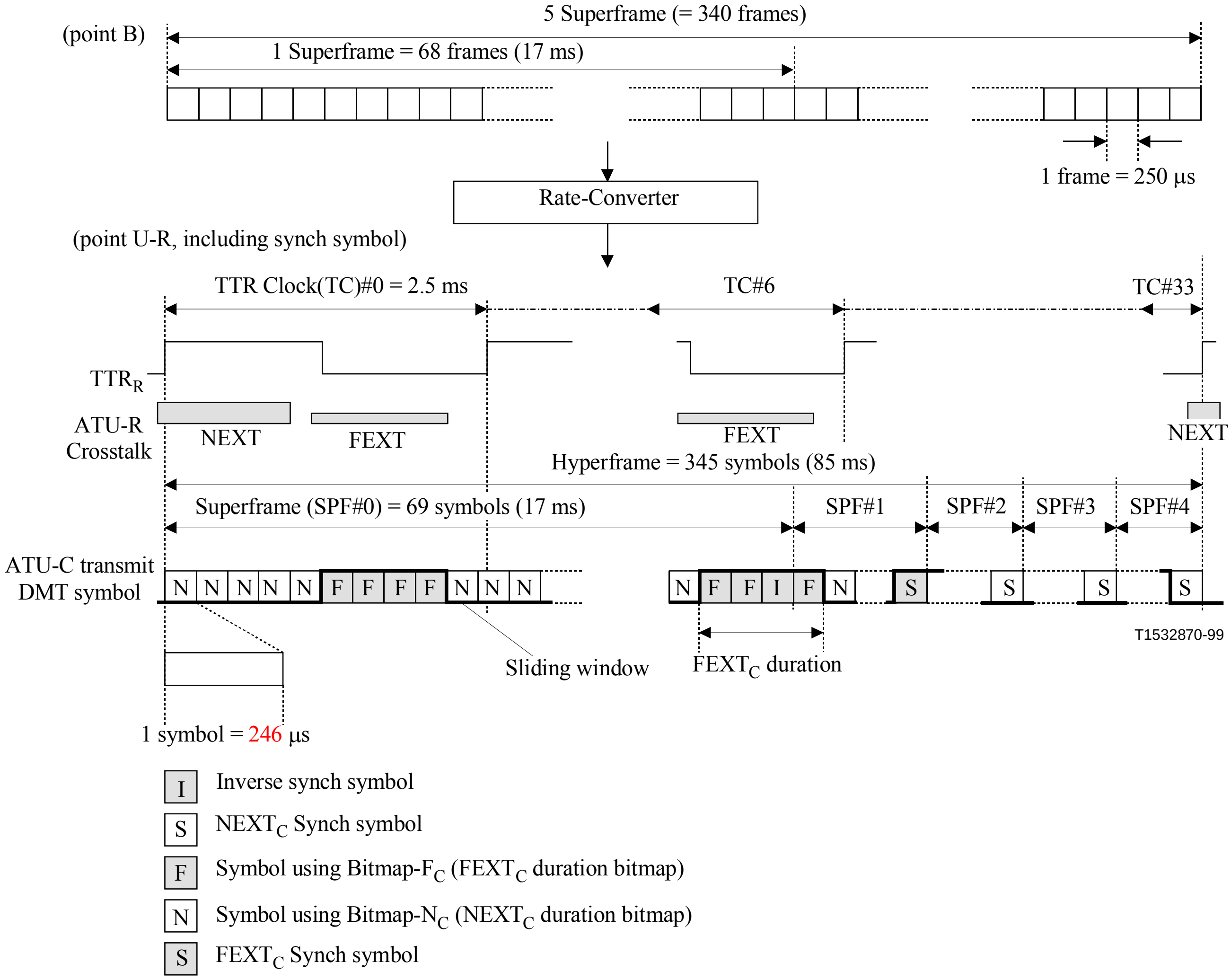


Figure Q.16/G.992.1 – Hyperframe structure for upstream

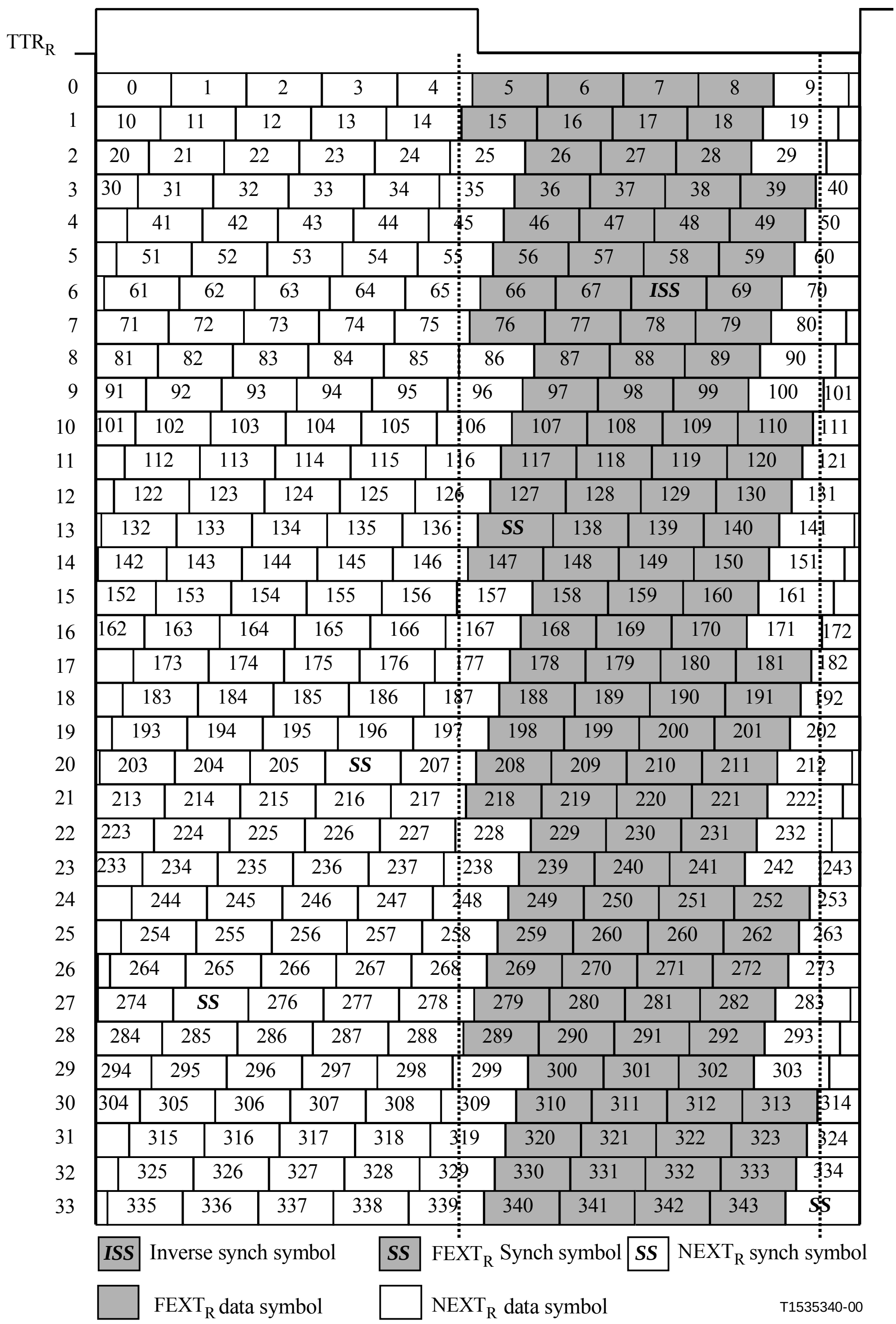


Figure Q.17/G.992.1 – Symbol pattern in a hyperframe with cyclic prefix – Upstream

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.

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

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

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 $t_{Cf} \le n_{C\max}$:

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

If $t_{Cf} > n_{C\max}$:

$$n_{Cf} = n_{C\max}$$
$$n_{Ci} = 0$$
$$f_{Cf} = \begin{cases} f_{Cf4} = \left\lceil \dfrac{t_{Cf} \times 10 - n_{Cf} \times 6}{4} \right\rceil \\ f_{Cf3} = \left\lceil \dfrac{t_{Cf} \times 10 - n_{Cf} \times 7}{3} \right\rceil \end{cases}$$
$$f_{Ci} = \begin{cases} f_{Ci4} = f_C - f_{C4} \\ f_{Ci3} = f_C - f_{Cf3} \end{cases}$$

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 for synch symbols.
f_{Cf4}	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.
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 $t_{Cf} \le n_{C\max}$:

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

If $t_{Cf} > n_{C\max}$:

$$dummy_{Cf4} = \left(f_{Cf} \times 4 + n_{Cf} \times 6\right) - t_{Cf} \times 10$$
$$dummy_{Cf3} = \left(f_{Cf} \times 3 + n_{Cf} \times 7\right) - t_{Cf} \times 10$$
$$dummy_{Ci} = \left(f_{Ci4} \times 96 + f_{Ci3} \times 30\right) - t_{Ci} \times 340$$

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)

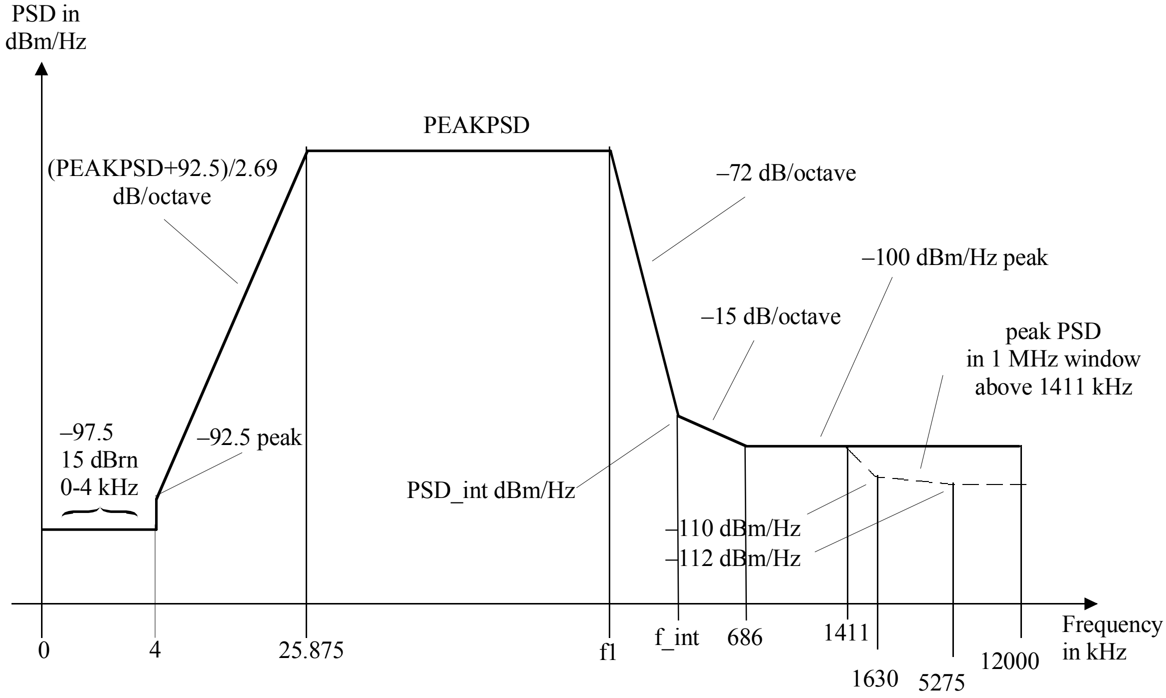
For Annex Q-EU, see A.2.2.

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:

Parameters in FEXT bitmap for mode 1, both bitmaps 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 ≤ fj, where fj is the frequency of the next specified breakpoint.

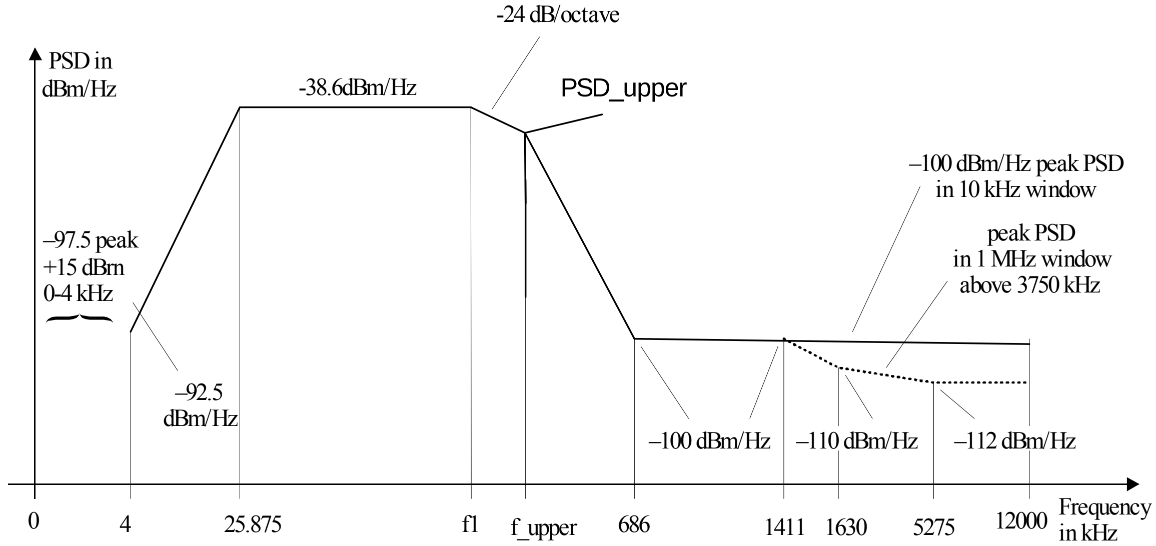
NOTE 4 – The power in a 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency i.e. power in the [f, f + 1 MHz] window shall conform to the specification at frequency f.

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.



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_upper	$PEAKPSD-24*\log_2(f/f1)$
f_upper < f < 686	PSD_upper-((PSD_upper+100)/log2(686/f_upper))*log2(f/f_upper)
f > 686	-100

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 *f_upper* (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-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, …344
    S = 256 x 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 Q.20).

For N_{dmt} = 0, 1, …, 344,
    S = 256 x 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 x 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 Q.17).

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

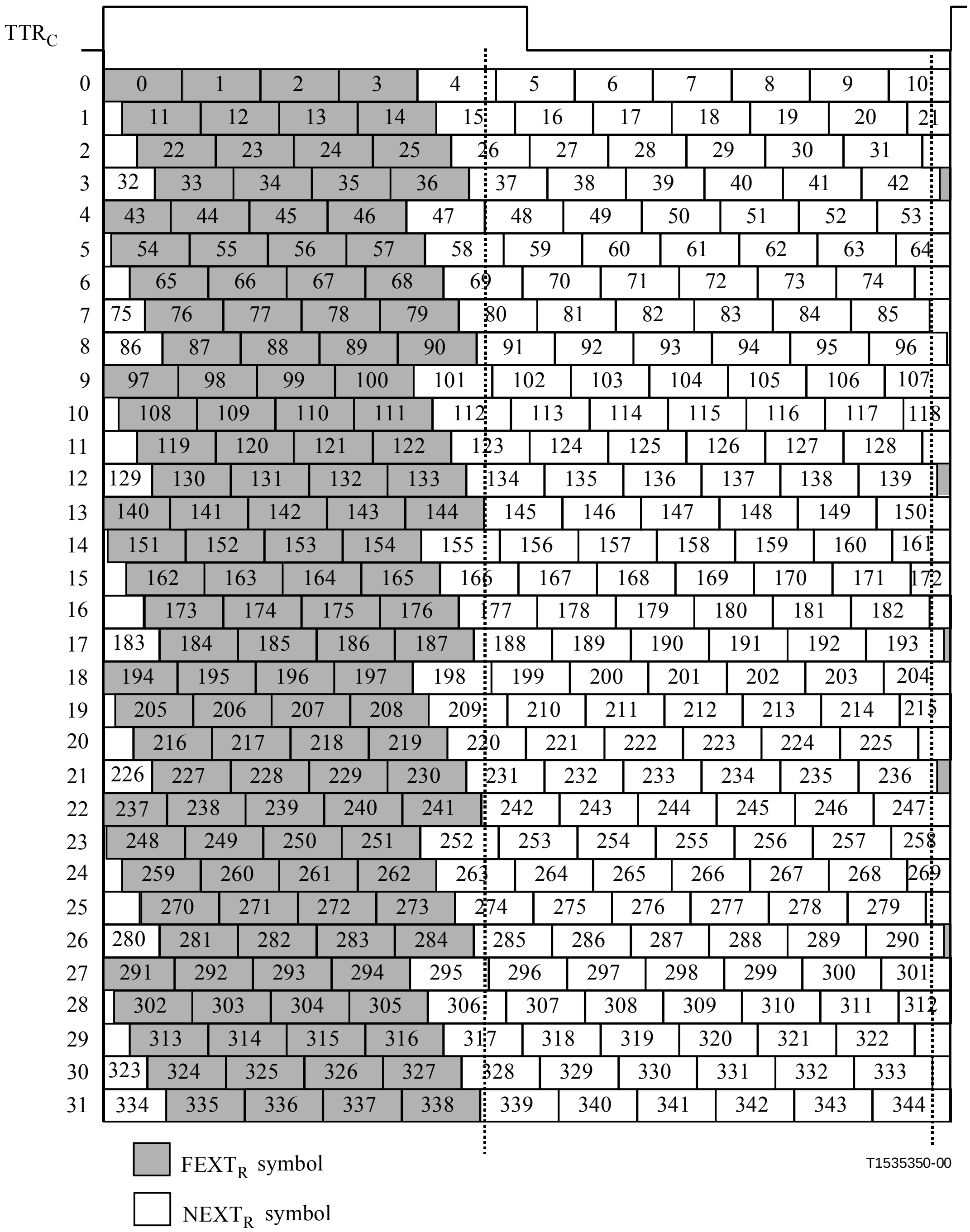


Figure Q.19/G.992.1 – Symbol pattern in a hyperframe without cyclic prefix – Downstream

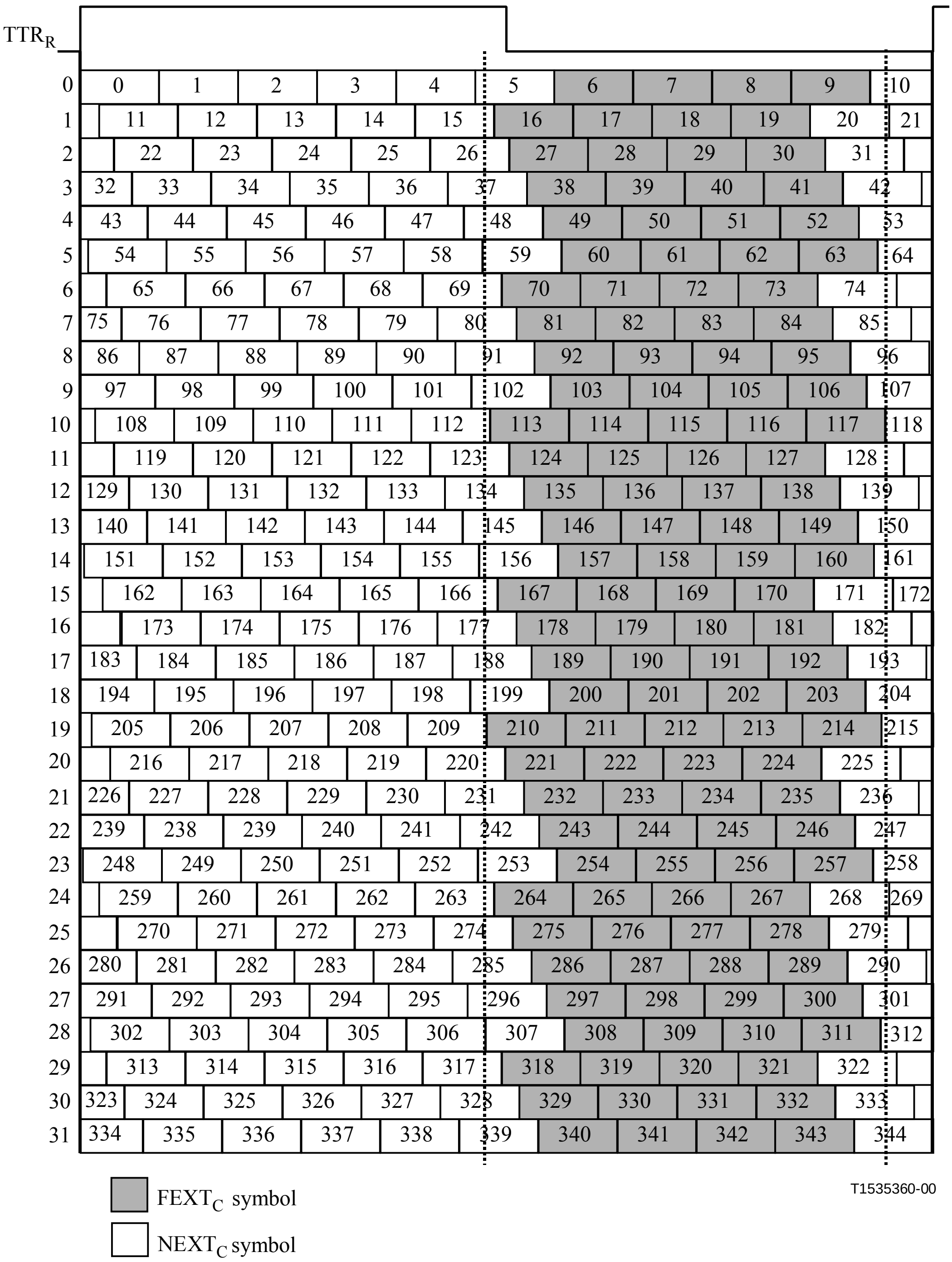


Figure Q.20/G.992.1 – Symbol pattern in a hyperframe without cyclic prefix – Upstream

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-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 §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".

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

Bits 8	7	6	5	4	3	2	1	**NPar(1)s**
x	x	x	x	x	x	x	1	Reserved for future use
x	x	x	x	x	x	1	x	Reserved for future use
x	x	x	x	x	1	x	x	Reserved for future use
x	x	x	x	1	x	x	x	Reserved for future use
x	x	x	1	x	x	x	x	Reserved for future use
x	x	1	x	x	x	x	x	Reserved for future use
x	1	x	x	x	x	x	x	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

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

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**
x	x	x	x	x	x	x	1	$n_{C\text{-}PILOT1} = 64$
x	x	x	x	x	x	1	x	$n_{C\text{-}PILOT1} = 128$
x	x	x	x	x	1	x	x	$n_{C\text{-}PILOT1} = 256$
x	x	x	x	1	x	x	x	Amateur radio notch – 1.8 MHz band
x	x	x	1	x	x	x	x	Amateur radio notch – 3.5 MHz band
x	x	1	x	x	x	x	x	$n_{C\text{-}PILOT1} = 96$
x	x	0	0	0	0	0	0	No parameters in this octet
Since A48 is the only TTR indication signal specified for Annex Q-EU, there is no need to include it in G.994.1.								

Table Q.7.1.1 – Non-standard information field – G.992.1 Annex Q NPar(2) coding – Octet 2

Bits 8	7	6	5	4	3	2	1	**G.992.1 Annex Q NPar(2)s – Octet 2**
x	x	x	x	x	x	x	1	R-ACK1
x	x	x	x	x	x	1	x	R-ACK2
x	x	x	x	x	1	x	x	Reserved for future use
x	x	x	x	1	x	x	x	Reserved for future use
x	x	x	1	x	x	x	x	Reserved for future use
x	x	1	x	x	x	x	x	G.997.1 – Clear EOC OAM
x	x	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.								

Table Q.7.2 – 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	x	x	x	x	x	x	1	Additional inband spectral shaping
x	x	x	x	x	x	1	x	Extended upstream
x	x	x	x	x	1	x	x	Reserved for future use
x	x	x	x	1	x	x	x	Reserved for future use
x	x	x	1	x	x	x	x	Reserved for future use
x	x	1	x	x	x	x	x	Reserved for future use
x	x	0	0	0	0	0	0	No parameters in this octet

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

Bits 8	7	6	5	4	3	2	1	G.992.1 Annex Q Additional inband spectral shaping Npar(3)s Octet 1
x	x					x	x	NOMINAL_PSD_lowband (bits 8 & 7)
x	x	x	x	x	x			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 8	7	6	5	4	3	2	1	G.992.1 Annex Q Additional inband spectral shaping Npar(3)s Octet 2
x	x	x	x	x	x	x	x	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					x	x	PSD level at 1622 kHz (bits 8 & 7)
x	x	x	x	x	x			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 8	7	6	5	4	3	2	1	G.992.1 Annex Q Additional inband spectral shaping Npar(3)s Octet 4
x	x	x	x	x	x	x	x	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	PSD level at 3750 kHz (bits 8 & 7)
x	x	x	x	x	x			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 8	7	6	5	4	3	2	1	G.992.1 Annex Q Additional inband spectral shaping Npar(3)s Octet 6
x	x	x	x	x	x	x	x	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	x	x	x	x	x	x	1	Mode 1 upstream mask
x	x	x	x	x	x	1	x	Mode 2 upstream mask
x	x	x	x	x	1	x	x	Optional upstream masks for non-overlapped spectrum
x	x	x	x	1	x	x	x	EU-64
x	x	x	1	x	x	x	x	EU-32
x	x	1	x	x	x	x	x	EU-36
x	x	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

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

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	x	x	x	X	x	x	1	EU-S68
x	x	x	x	X	x	1	x	EU-S72
x	x	x	x	X	1	x	x	EU-S76
x	x	x	x	1	x	x	x	EU-S80
x	x	x	1	x	x	x	x	EU-S84
x	x	1	x	x	x	x	x	EU-S88
x	x	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	x	x	x	X	x	x	1	EU-S92
x	x	x	x	X	x	1	x	EU-S96
x	x	x	x	X	1	x	x	Reserved for future use
x	x	x	x	1	x	x	x	Reserved for future use
x	x	x	1	x	x	x	x	Reserved for future use
x	x	1	x	x	x	x	x	Reserved for future use
x	x	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.

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

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.
$n_{C\text{-PILOT1}}=64$	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 64.
$n_{C\text{-PILOT1}}=96$	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 96.
$n_{C\text{-PILOT1}}=128$	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 128.
$n_{C\text{-PILOT1}}=256$	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.

Q.7.3.1.2 MS messages (supplements 10.2.2)

See Table Q.9.

Table Q.9/G.992.1 – ATU-C 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-C is selecting G.992.1 Annex Q, and possibly Annex Q-EU.
$n_{C\text{-}PILOT1}$=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).
$n_{C\text{-}PILOT1}$=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).
$n_{C\text{-}PILOT1}$=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).
$n_{C\text{-}PILOT1}$=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.

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.
$n_{C\text{-}PILOT1}=64$	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 64.
$n_{C\text{-}PILOT1}=96$	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 96.
$n_{C\text{-}PILOT1}=128$	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 128.
$n_{C\text{-}PILOT1}=256$	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.

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.
$n_{C\text{-}PILOT1}$=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).
$n_{C\text{-}PILOT1}$=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).
$n_{C\text{-}PILOT1}$=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).
$n_{C\text{-}PILOT1}$=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 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 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
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.
$n_{C\text{-}PILOT1}=64$	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the pilot tone on subcarrier 64 (Note 1).
$n_{C\text{-}PILOT1}=96$	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is proposing the pilot tone on subcarrier 96 (Note 1).
$n_{C\text{-}PILOT1}=128$	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the pilot tone on subcarrier 128 (Note 1).
$n_{C\text{-}PILOT1}=256$	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.
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 $f_{\text{C-PILOT1}}$ defined as:

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

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

8. $f_{\text{C-PILOT1}}$ = 276 kHz ($n_{\text{C-PILOT1}}$ = 64).
9. $f_{\text{C-PILOT1}}$ = 414 kHz ($n_{\text{C-PILOT1}}$ = 96).
10. $f_{\text{C-PILOT1}}$ = 552 kHz ($n_{\text{C-PILOT1}}$ = 128).
11. $f_{\text{C-PILOT1}}$ = 1104 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:

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.

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.

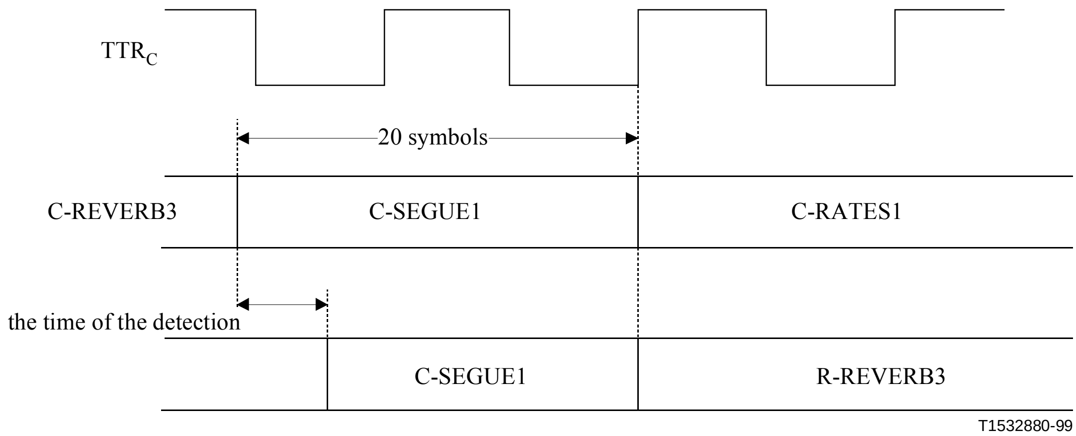


Figure Q.22/G.992.1 – Timing diagram from C-SEGUE1 to C-RATES1

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:

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

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:

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

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:

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

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 2^{14}-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

$S = 272 \times N_{dmt} \bmod 2760$

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).

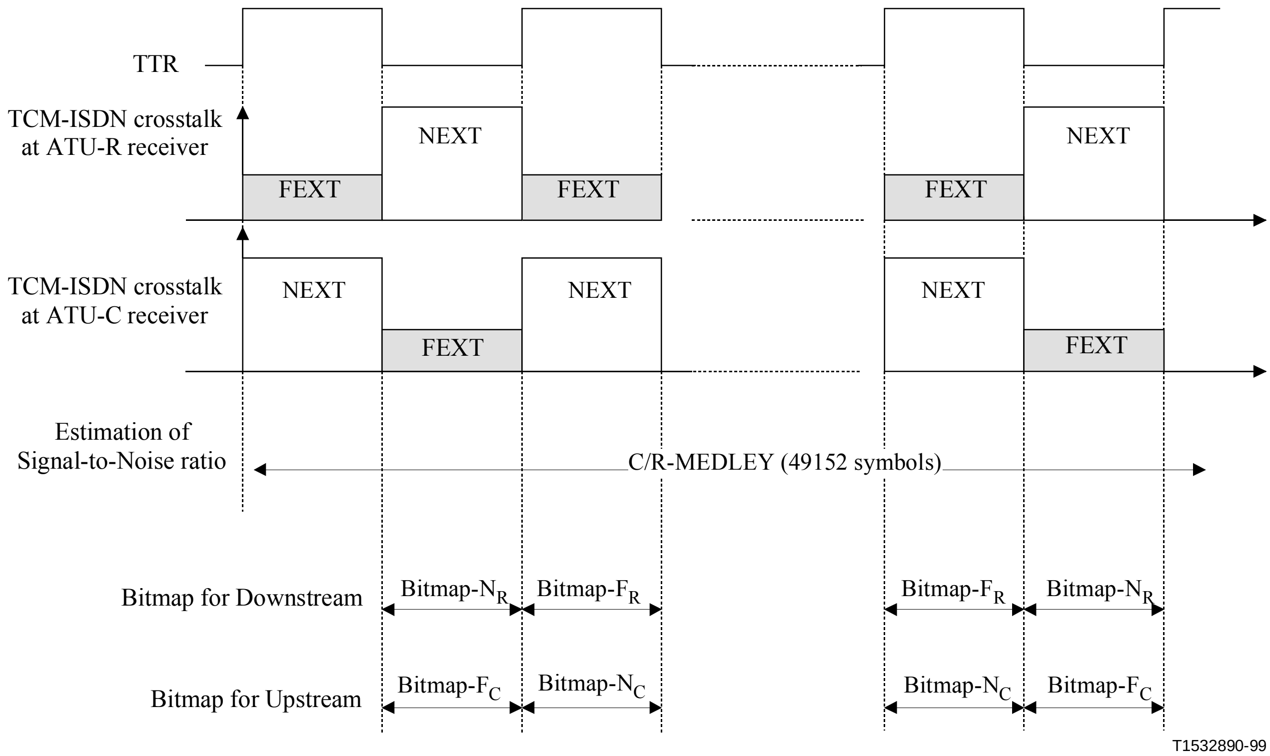


Figure Q.23/G.992.1 – Estimation of periodic Signal-to-Noise Ratio

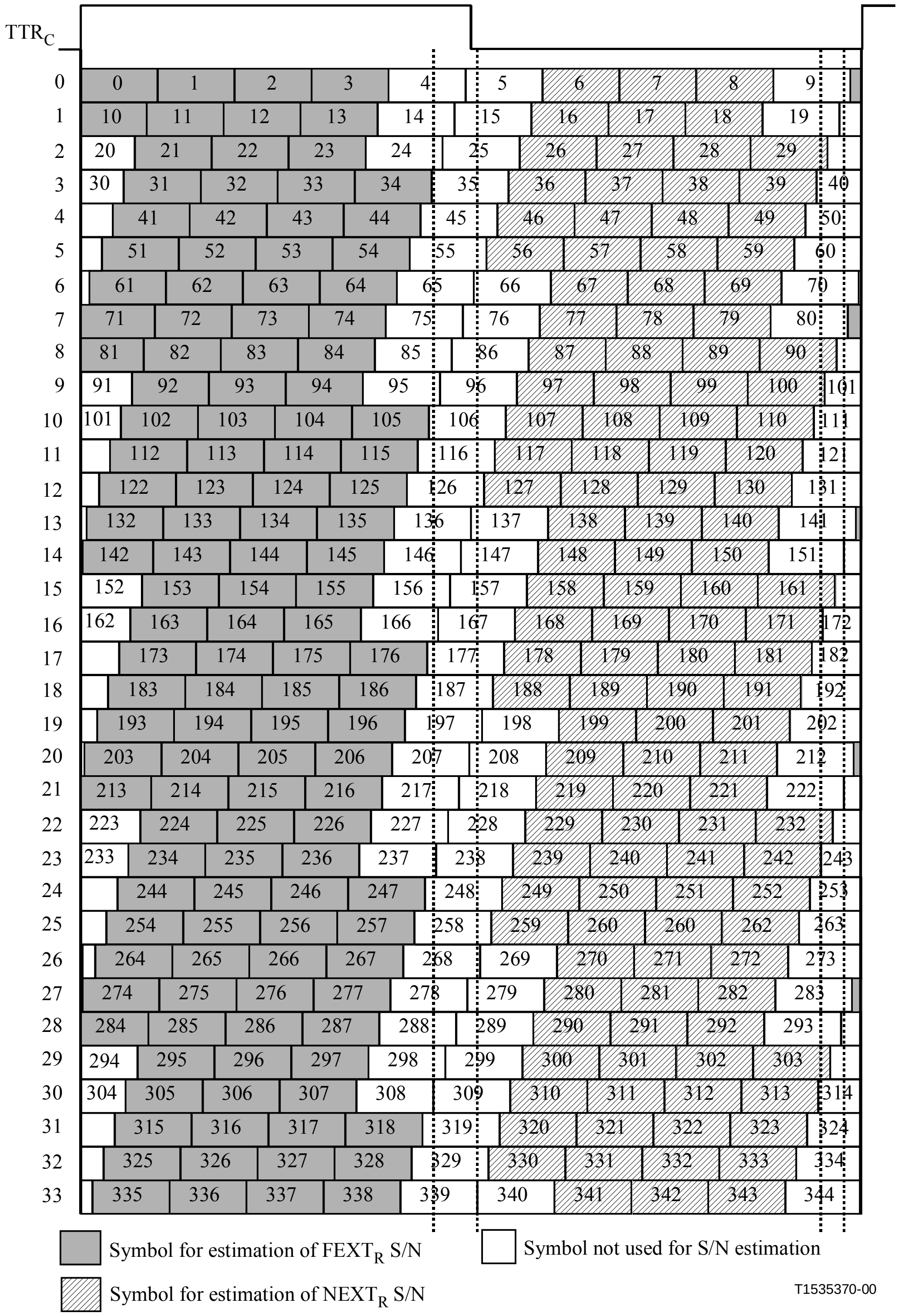


Figure Q.24/G.992.1 – Symbol pattern in a hyperframe for S/N estimation – Downstream

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., $RS_I = R_I/(n*S)$.

Q.7.6.4 C-MSG1 (supplements 10.6.4)

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; binary coded 0-15 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 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:

$$d_n = 1 \text{ for } n = 1 \text{ to } 23 \text{ and } d_n = d_{n-18} \oplus d_{n-23} \text{ for } n > 23.$$

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 x 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).

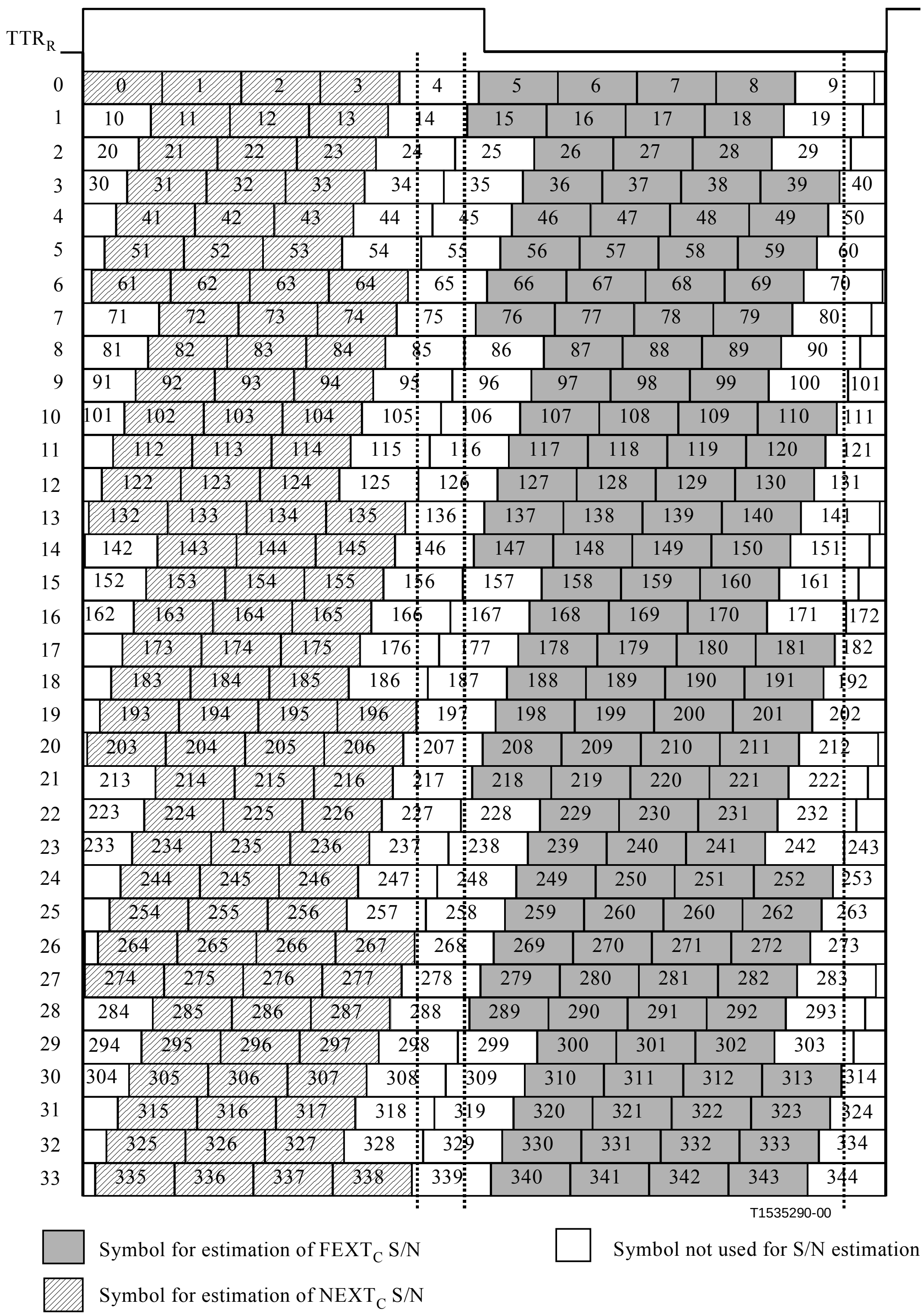


Figure Q.25/G.992.1 – Symbol pattern in a hyperframe for S/N estimation – Upstream

Q.7.8.4 R-MSG1 (supplements 10.7.6)

Table Q.14/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 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 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 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.

Table Q.15/G.992.1 – Assignment of 32 bits of C-MSG2

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".	

For NSCus=32,

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

Otherwise,

$n_{1C\text{-}MSG2} = 139$
$n_{2C\text{-}MSG2} = 187$

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 x 126 + 88 x 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), $\{m_{10}, ..., m_0\} = 00001111111_2$].

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

$\mathrm{NEXT_C}$ symbols; g_i of Bitmap-$\mathrm{N_C}$ indicates the scale factor that shall be applied to the (i – NSCus) th upstream carrier in $\mathrm{NEXT_C}$ 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}, $b_{2*\mathrm{NSCus}}$, and $g_{2*\mathrm{NSCus}}$ 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_is 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 (00000_2 and $00000000\ 000_2$, 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 (000.00110000_2 to 001.01010101_2).

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:

$$m = \{m_{32*(\mathrm{NSCu}-1)-1}, m_{32(\mathrm{NSCu}-1)-2}, \ldots, m_1, m_0\} = \{ g_{2*\mathrm{NSCu}-1}, b_{2*\mathrm{NSCu}-1}, \ldots, g_{\mathrm{NSCu}+1}, b_{\mathrm{NSCu}+1}, g_{\mathrm{NSCu}-1}, b_{\mathrm{NSCu}-1}, \ldots, g_1, b_1\}, \quad \text{(C.10-2)}$$

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) $\mathrm{FEXT_R}$ 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-$\mathrm{N_C}$ is disabled (FEXT Bitmap mode), b_i and g_i of Bitmap-$\mathrm{N_C}$ 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-$\mathrm{F_R}$ and Bitmap-$\mathrm{N_R}$ with the sliding window.

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

Q.7.9.4 C-RATES-RA (supplements 10.8.3)

Table Q.16/G.992.1 – RRSI fields of C-RATES-RA

	← bits →							
fields	7	6	5	4	3	2	1	0
RS_F	B_{10} (AS0)	0	value of RS_F MSB LSB					
RS_I	B_8 (AS0)	B_9 (AS0)	value of RS_I MSB LSB					
S	I_9	I_8	value of S MSB LSB					
I	I_7	I_6	I_5	I_4	I_3	I_2	I_1	I_0
FS(LS2)	value of FS(LS2) *set to* $\{00000000_2\}$							

The RS_I field has been extended to include bit B_9 of B_I (AS0) in bit 6, and The RS_F field has been extended to include the most significant bit B_{10} 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.

Table Q.17/G.992.1 – Assignment of 80 bits of R-MSG-RA (Annex Q-EU)

Suffix(ces) of m_i (Note)	Parameter 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	$B_{fast\text{-}max}$
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 separate fields the least significant bits have the lowest subscripts.	

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 $B_{fast\text{-}max}$ (new)

$B_{fast\text{-}max}$ 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 $B_{fast\text{-}max}$ is t_f.

Q.7.10.2 R-MSG2 (supplements 10.9.8)

Table Q.18/G.992.1 – Assignment of 32 bits of R-MSG2

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 - 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".	

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

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 96 is reserved as the pilot tone, b_{96} and $b_{NSCds+96}$, shall be set to 0, g_{96} and $g_{NSCds+96}$ 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 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) 001.01000000_2 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 (00000_2 and $00000000\ 000_2$, 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 (000.00110000_2 to 001.01010101_2).

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

$$m = \{m_{(2*NSCds-2)*16-1}, m_{(2*NSCds-2)*16-2}, \ldots, m_1, m_0\} = \{ g_{2*NSCds-1}, b_{2*NSCds-1}, \ldots, g_{NSCds+1}, b_{NSCds+1}, g_{NSCds-1}, b_{NSCds-1}, \ldots, g_1, b_1\}, \quad \text{(Q.10-3)}$$

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.

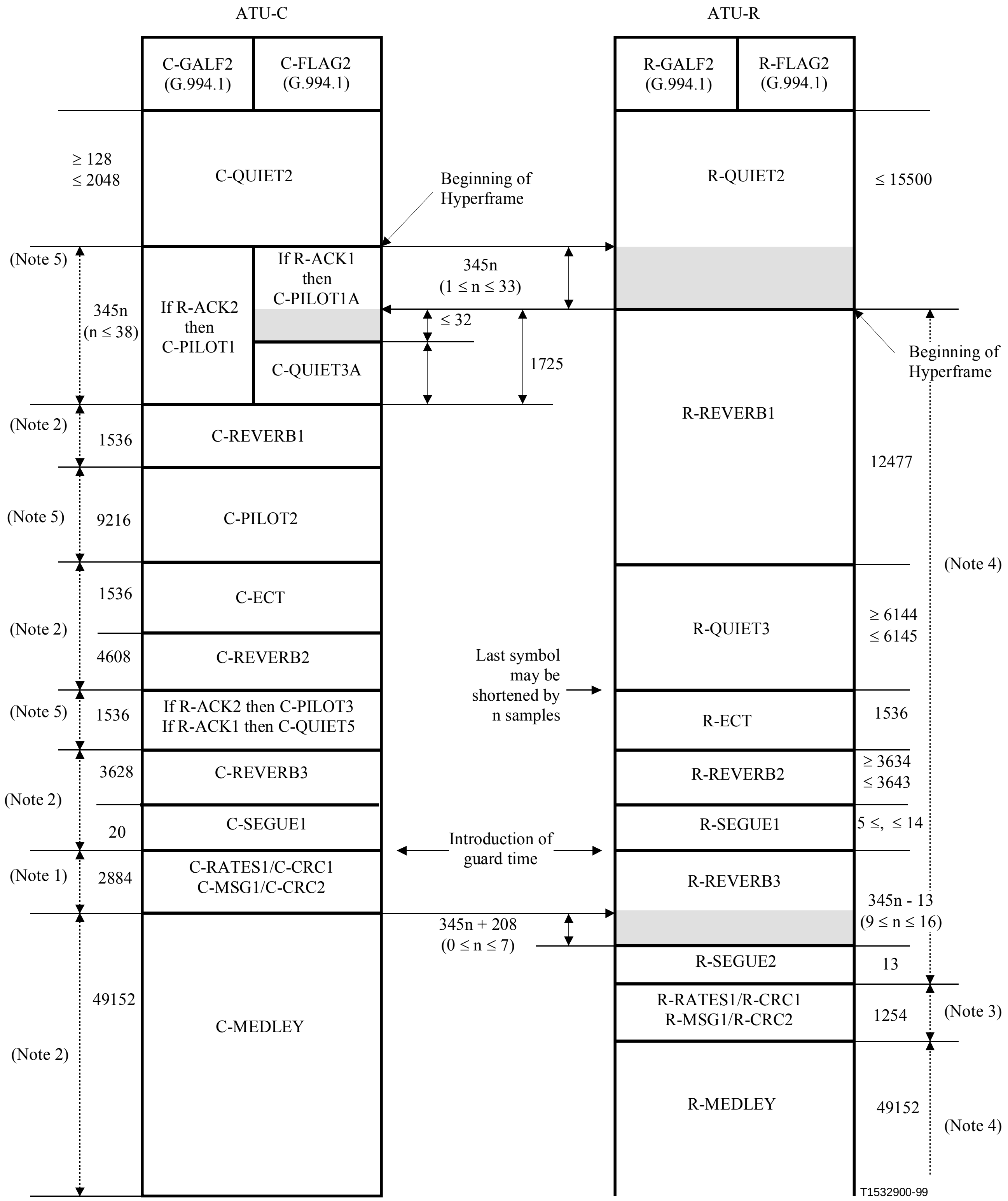
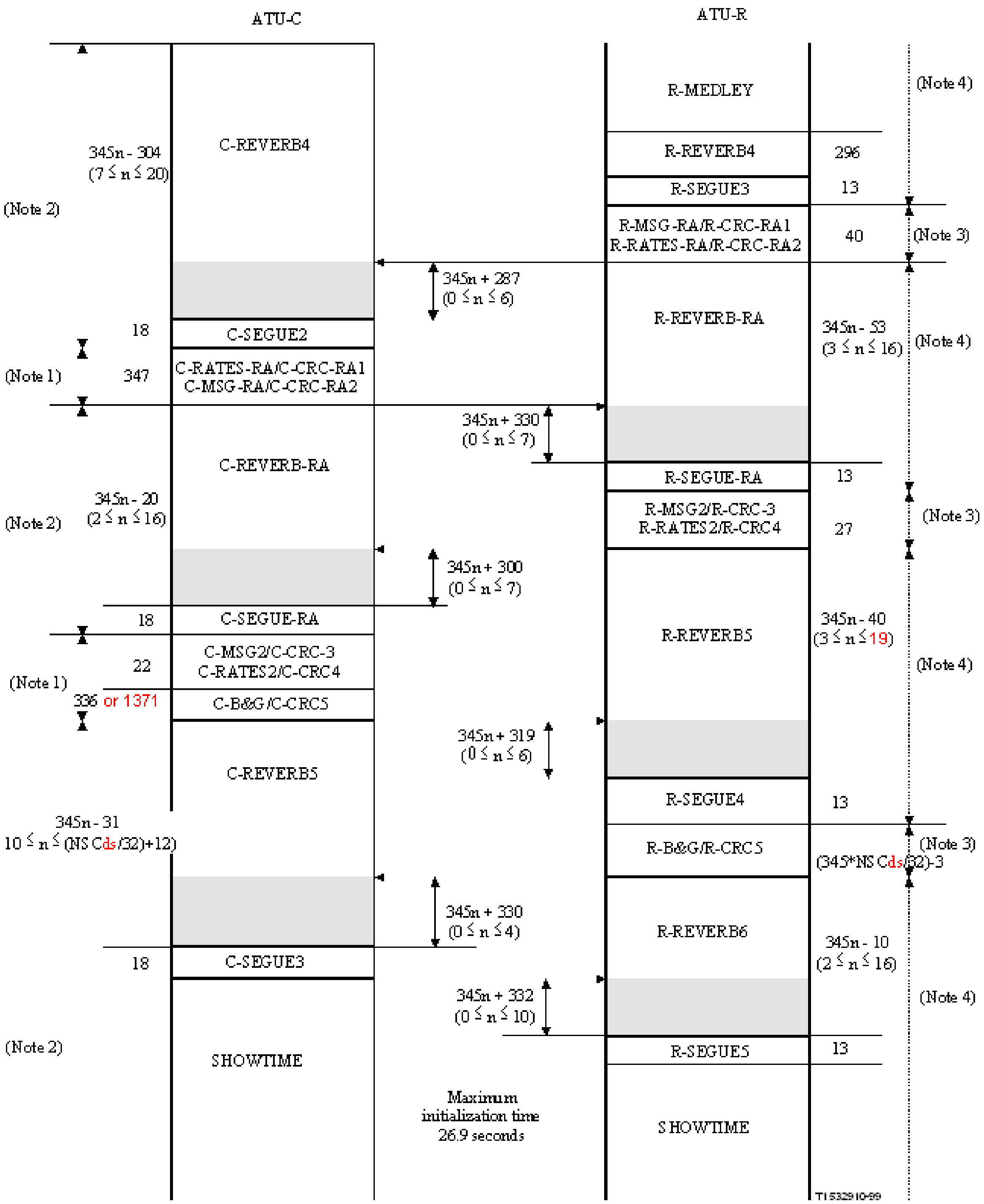


Figure Q.26/G.992.1 – Timing diagram of the initialization sequence – Part 1



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.

Table Q.19/G.992.1 – Format of the bit swap request message

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

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.

Table Q.20/G.992.1 – Bit swap request command

Value (8 bit)	Interpretation
$yzz00000_2$	Do nothing
$yzz00001_2$	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
$yzz00110_2$	Reduce the transmitted power by 1 dB
$yzz00111_2$	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	

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:

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

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.

Table Q.21/G.992.1 – Format of the bit swap request message

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)

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 → increased number of subcarriers, NSCus=112
- Increased bit loading, beyond 15 bits/bin
- Extended framing → 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 Q-EU also implements Annexes I and C.

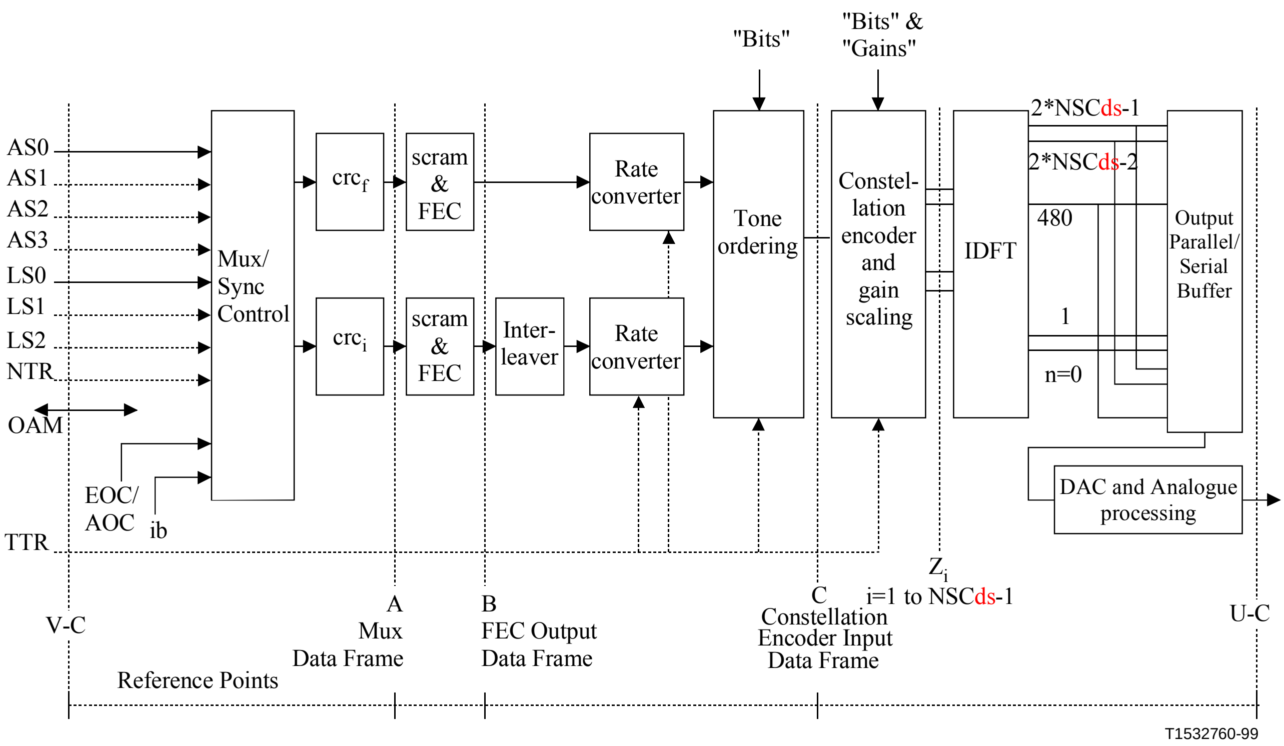
Q.2 Definitions

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 Bitmap	The Dual Bitmap method has dual bit rates under the FEXT and NEXT noise from TCM-ISDN
FEXT Bitmap	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	5 Superframes structure which synchronized TTR
$NEXT_C$ duration	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	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)

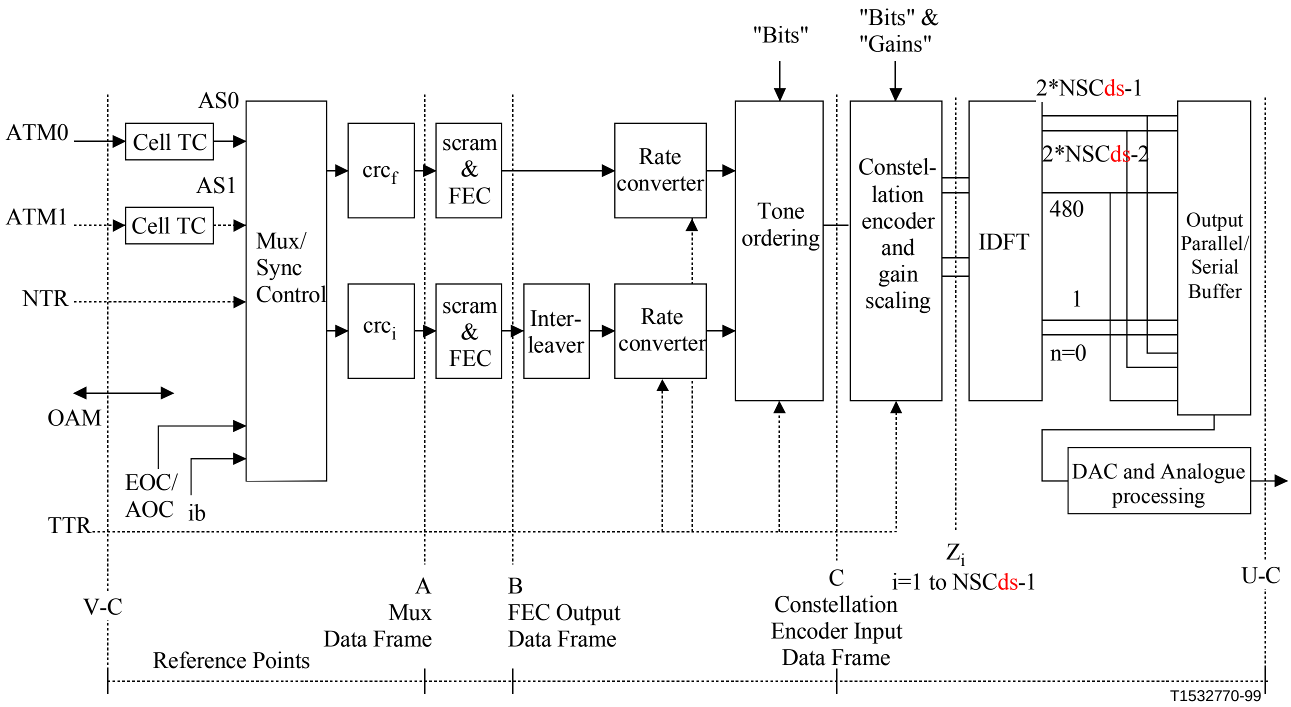
See Figure Q.1 and Figure Q.2.



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

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

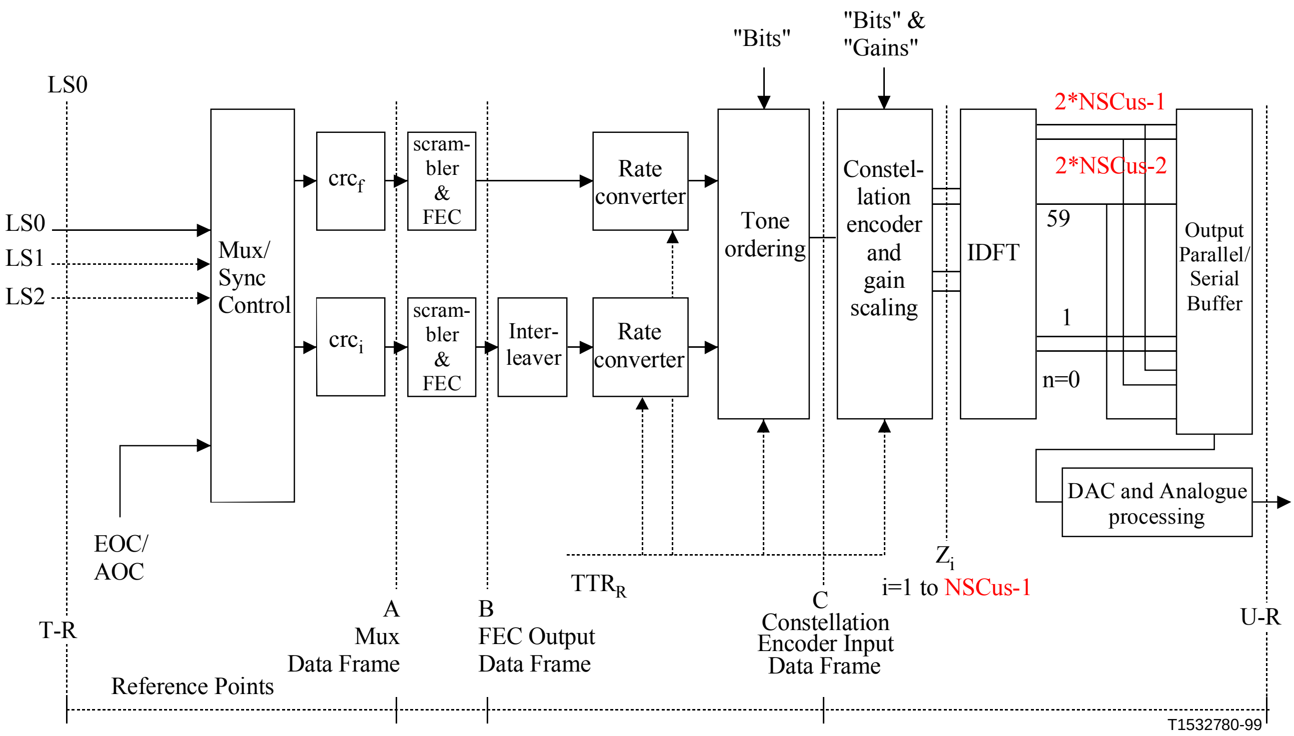


NOTE – The TTR may be generated in ATU-C without being provided from the TCM-ISDN clock.

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)

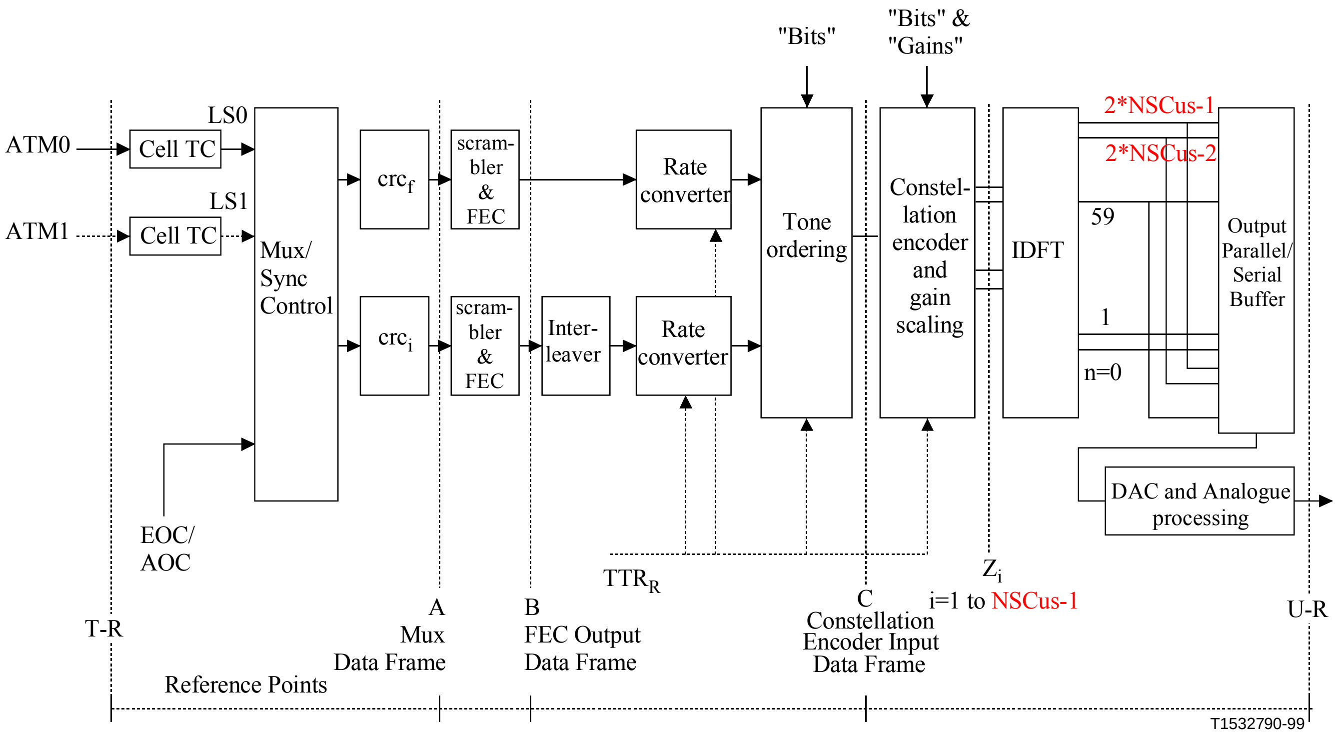
See Figure Q.3 and Figure Q.4.



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.



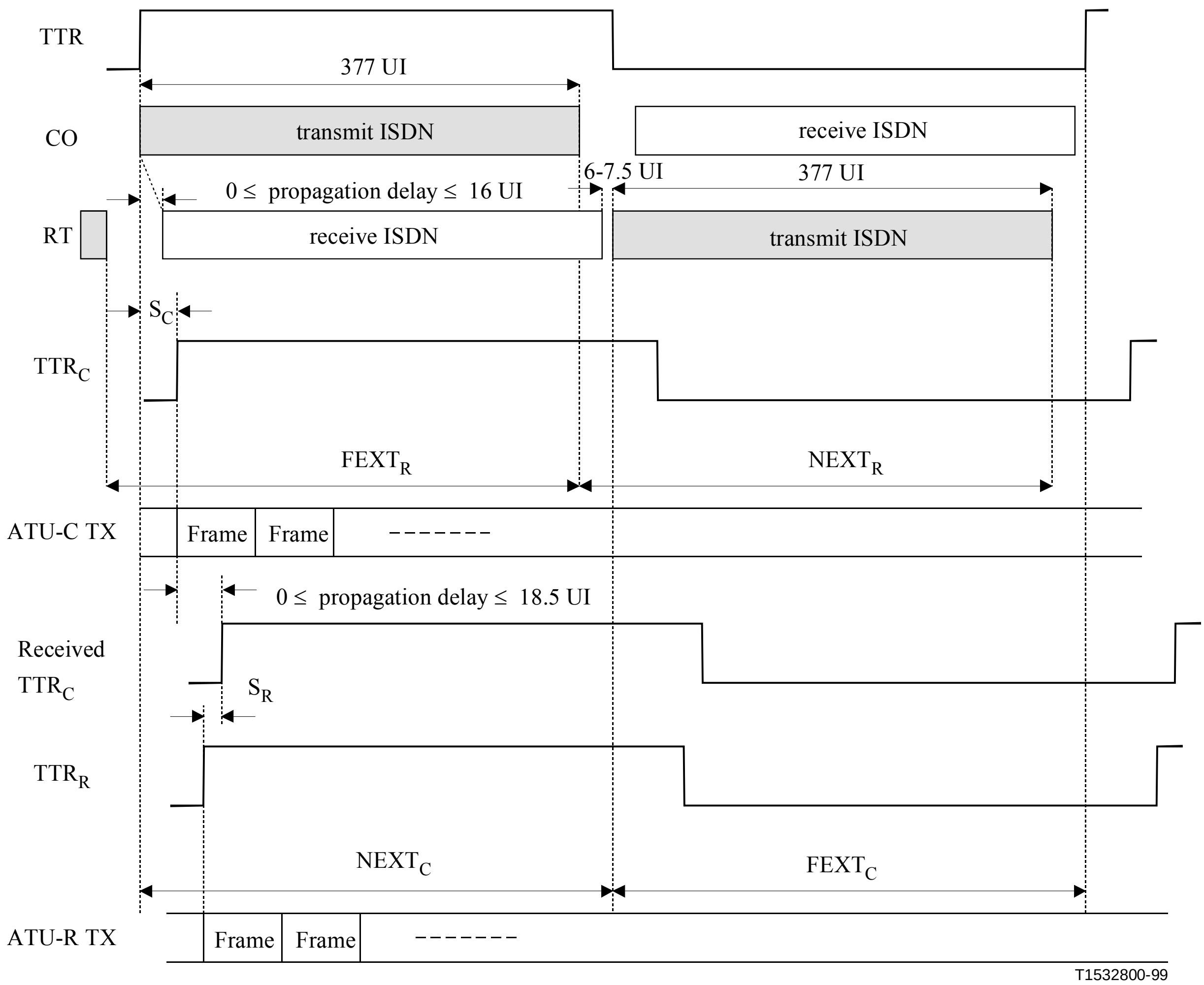
NOTE – The TTR_R shall be generated in ATU-R from the received TTR_C signal, and it is locked to 690 periods of upstream sampling clock (1.104 MHz).

Figure Q.4/G.992.1 – ATU-R transmitter reference model for ATM transport

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.



1 UI = 3.125 µs

FEXT$_R$ and **NEXT$_R$** are estimated by ATU-C

FEXT$_C$ and **NEXT$_C$** are estimated by ATU-R

TTR	TCM-ISDN timing reference
TTR$_C$	Timing reference used in ATU-C
Received TTR$_C$	Received TTR$_C$ at ATU-R
TTR$_R$	Timing reference used in ATU-R
S$_C$	55 × 0.9058 µs: Offset from TTR to TTR$_C$
S$_R$	–42 × 0.9058 µs: Offset from received TTR$_C$ to TTR$_R$

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.

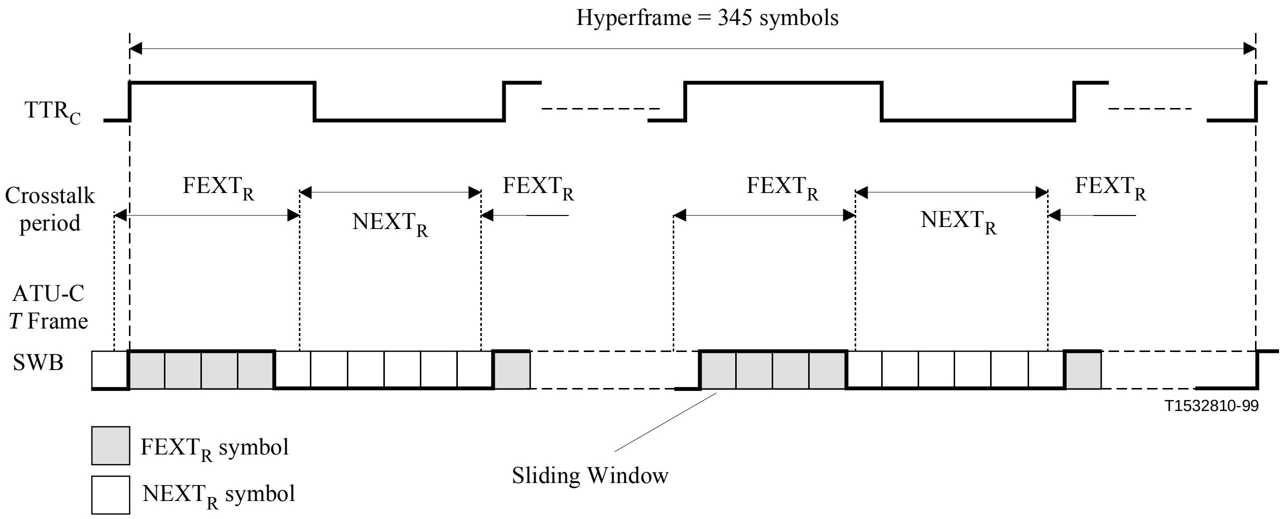


Figure Q.6/G.992.1 – Sliding window for downstream symbols

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

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.

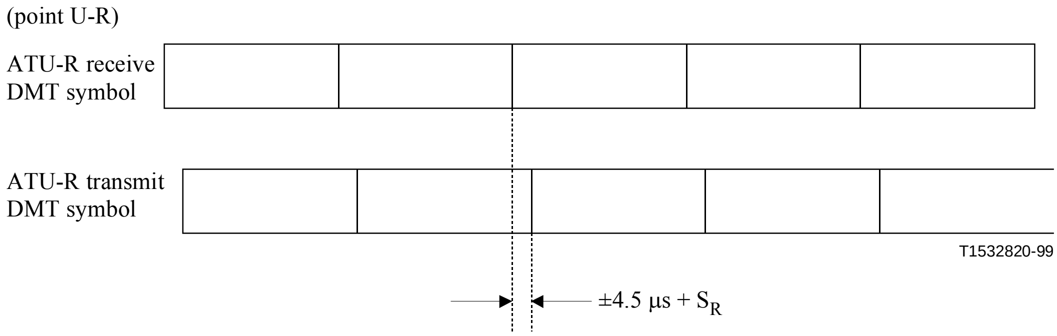


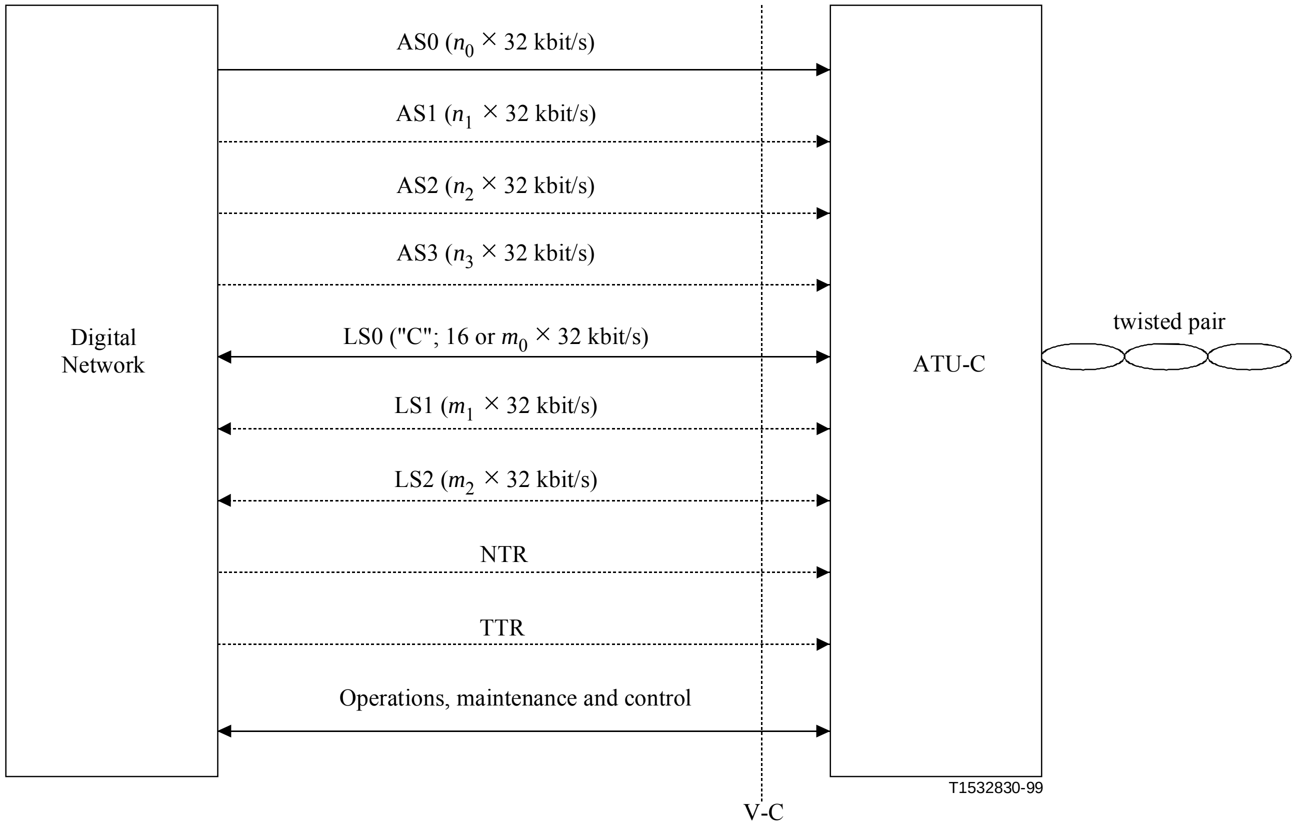
Figure Q.7/G.992.1 – Loop timing for ATU-R

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

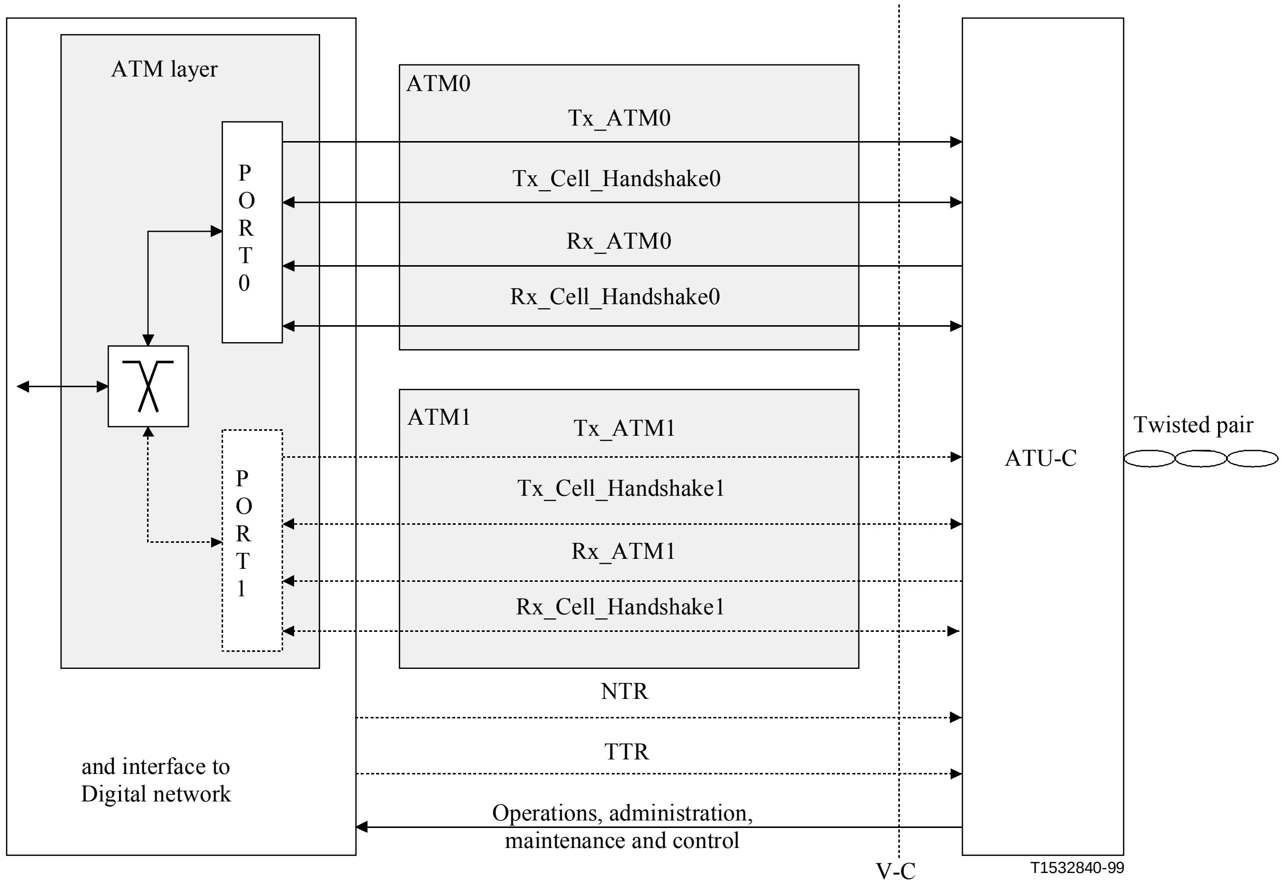
Q.4.1.2 Payload transfer delay (supplements 7.1.4)

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 $NEXT_R$ symbol in a $FEXT_R$ 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).

For $N_{dmt} = 0, 1, ..., 344$

$S = 272 \times N_{dmt} \bmod 2760$

if { (S + 271 < a) 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.

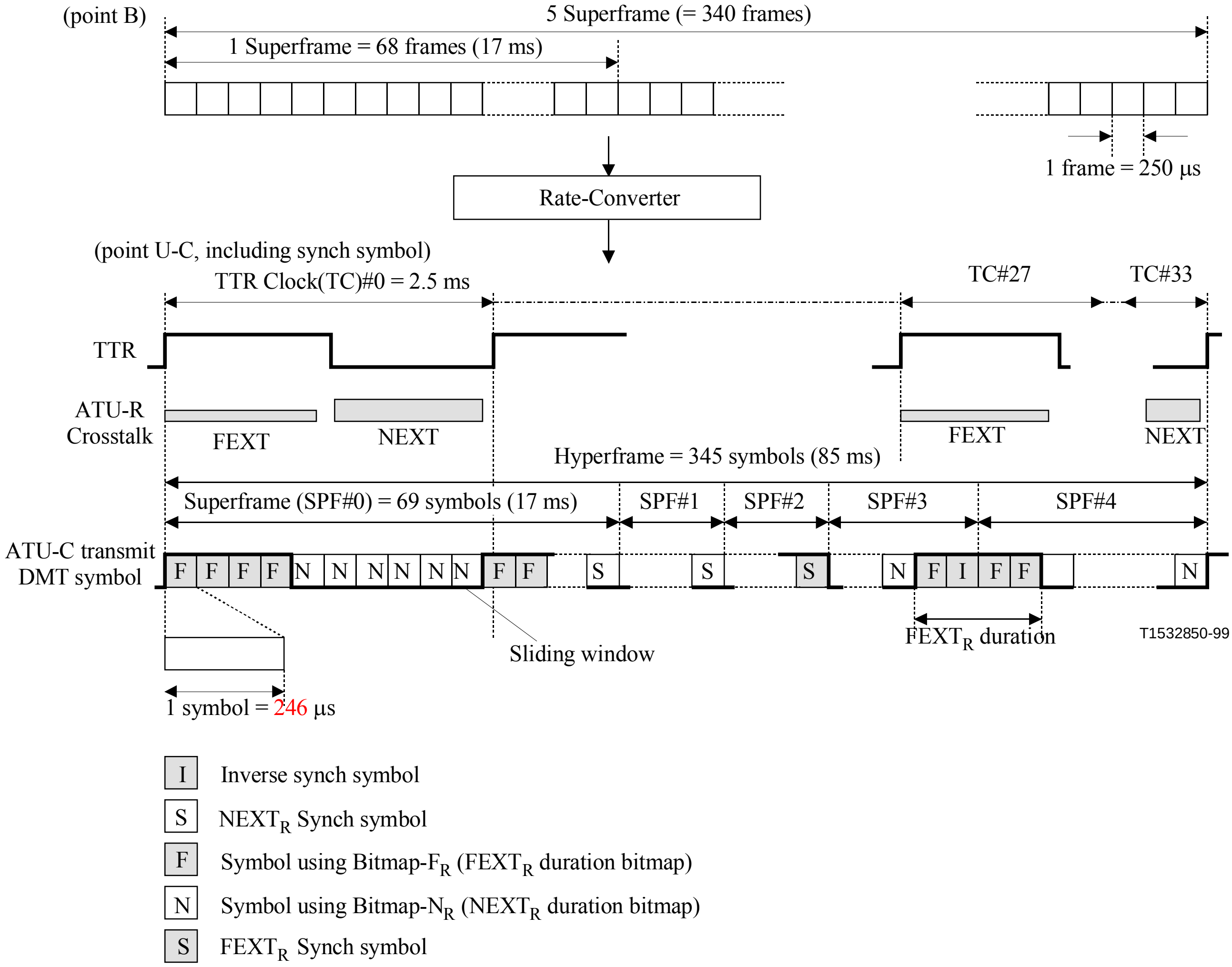


Figure Q.10/G.992.1 – Hyperframe structure for downstream

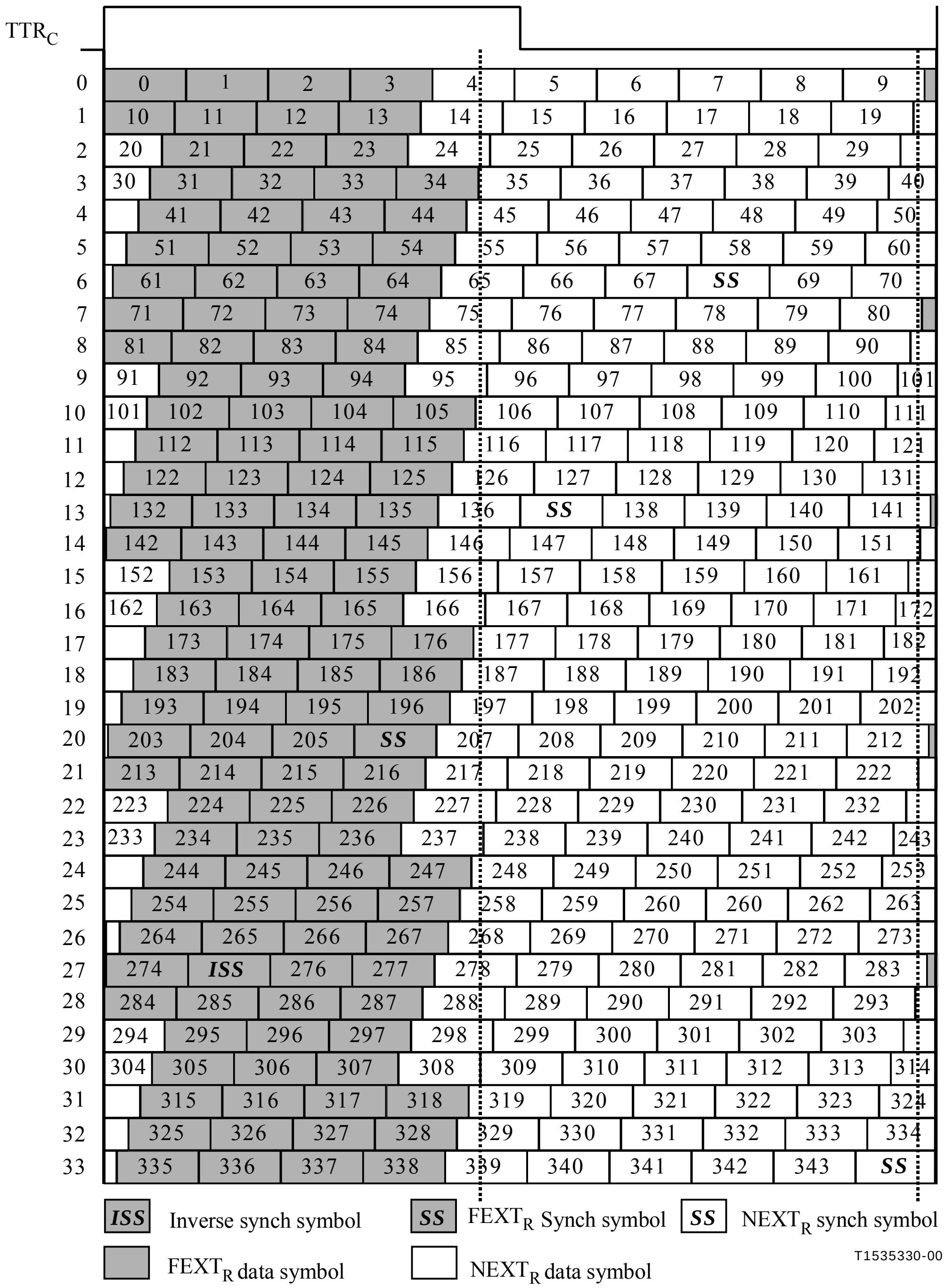


Figure Q.11/G.992.1 – Symbol pattern in a hyperframe with cyclic prefix – Downstream

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.

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

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

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 $t_{Rf} \le n_{R\max}$:

$$n_{Rf} = t_{Rf}$$
$$n_{Ri} = n_R - n_{Rf}$$
$$f_{Rf} = t_{Rf}$$
$$f_{Ri} = f_R - f_{Rf}$$

If $t_{Rf} > n_{R\max}$:

$$n_{Rf} = n_{R\max}$$
$$n_{Ri} = 0$$
$$f_{Rf} = \begin{cases} f_{Rf4} = \left\lceil \dfrac{t_{Rf} \times 10 - n_{Rf} \times 6}{4} \right\rceil \\ f_{Rf3} = \left\lceil \dfrac{t_{Rf} \times 10 - n_{Rf} \times 7}{3} \right\rceil \end{cases}$$
$$f_{Ri} = \begin{cases} f_{Ri4} = f_R = f_{Rf4} \\ f_{Ri3} = f_R - f_{Rf3} \end{cases}$$

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 for synch symbols.
f_{Rf4}	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.
n_R	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 $t_{Rf} \le n_{R\max}$:

$$dummy_{Rf} = 0$$

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

If $t_{Rf} > n_{R\max}$:

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

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

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

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.

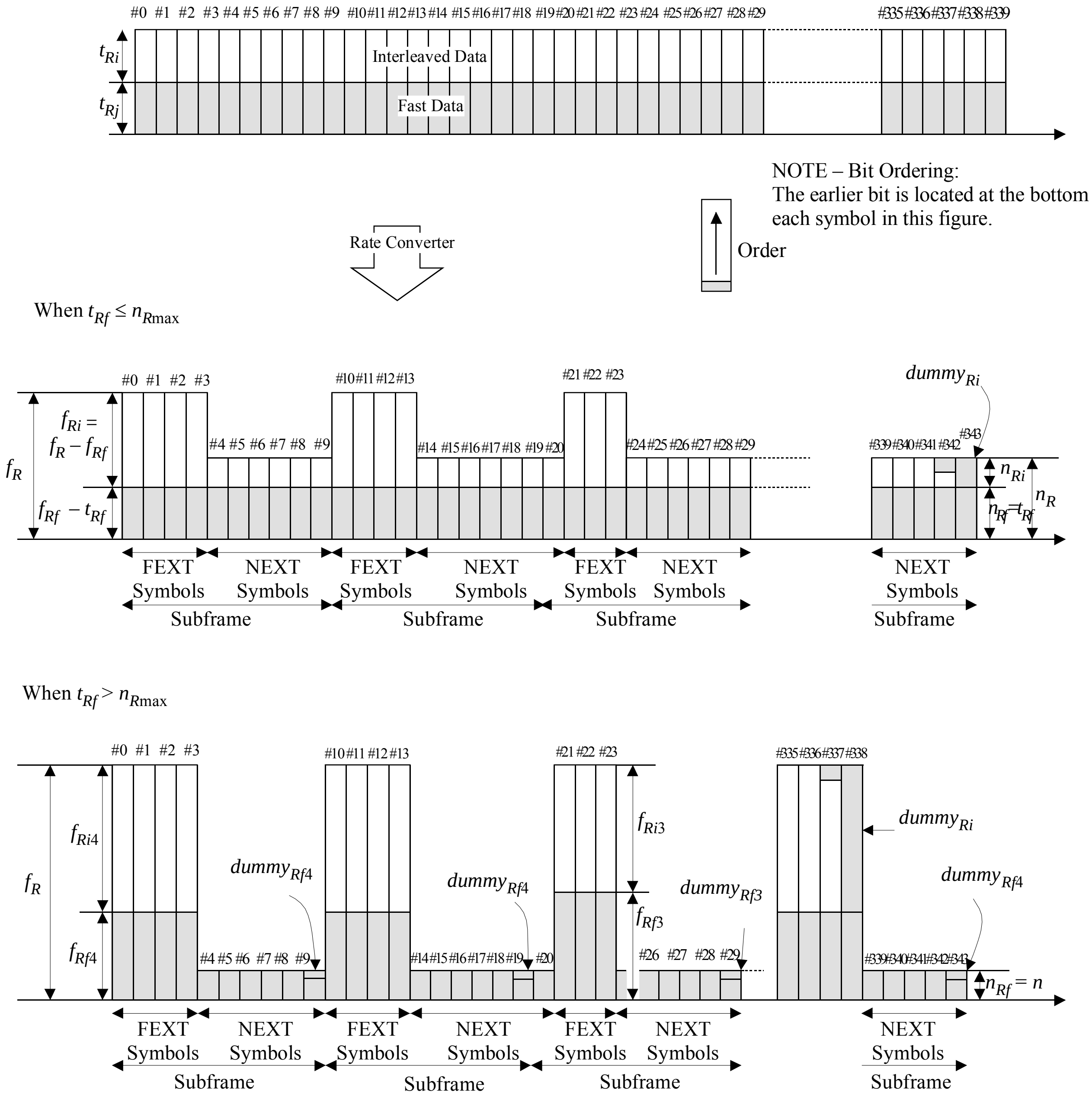


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Figure Q.12/G.992.1 – Bit distribution for Rate Converter under Dual latency and Dual Bitmap mode

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:

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

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 = conj ($Z'_{2*NSCds-i}$) for i = NSCds+1 to 2*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, Δf = 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.

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

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,

$$(2 + 0.125)\text{*NSCds} \times 69 = (2 + 0.15625)\text{*NSCds} \times 68 \quad (7\text{-}24)$$

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

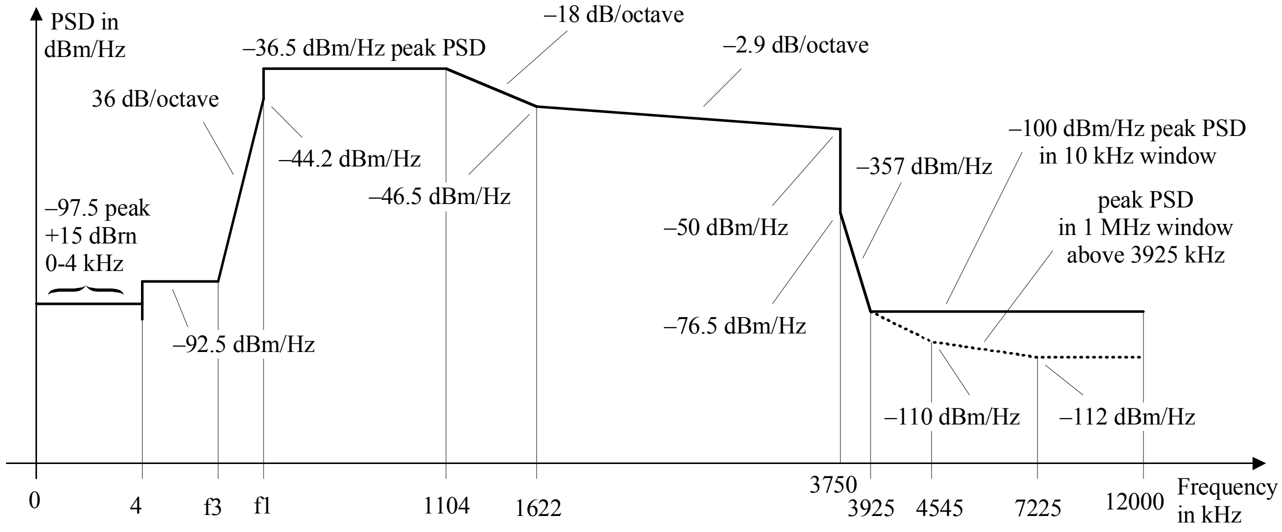
The cyclic prefix shall be used for all symbols beginning with the C-RATES1 segment of the initialization sequence, as defined in 10.6.2.

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*log2(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
f1	-44.2	10 kHz
f1	-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 ≤ 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.

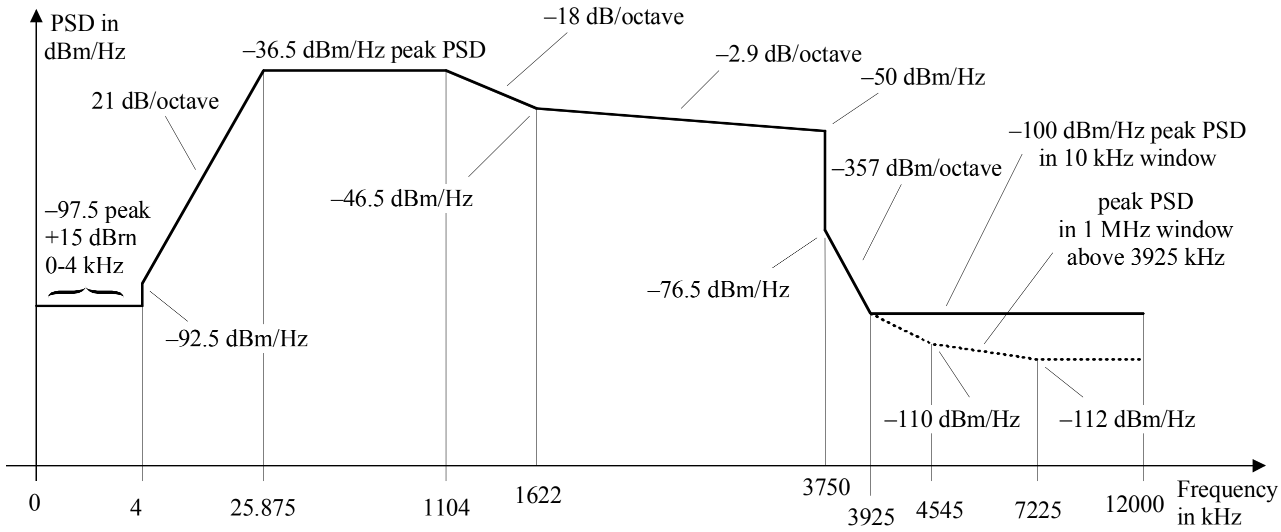
NOTE 6 – All PSD and power measurements shall be made at the U-C interface.

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*log2(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 ≤ 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:

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

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.

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

Tone Index	Log_ssv$_i$ (dB)	Comments
n1	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.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 $n \geq 1$, 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.

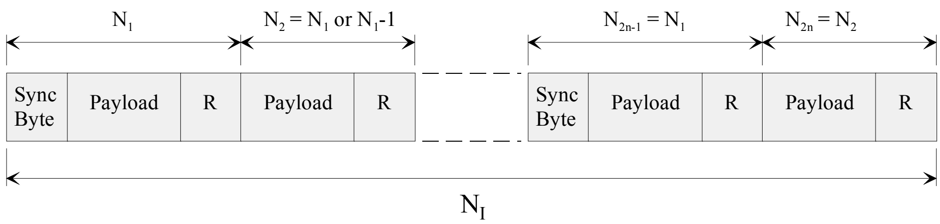


Figure Q.15 – Data frame for S = 1/2n mode

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.

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

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]

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

$S = 272 \times N_{dmt} \bmod 2760$

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.

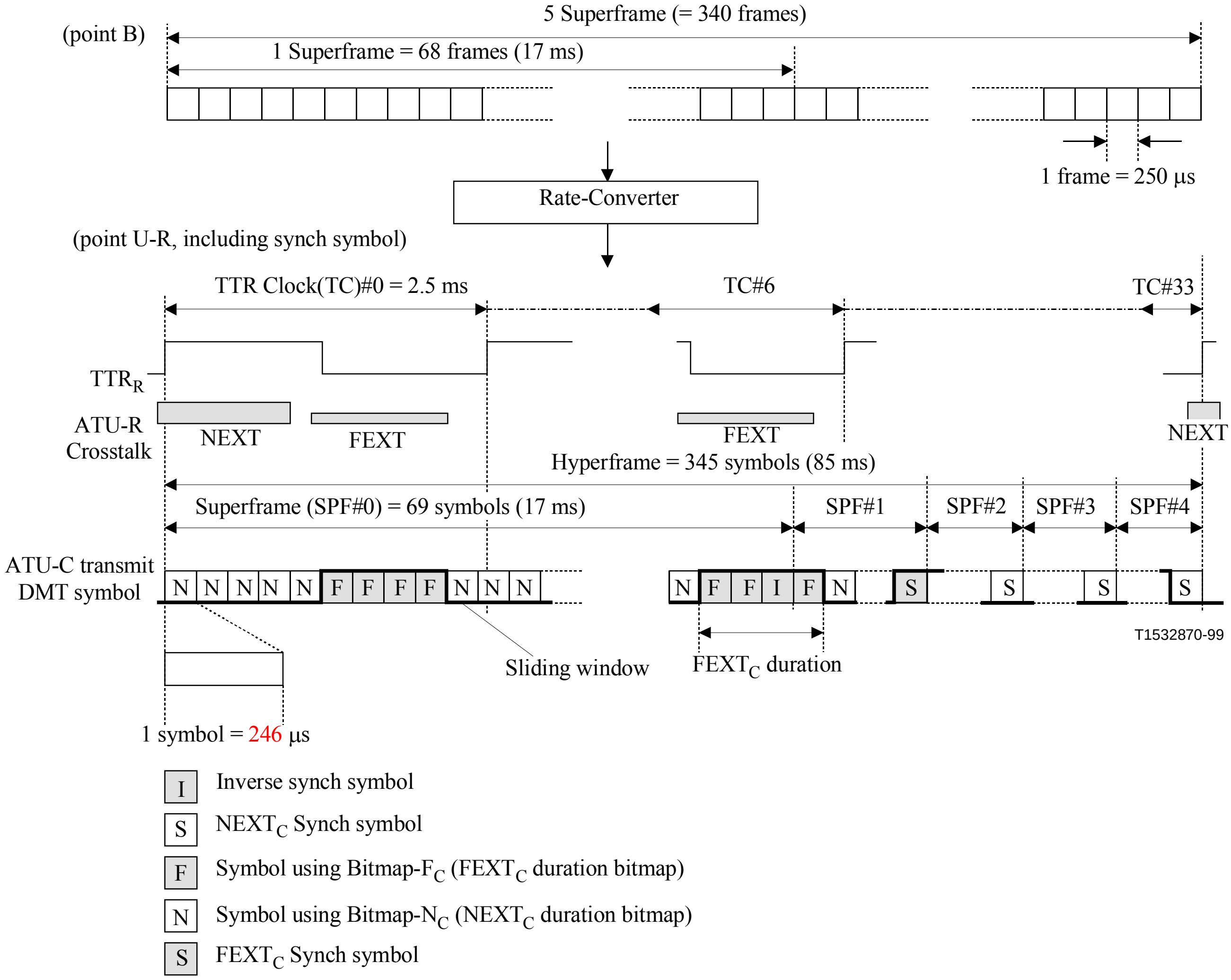


Figure Q.16/G.992.1 – Hyperframe structure for upstream

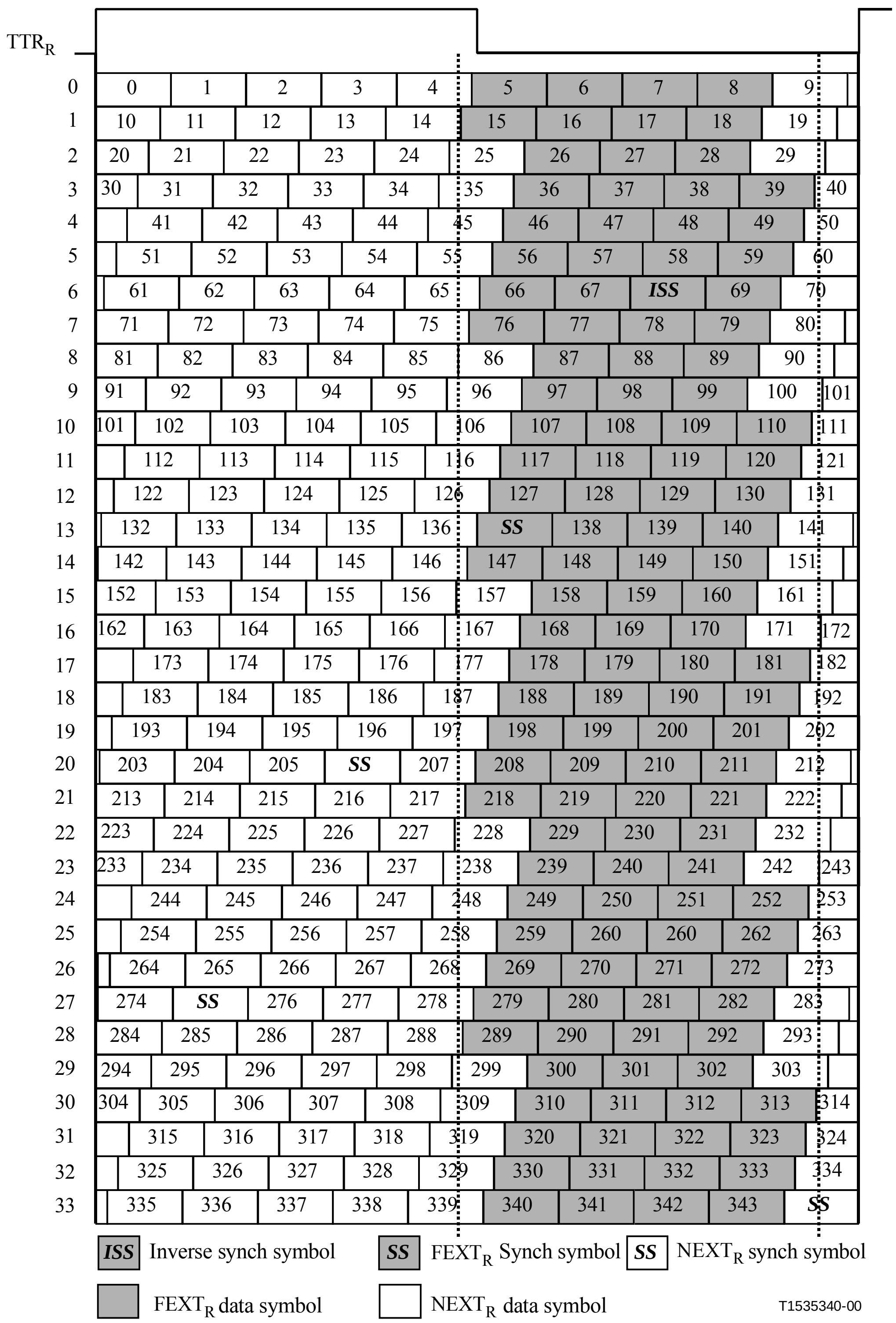


Figure Q.17/G.992.1 – Symbol pattern in a hyperframe with cyclic prefix – Upstream

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.

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

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

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 $t_{Cf} \le n_{C\max}$:

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

If $t_{Cf} > n_{C\max}$:

$$n_{Cf} = n_{C\max}$$
$$n_{Ci} = 0$$
$$f_{Cf} = \begin{cases} f_{Cf4} = \left\lceil \dfrac{t_{Cf} \times 10 - n_{Cf} \times 6}{4} \right\rceil \\ f_{Cf3} = \left\lceil \dfrac{t_{Cf} \times 10 - n_{Cf} \times 7}{3} \right\rceil \end{cases}$$
$$f_{Ci} = \begin{cases} f_{Ci4} = f_C - f_{C4} \\ f_{Ci3} = f_C - f_{Cf3} \end{cases}$$

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 for synch symbols.
f_{Cf4}	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.
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 $t_{Cf} \le n_{C\max}$:

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

If $t_{Cf} > n_{C\max}$:

$$dummy_{Cf4} = \left(f_{Cf} \times 4 + n_{Cf} \times 6 \right) - t_{Cf} \times 10$$
$$dummy_{Cf3} = \left(f_{Cf} \times 3 + n_{Cf} \times 7 \right) - t_{Cf} \times 10$$
$$dummy_{Ci} = \left(f_{Ci4} \times 96 + f_{Ci3} \times 30 \right) - t_{Ci} \times 340$$

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 $+10\log(g_{sync}^2)$ 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.

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)

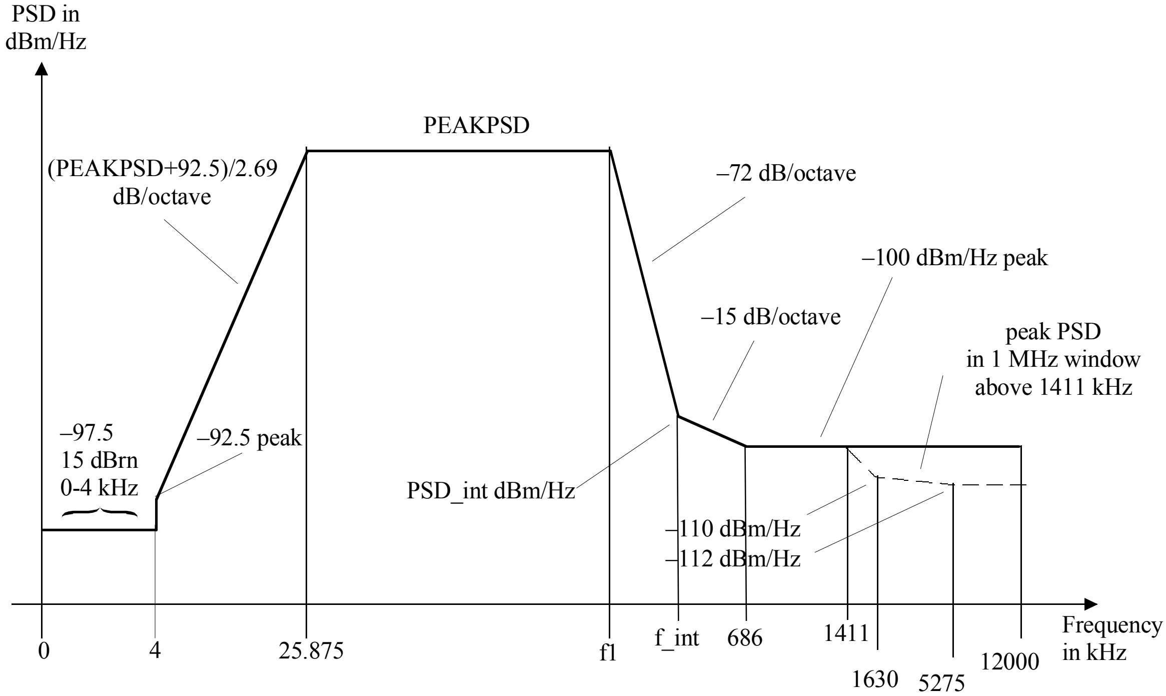
For Annex Q-EU, see A.2.2.

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

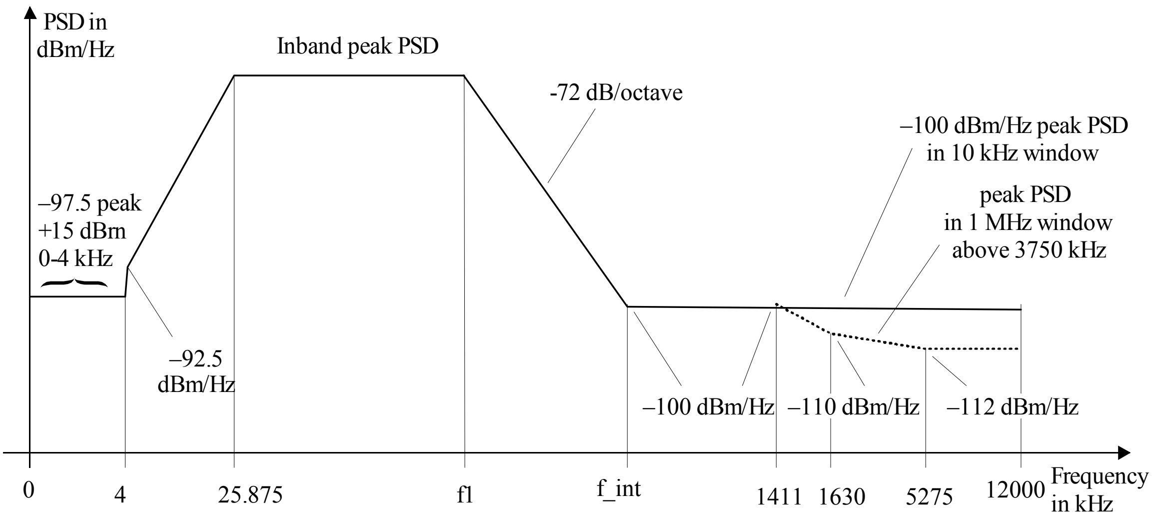
NSCus is a function of the upstream mask parameters, which are defined as follows:

Parameters in FEXT bitmap for mode 1, both bitmaps 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
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

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
f1	Inband_peak_PSD	10 kHz
f_int	-100	10 kHz
5275	-100	10 kHz
12000	-100	10 kHz

Figure C.x1: Mask definition for EU-92 to EU-112

Designator	**Template Nominal PSD P_0 (dBm/Hz)**	**Template Maximum Aggregate Transmit Power (dBm)**	**Inband Peak PSD (dBm/Hz)**	**Frequency *f1* (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

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 ≤ 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-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, …344

$S = 256 \times N_{dmt} \bmod 2760$

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 Q.20).

For N_{dmt} = 0, 1, …, 344,

$S = 256 \times N_{dmt} \bmod 2760$

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

$S = 272 \times N_{dmt} \bmod 2760$

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 Q.17).

For N_{dmt} = 0, 1, ..., 344

$S = 272 \times N_{dmt} \bmod 2760$

if { (S > a) and (S + 271 < a + b) } then $FEXT_C$ symbols

else then $NEXT_C$ symbols

where a = 1315, b = 1293

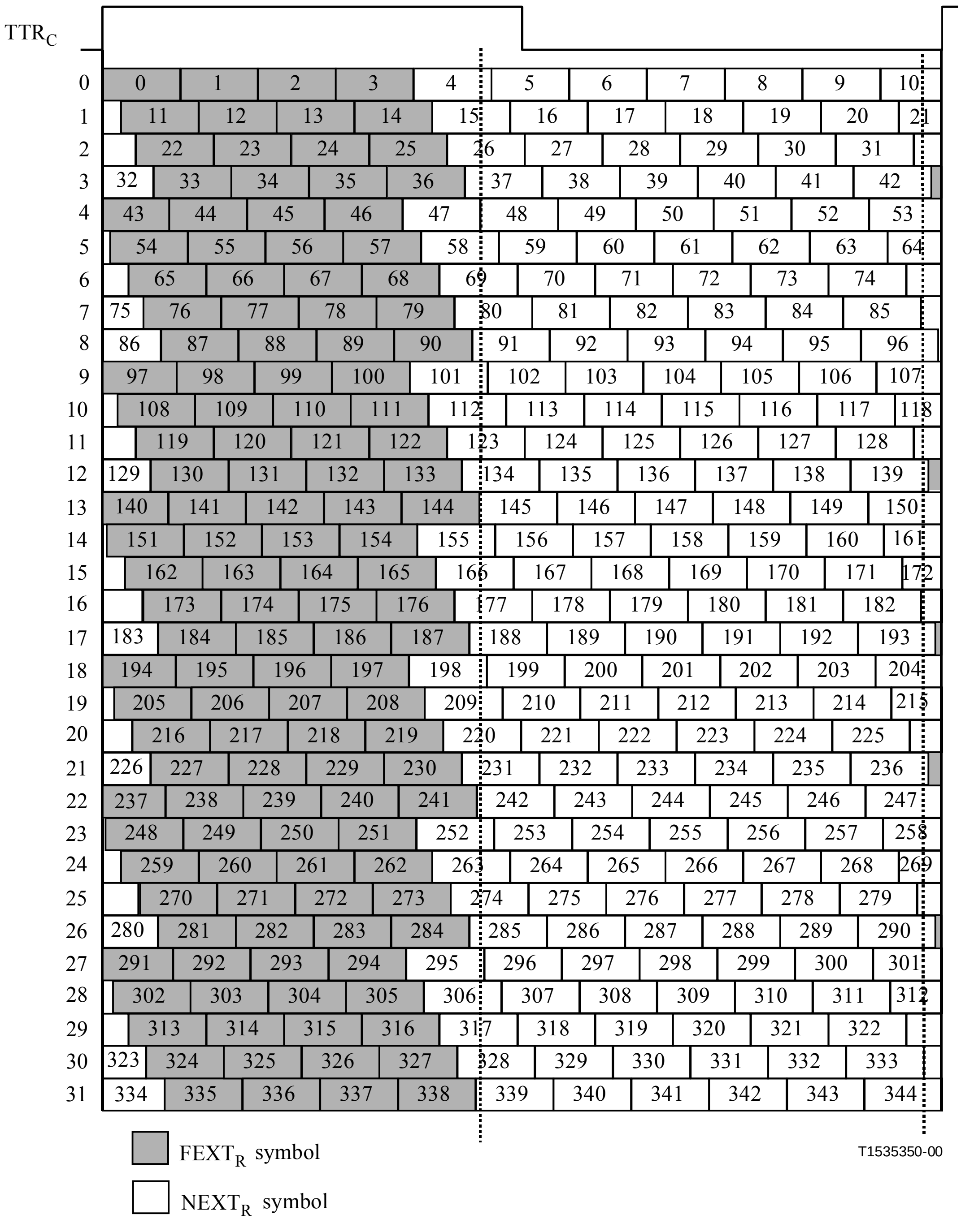


Figure Q.19/G.992.1 – Symbol pattern in a hyperframe without cyclic prefix – Downstream

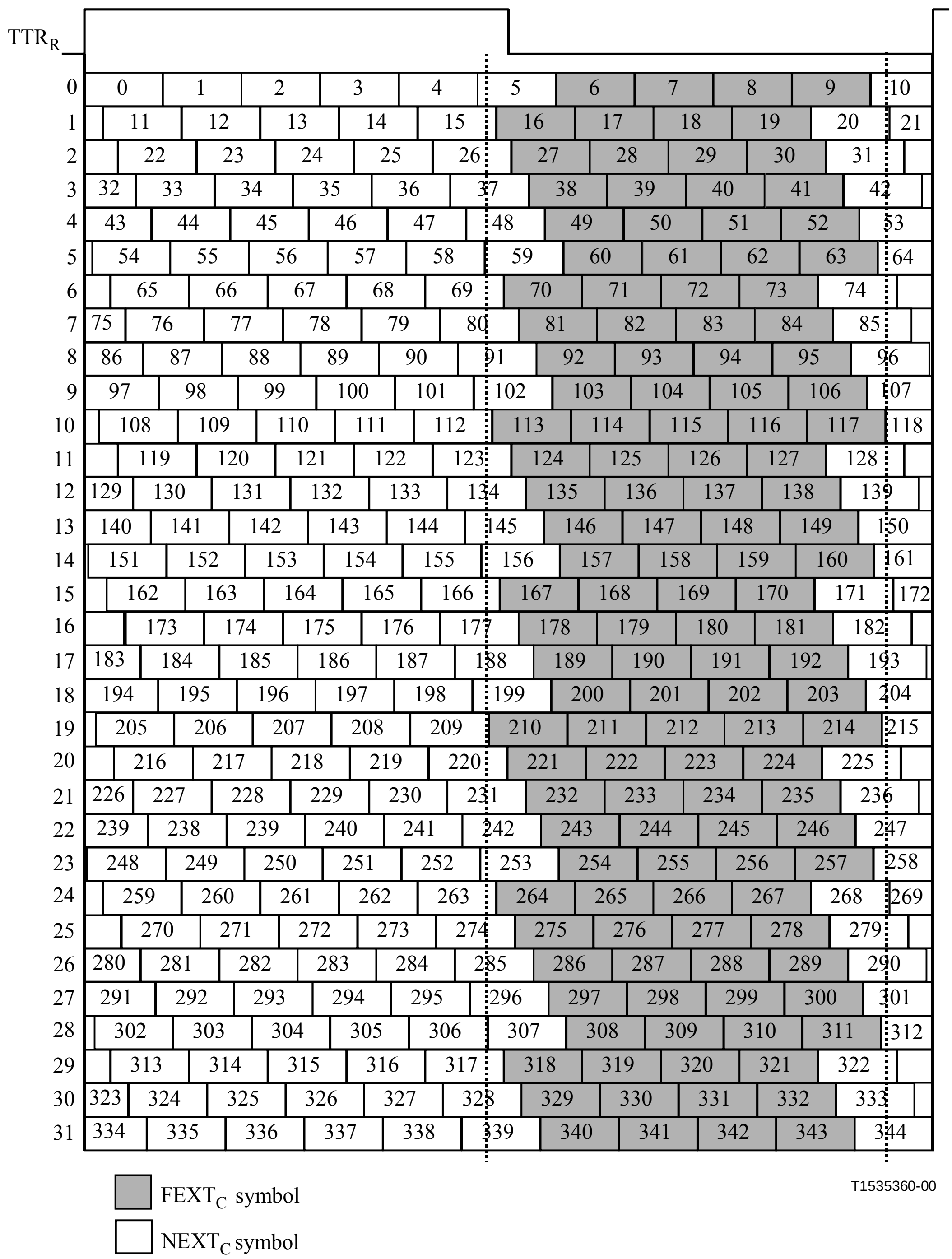


Figure Q.20/G.992.1 – Symbol pattern in a hyperframe without cyclic prefix – Upstream

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-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 §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".

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

Bits 8	7	6	5	4	3	2	1	**NPar(1)s**
x	x	x	x	x	x	x	1	Reserved for future use
x	x	x	x	x	x	1	x	Reserved for future use
x	x	x	x	x	1	x	x	Reserved for future use
x	x	x	x	1	x	x	x	Reserved for future use
x	x	x	1	x	x	x	x	Reserved for future use
x	x	1	x	x	x	x	x	Reserved for future use
x	1	x	x	x	x	x	x	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

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

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**
x	x	x	x	x	x	x	1	$n_{\text{C-PILOT1}} = 64$
x	x	x	x	x	x	1	x	$n_{\text{C-PILOT1}} = 128$
x	x	x	x	x	1	x	x	$n_{\text{C-PILOT1}} = 256$
x	x	x	x	1	x	x	x	Amateur radio notch – 1.8 MHz band
x	x	x	1	x	x	x	x	Amateur radio notch – 3.5 MHz band
x	x	1	x	x	x	x	x	$n_{\text{C-PILOT1}} = 96$
x	x	0	0	0	0	0	0	No parameters in this octet
Since A48 is the only TTR indication signal specified for Annex Q-EU, there is no need to include it in G.994.1.								

Table Q.7.1.1 – Non-standard information field – G.992.1 Annex Q NPar(2) coding – Octet 2

Bits 8	7	6	5	4	3	2	1	**G.992.1 Annex Q NPar(2)s – Octet 2**
x	x	x	x	x	x	x	1	R-ACK1
x	x	x	x	x	x	1	x	R-ACK2
x	x	x	x	x	1	x	x	Reserved for future use
x	x	x	x	1	x	x	x	Reserved for future use
x	x	x	1	x	x	x	x	Reserved for future use
x	x	1	x	x	x	x	x	G.997.1 – Clear EOC OAM
x	x	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.								

Table Q.7.2 – 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	x	x	x	x	x	x	1	Additional inband spectral shaping
x	x	x	x	x	x	1	x	Extended upstream
x	x	x	x	x	1	x	x	Reserved for future use
x	x	x	x	1	x	x	x	Reserved for future use
x	x	x	1	x	x	x	x	Reserved for future use
x	x	1	x	x	x	x	x	Reserved for future use
x	x	0	0	0	0	0	0	No parameters in this octet

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

Bits 8	7	6	5	4	3	2	1	G.992.1 Annex Q Additional inband spectral shaping Npar(3)s Octet 1
x	x					x	x	NOMINAL_PSD_lowband (bits 8 & 7)
x	x	x	x	x	x			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 8	7	6	5	4	3	2	1	G.992.1 Annex Q Additional inband spectral shaping Npar(3)s Octet 2
x	x	x	x	x	x	x	x	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					x	x	PSD level at 1622 kHz (bits 8 & 7)
x	x	x	x	x	x			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 8	7	6	5	4	3	2	1	G.992.1 Annex Q Additional inband spectral shaping Npar(3)s Octet 4
x	x	x	x	x	x	x	x	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	PSD level at 3750 kHz (bits 8 & 7)
x	x	x	x	x	x			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 8	7	6	5	4	3	2	1	G.992.1 Annex Q Additional inband spectral shaping Npar(3)s Octet 6
x	x	x	x	x	x	x	x	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	x	x	x	x	x	x	1	Mode 1 upstream mask
x	x	x	x	x	x	1	x	Mode 2 upstream mask
x	x	x	x	x	1	x	x	Optional upstream masks for non-overlapped spectrum
x	x	x	x	1	x	x	x	EU-64
x	x	x	1	x	x	x	x	EU-32
x	x	1	x	x	x	x	x	EU-36
x	x	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

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

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	x	x	x	x	x	x	1	EU-68
x	x	x	x	x	x	1	x	EU-72
x	x	x	x	x	1	x	x	EU-76
x	x	x	x	1	x	x	x	EU-80
x	x	x	1	x	x	x	x	EU-84
x	x	1	x	x	x	x	x	EU-88
x	x	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	x	x	x	x	x	x	1	EU-92
x	x	x	x	x	x	1	x	EU-96
x	x	x	x	x	1	x	x	EU-100
x	x	x	x	1	x	x	x	EU-104
x	x	x	1	x	x	x	x	EU-108
x	x	1	x	x	x	x	x	EU-112
x	x	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.

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

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.
$n_{C\text{-}PILOT1}=64$	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 64.
$n_{C\text{-}PILOT1}=96$	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 96.
$n_{C\text{-}PILOT1}=128$	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 128.
$n_{C\text{-}PILOT1}=256$	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.

Q.7.3.1.2 MS messages (supplements 10.2.2)

See Table Q.9.

Table Q.9/G.992.1 – ATU-C 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-C is selecting G.992.1 Annex Q, and possibly Annex Q-EU.
$n_{C\text{-PILOT1}}=64$	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 64 (Note 1).
$n_{C\text{-PILOT1}}=96$	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 96 (Note 1).
$n_{C\text{-PILOT1}}=128$	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 128 (Note 1).
$n_{C\text{-PILOT1}}=256$	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.

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.
$n_{C\text{-}PILOT1}$=64	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 64.
$n_{C\text{-}PILOT1}$=96	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 96.
$n_{C\text{-}PILOT1}$=128	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 128.
$n_{C\text{-}PILOT1}$=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.

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.
$n_{C\text{-}PILOT1}$=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).
$n_{C\text{-}PILOT1}$=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).
$n_{C\text{-}PILOT1}$=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).
$n_{C\text{-}PILOT1}$=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 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 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
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.
$n_{C\text{-}PILOT1}=64$	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the pilot tone on subcarrier 64 (Note 1).
$n_{C\text{-}PILOT1}=96$	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is proposing the pilot tone on subcarrier 96 (Note 1).
$n_{C\text{-}PILOT1}=128$	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the pilot tone on subcarrier 128 (Note 1).
$n_{C\text{-}PILOT1}=256$	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.
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 $f_{\text{C-PILOT1}}$ 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. $f_{\text{C-PILOT1}}$ = 276 kHz ($n_{\text{C-PILOT1}}$ = 64).
13. $f_{\text{C-PILOT1}}$ = 414 kHz ($n_{\text{C-PILOT1}}$ = 96).
14. $f_{\text{C-PILOT1}}$ = 552 kHz ($n_{\text{C-PILOT1}}$ = 128).
15. $f_{\text{C-PILOT1}}$ = 1104 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:

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.

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.

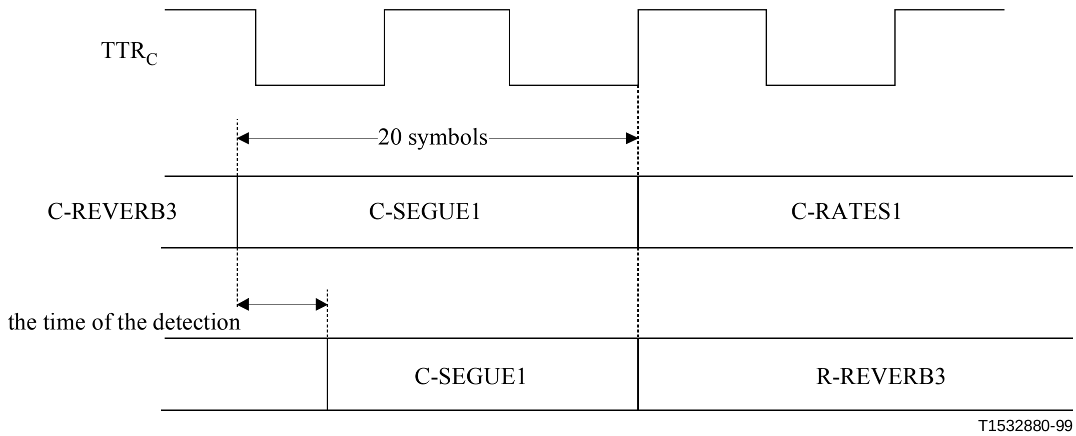


Figure Q.22/G.992.1 – Timing diagram from C-SEGUE1 to C-RATES1

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:

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

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:

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

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:

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

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 2^{14}-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

$S = 272 \times N_{dmt} \bmod 2760$

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).

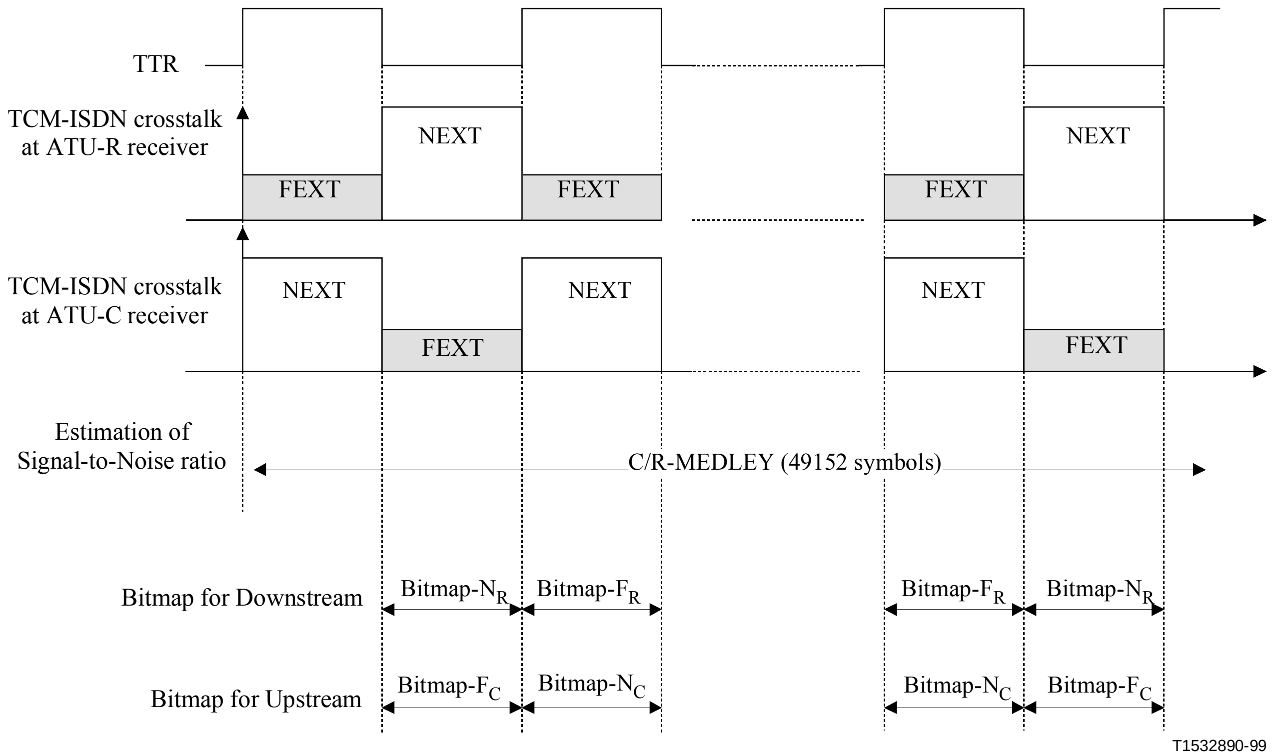


Figure Q.23/G.992.1 – Estimation of periodic Signal-to-Noise Ratio

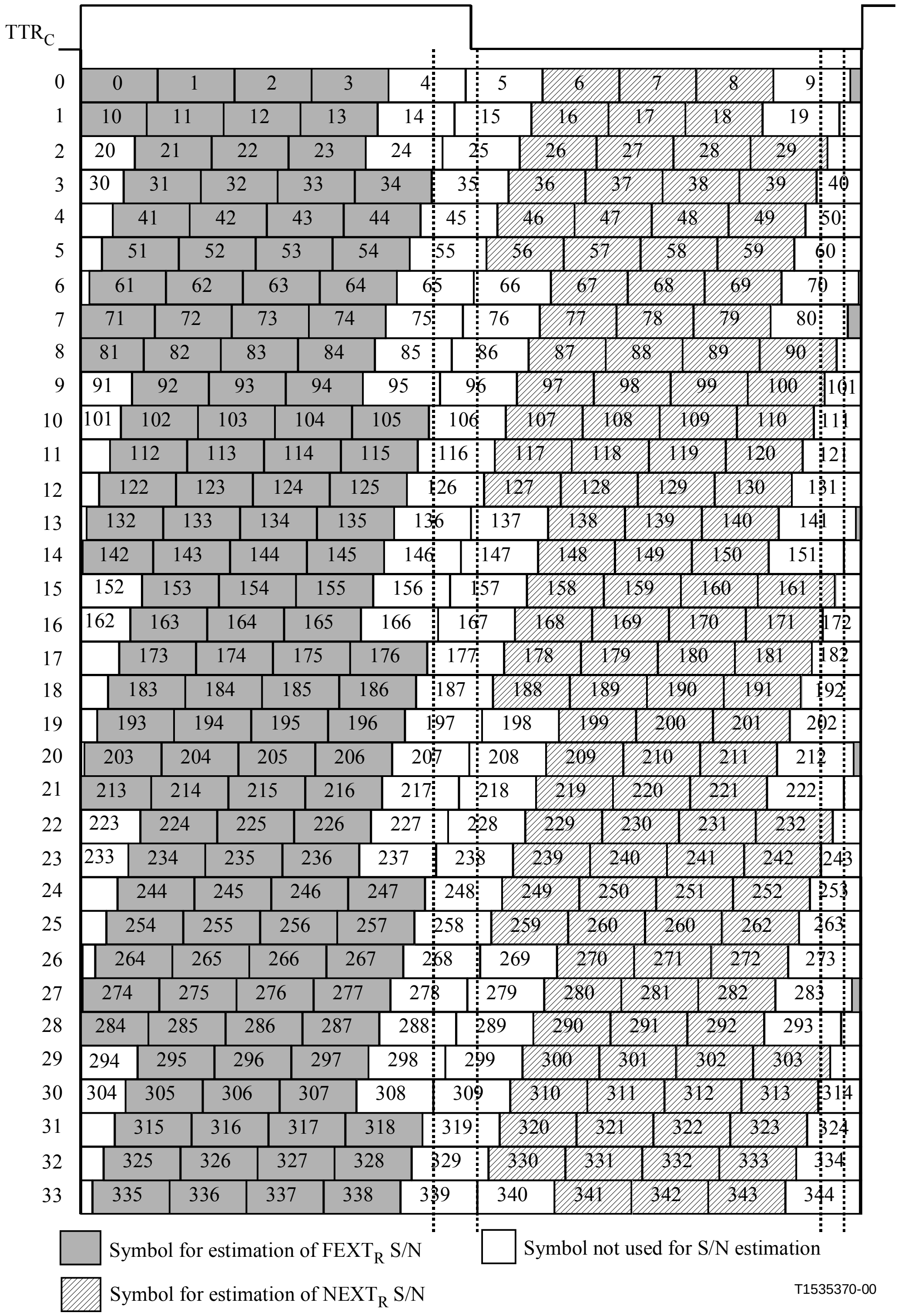


Figure Q.24/G.992.1 – Symbol pattern in a hyperframe for S/N estimation – Downstream

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., $RS_I = R_I/(n*S)$.

Q.7.6.4 C-MSG1 (supplements 10.6.4)

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; binary coded 0-15 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 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:

$$d_n = 1 \text{ for } n = 1 \text{ to } 23 \text{ and } d_n = d_{n-18} \oplus d_{n-23} \text{ for } n > 23.$$

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 x 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).

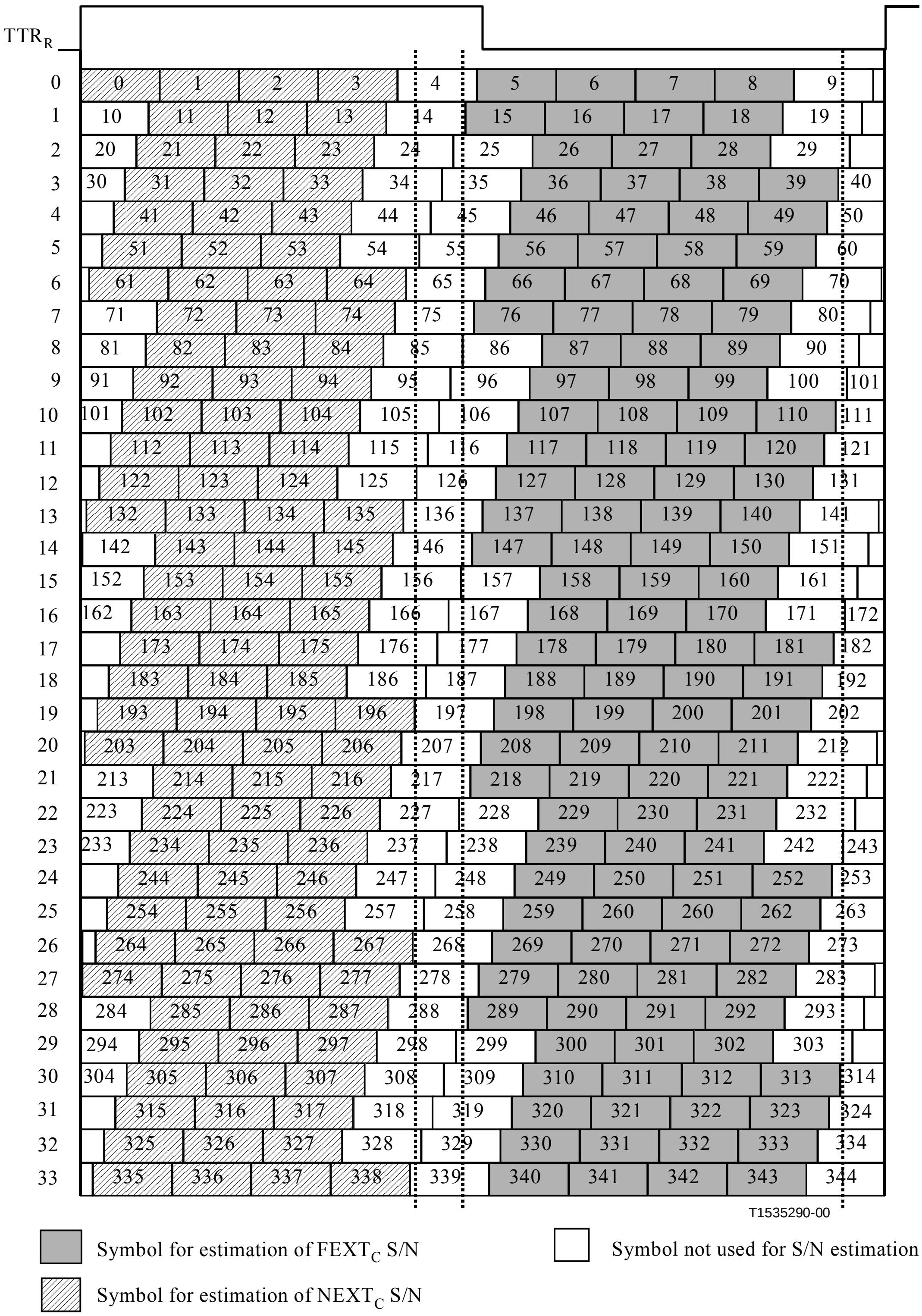


Figure Q.25/G.992.1 – Symbol pattern in a hyperframe for S/N estimation – Upstream

Q.7.8.4 R-MSG1 (supplements 10.7.6)

Table Q.14/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 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 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 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.

Table Q.15/G.992.1 – Assignment of 32 bits of C-MSG2

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".	

For NSCus=32,

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

Otherwise,

$n_{1C\text{-}MSG2} = 139$
$n_{2C\text{-}MSG2} = 187$

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 x 126 + 88 x 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), $\{m_{10}, ..., m_0\} = 00001111111_2$].

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}, $b_{2*\mathrm{NSCus}}$, and $g_{2*\mathrm{NSCus}}$ 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_is 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 (00000_2 and $00000000\ 000_2$, 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 (000.00110000_2 to 001.01010101_2).

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:

$$m = \{m_{32*(\mathrm{NSCu}-1)-1}, m_{32(\mathrm{NSCu}-1)-2}, \ldots, m_1, m_0\} = \{ g_{2*\mathrm{NSCu}-1}, b_{2*\mathrm{NSCu}-1}, \ldots, g_{\mathrm{NSCu}+1}, b_{\mathrm{NSCu}+1}, g_{\mathrm{NSCu}-1}, b_{\mathrm{NSCu}-1}, \ldots, g_1, b_1\}, \qquad \text{(C.10-2)}$$

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.

Q.7.9.4 C-RATES-RA (supplements 10.8.3)

Table Q.16/G.992.1 – RRSI fields of C-RATES-RA

	←bits→							
fields	7	6	5	4	3	2	1	0
RS_F	B_{10} (AS0)	0	value of RS_F MSB					LSB
RS_I	B_8 (AS0)	B_9 (AS0)	value of RS_I MSB					LSB
S	I_9	I_8	value of S MSB					LSB
I	I_7	I_6	I_5	I_4	I_3	I_2	I_1	I_0
FS(LS2)	value of FS(LS2) *set to* $\{00000000_2\}$							

The RS_I field has been extended to include bit B_9 of B_I (AS0) in bit 6, and The RS_F field has been extended to include the most significant bit B_{10} 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.

Table Q.17/G.992.1 – Assignment of 80 bits of R-MSG-RA (Annex Q-EU)

Suffix(ces) of m_i (Note)	Parameter 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	$B_{fast\text{-}max}$
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 separate fields the least significant bits have the lowest subscripts.	

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 $B_{fast\text{-}max}$ (new)

$B_{fast\text{-}max}$ 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 $B_{fast\text{-}max}$ is t_f.

Q.7.10.2 R-MSG2 (supplements 10.9.8)

Table Q.18/G.992.1 – Assignment of 32 bits of R-MSG2

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 - 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".	

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

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 96 is reserved as the pilot tone, b_{96} and $b_{NSCds+96}$, shall be set to 0, g_{96} and $g_{NSCds+96}$ 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 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) 001.01000000_2 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 (00000_2 and $00000000\ 000_2$, 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 (000.00110000_2 to 001.01010101_2).

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

$$m = \{m_{(2*NSCds-2)*16-1}, m_{(2*NSCds-2)*16-2}, \dots, m_1, m_0\} = \{ g_{2*NSCds-1}, b_{2*NSCds-1}, \dots, g_{NSCds+1}, b_{NSCds+1}, g_{NSCds-1}, b_{NSCds-1}, \dots, g_1, b_1\}, \quad (Q.10-3)$$

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.

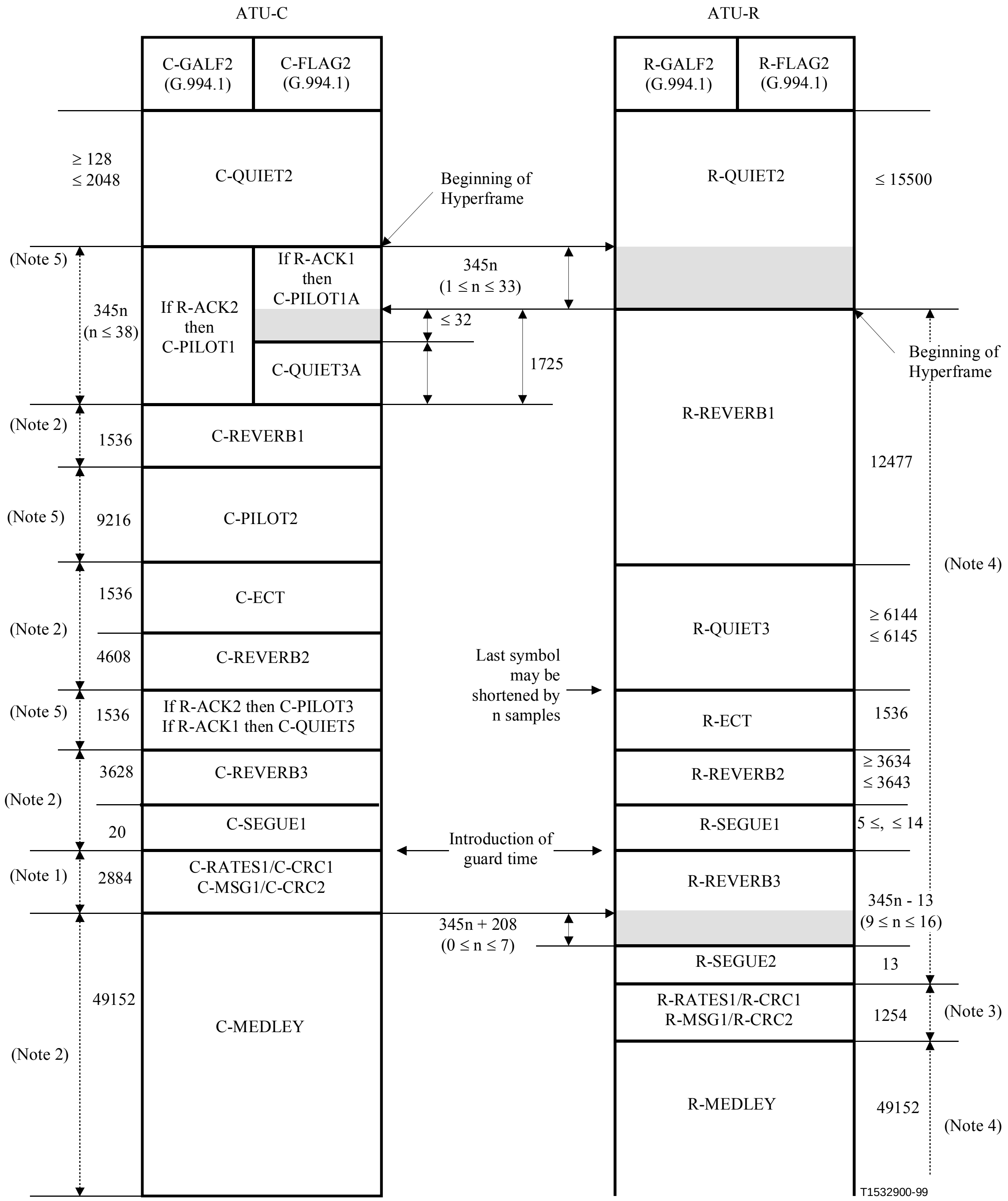
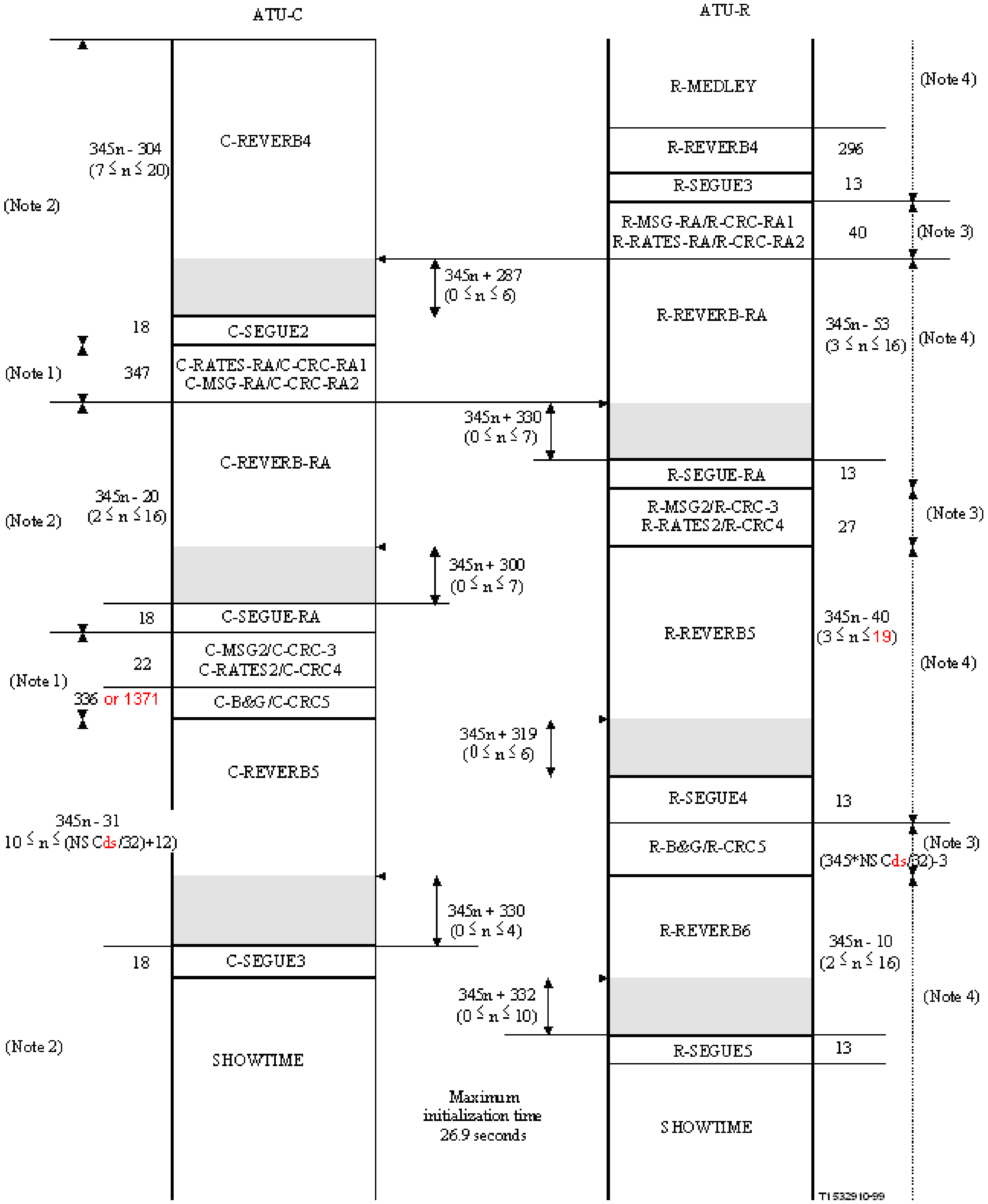


Figure Q.26/G.992.1 – Timing diagram of the initialization sequence – Part 1



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.

Table Q.19/G.992.1 – Format of the bit swap request message

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

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.

Table Q.20/G.992.1 – Bit swap request command

Value (8 bit)	Interpretation
$yzz00000_2$	Do nothing
$yzz00001_2$	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
$yzz00110_2$	Reduce the transmitted power by 1 dB
$yzz00111_2$	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	

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:

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

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.

Table Q.21/G.992.1 – Format of the bit swap request message

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)

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 → 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 I also implements Annex C.

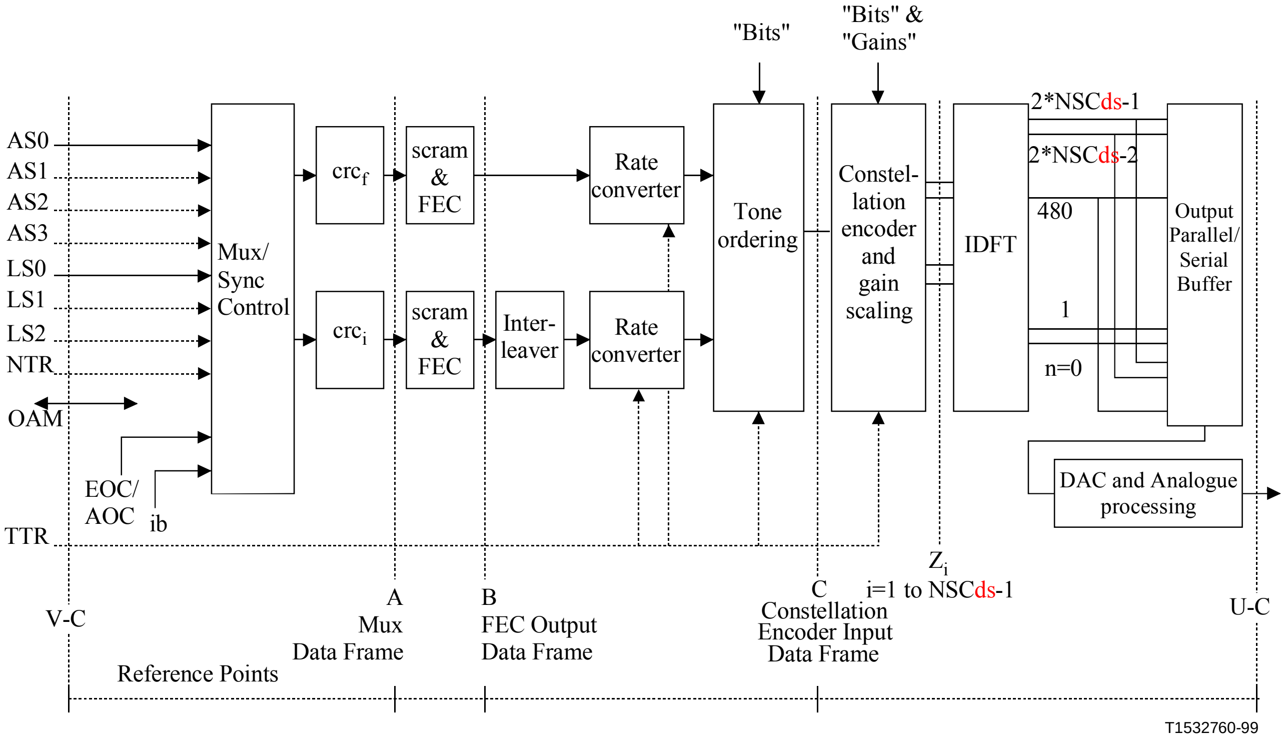
I.2 Definitions

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	The Dual Bitmap method has dual bit rates under the FEXT and NEXT noise from TCM-ISDN
FEXT Bitmap	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	5 Superframes structure which synchronized TTR
$NEXT_C$ duration	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	TCM-ISDN Timing Reference
TTR_C	Timing reference used in ATU-C
TTR_R	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)

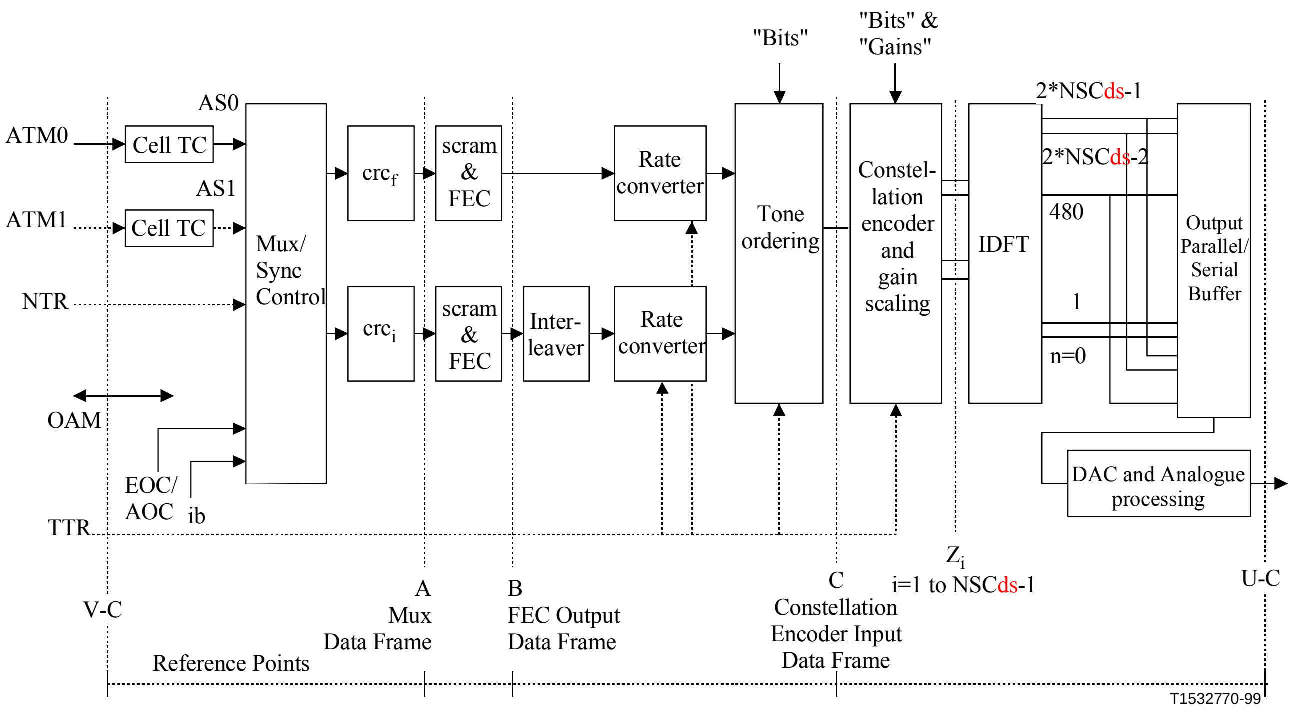
See Figure I.1 and Figure I.2.



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

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

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

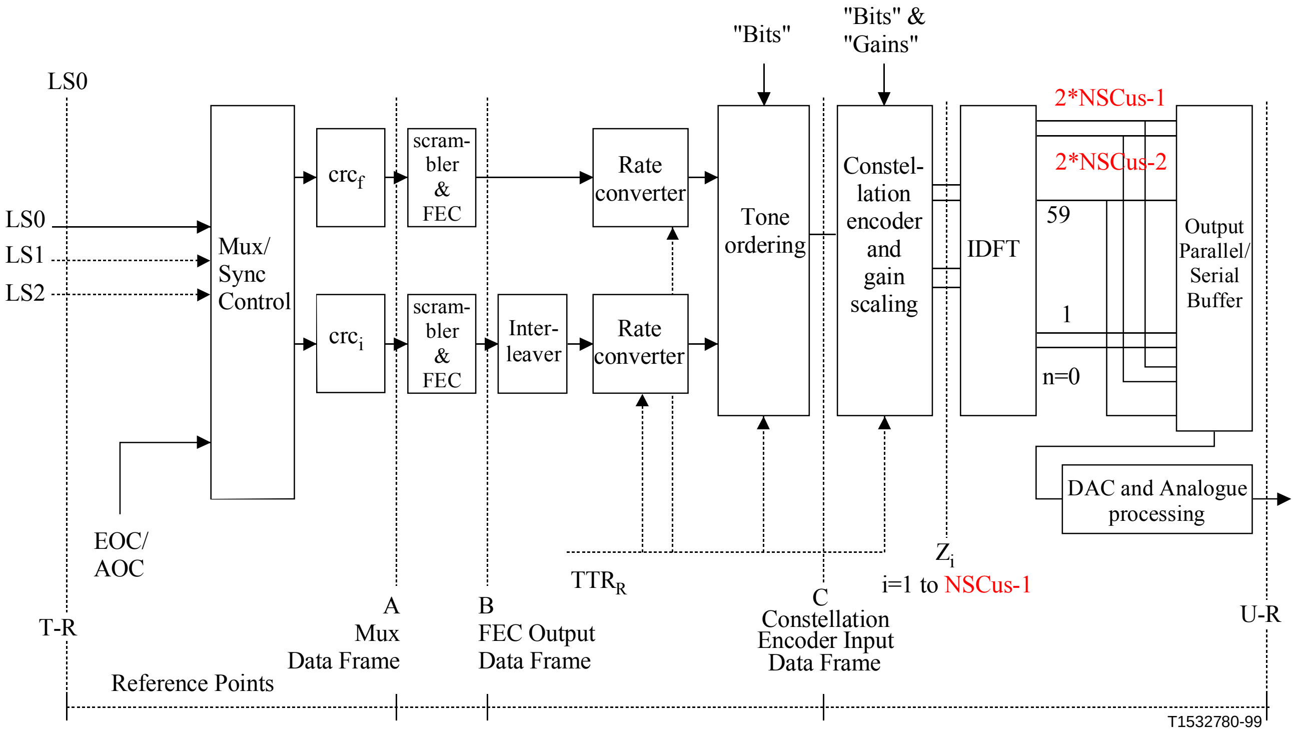


NOTE – The TTR may be generated in ATU-C without being provided from the TCM-ISDN clock.

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)

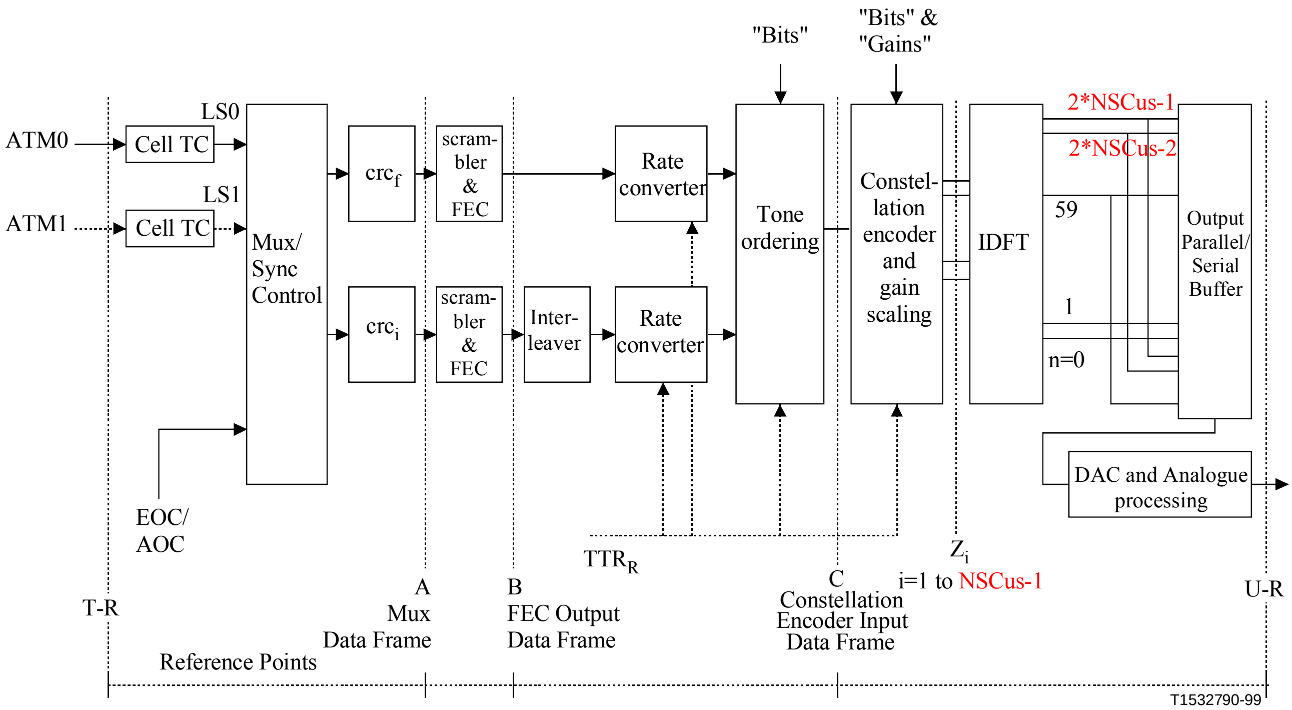
See Figure I.3 and Figure I.4.



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.



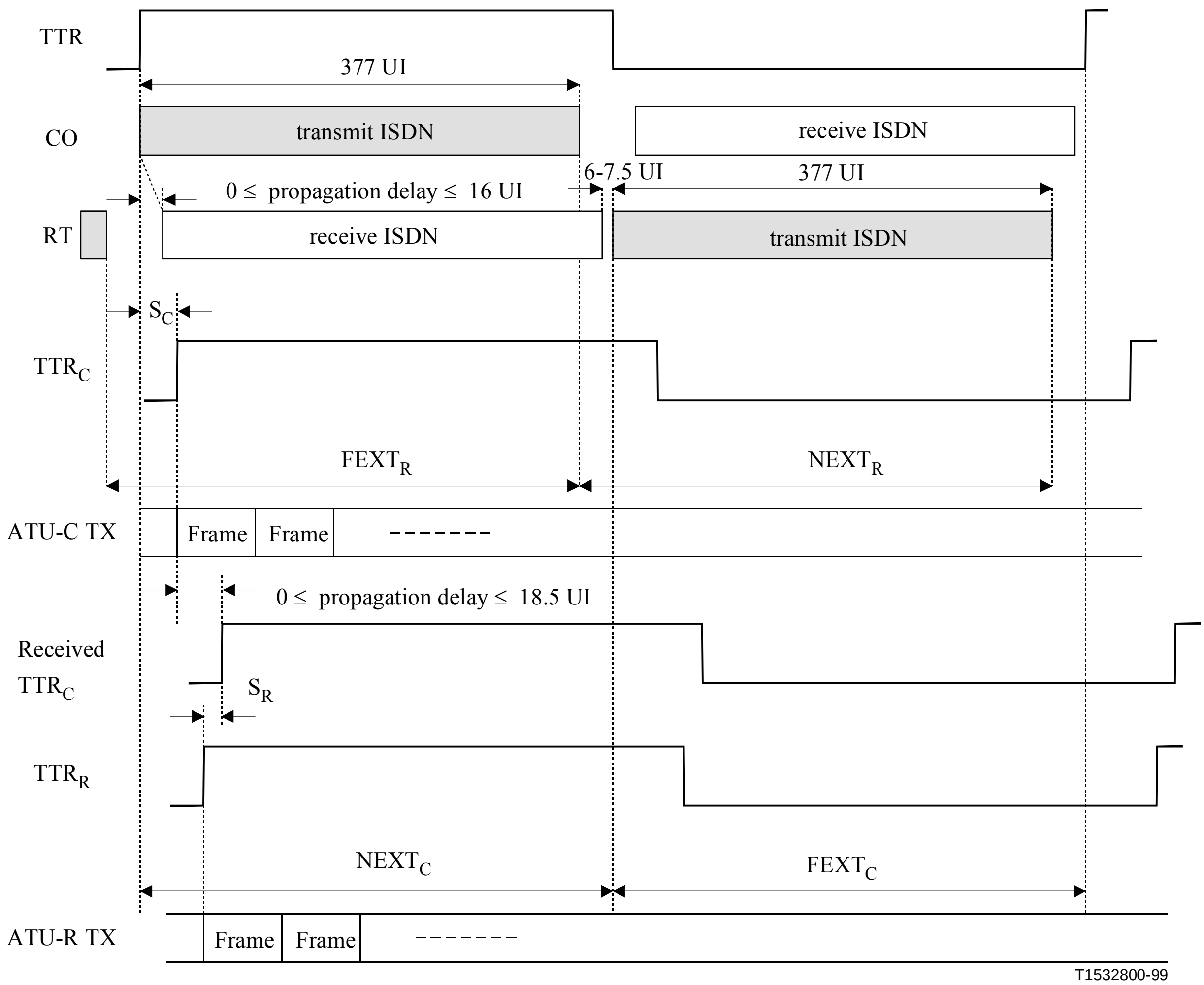
NOTE – The TTR_R shall be generated in ATU-R from the received TTR_C signal, and it is locked to 690 periods of upstream sampling clock (1.104 MHz).

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.



1 UI = 3.125 µs

$\mathbf{FEXT_R}$ and $\mathbf{NEXT_R}$ are estimated by ATU-C

$\mathbf{FEXT_C}$ and $\mathbf{NEXT_C}$ are estimated by ATU-R

TTR	TCM-ISDN timing reference
TTR_C	Timing reference used in ATU-C
Received TTR_C	Received TTR_C at ATU-R
TTR_R	Timing reference used in ATU-R
S_C	55 × 0.9058 µs: Offset from TTR to TTR_C
S_R	–42 × 0.9058 µs: Offset from received TTR_C to TTR_R

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.

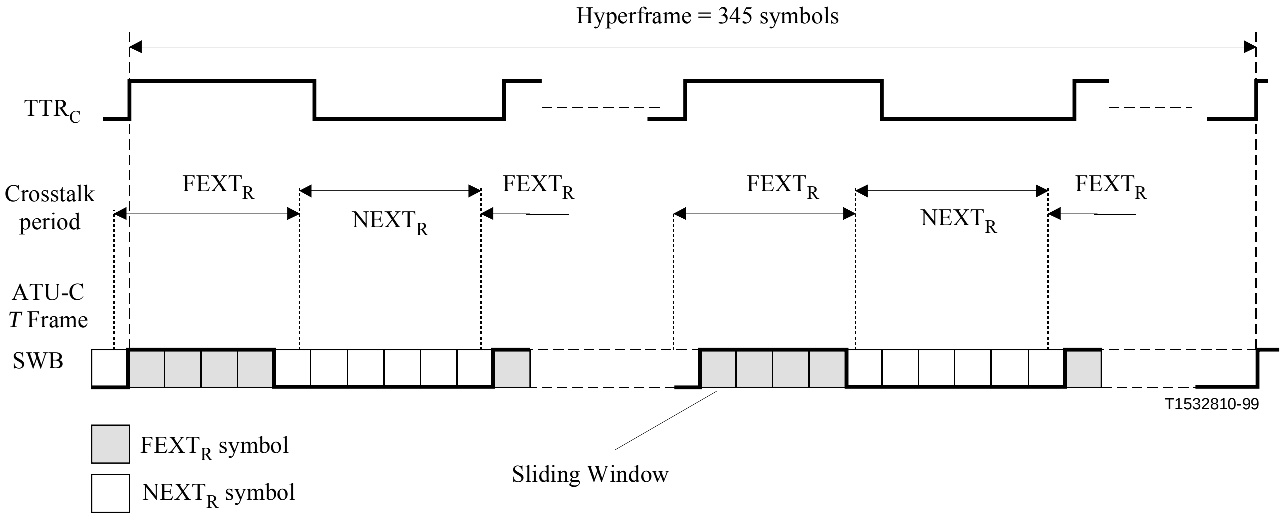


Figure I.6/G.992.1 – Sliding window for downstream symbols

The Sliding Window defines the transmission symbols under the crosstalk noise environment synchronized to the period of TTR. The $FEXT_{C/R}$ symbol represents the symbol completely inside the $FEXT_{C/R}$ duration. The $NEXT_{C/R}$ symbol represents any symbol containing the $NEXT_{C/R}$ duration. Thus, there are more $NEXT_{C/R}$ symbols than $FEXT_{C/R}$ 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-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.

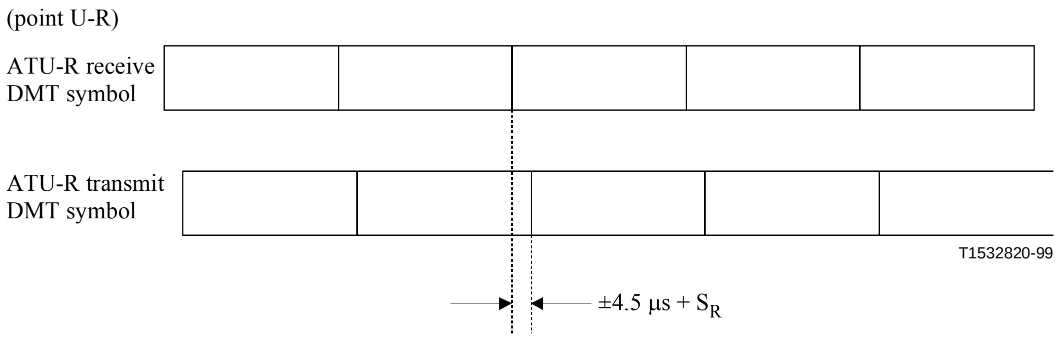


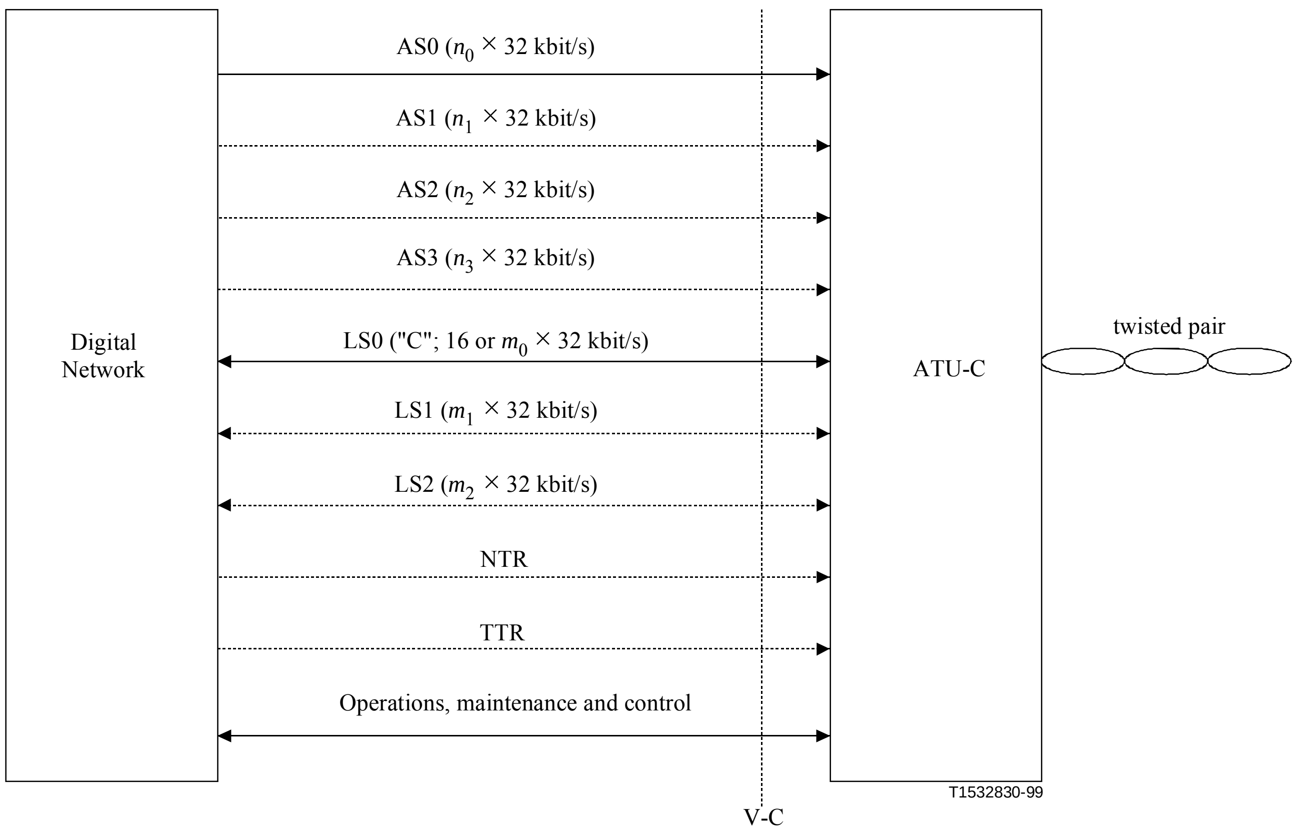
Figure I.7/G.992.1 – Loop timing for ATU-R

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

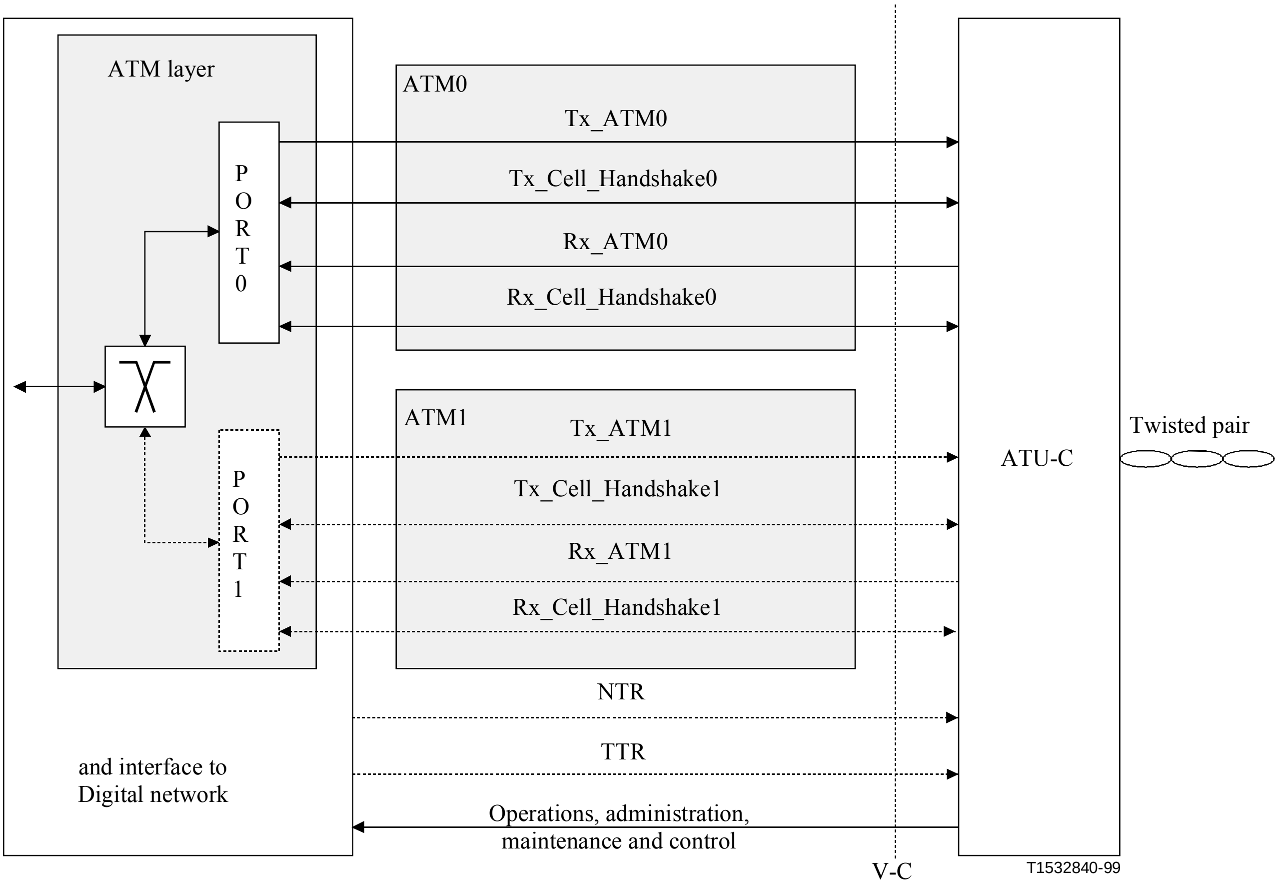
I.4.1.2 Payload transfer delay (supplements 7.1.4)

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

$S = 272 \times N_{dmt} \bmod 2760$

if { (S + 271 < a) 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.

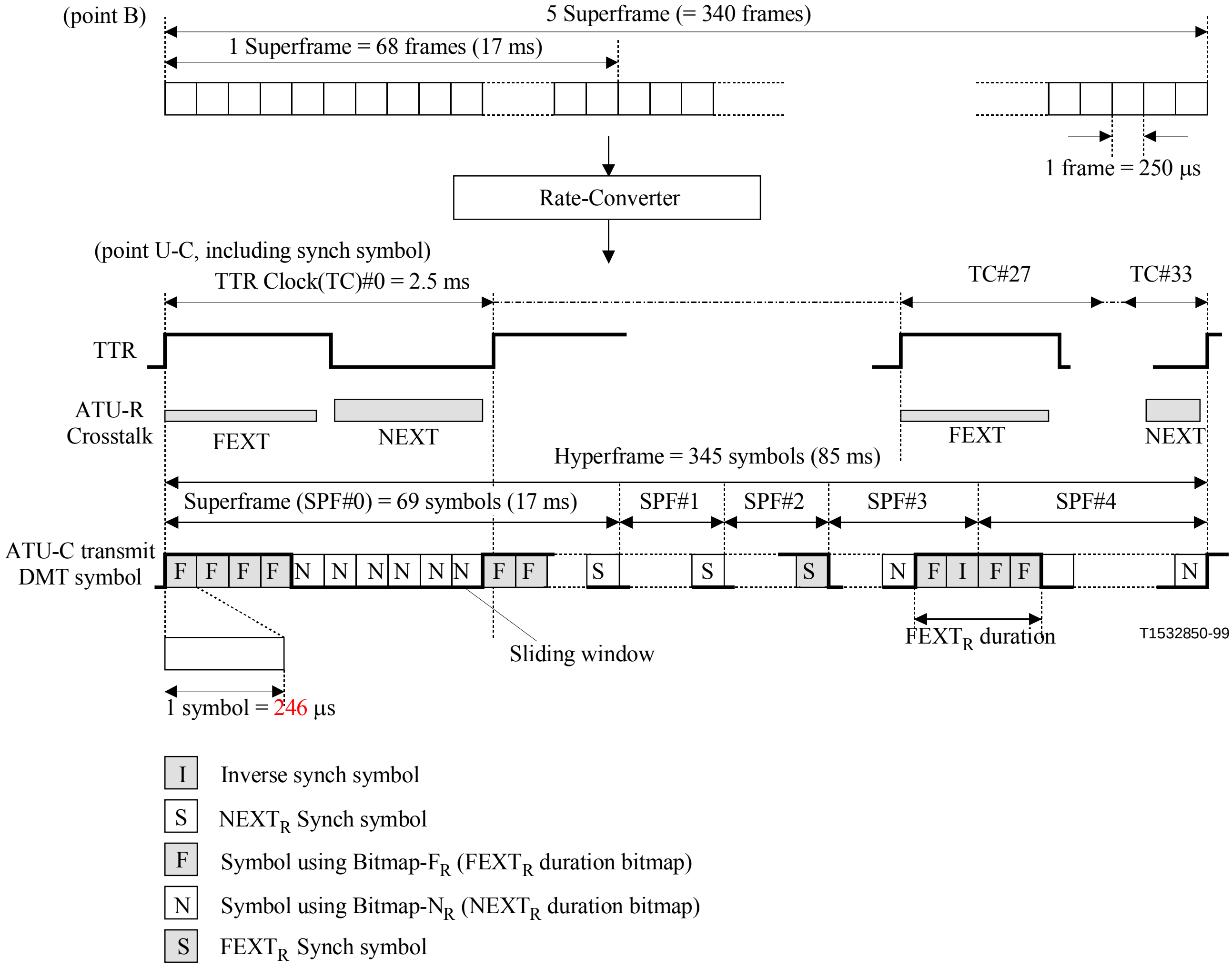


Figure I.10/G.992.1 – Hyperframe structure for downstream

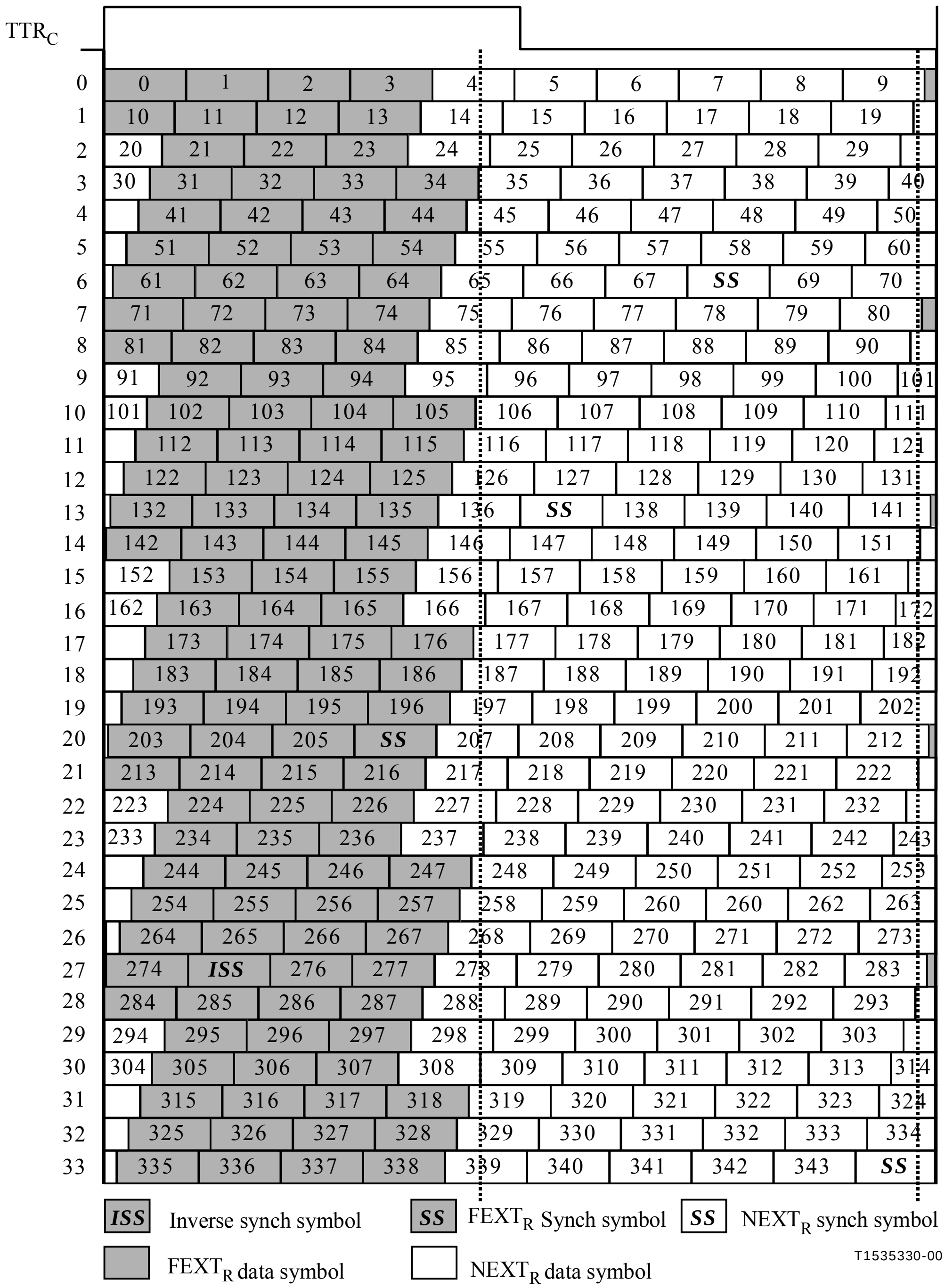


Figure I.11/G.992.1 – Symbol pattern in a hyperframe with cyclic prefix – Downstream

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.

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

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

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 $t_{Rf} \le n_{R\max}$:

$$n_{Rf} = t_{Rf}$$
$$n_{Ri} = n_R - n_{Rf}$$
$$f_{Rf} = t_{Rf}$$
$$f_{Ri} = f_R - f_{Rf}$$

If $t_{Rf} > n_{R\max}$:

$$n_{Rf} = n_{R\max}$$
$$n_{Ri} = 0$$
$$f_{Rf} = \begin{cases} f_{Rf4} = \left\lceil \dfrac{t_{Rf} \times 10 - n_{Rf} \times 6}{4} \right\rceil \\ f_{Rf3} = \left\lceil \dfrac{t_{Rf} \times 10 - n_{Rf} \times 7}{3} \right\rceil \end{cases}$$
$$f_{Ri} = \begin{cases} f_{Ri4} = f_R = f_{Rf4} \\ f_{Ri3} = f_R - f_{Rf3} \end{cases}$$

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 synch symbols.
f_{Rf4}	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.
n_R	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 $t_{Rf} \le n_{R\max}$:

$$dummy_{Rf} = 0$$

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

If $t_{Rf} > n_{R\max}$:

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

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

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

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.

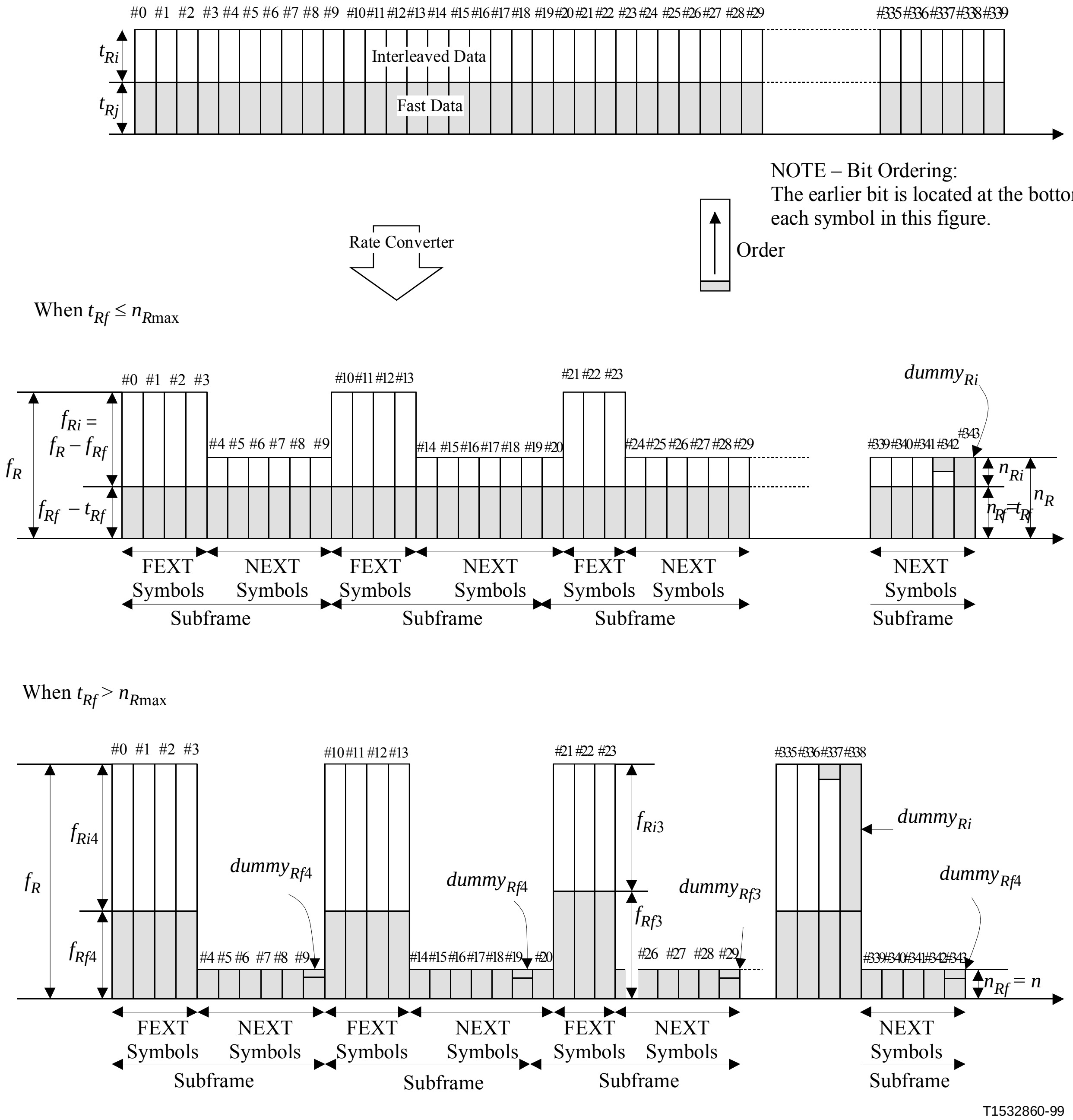


Figure I.12/G.992.1 – Bit distribution for Rate Converter under Dual latency and Dual Bitmap mode

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:

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

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,

$Z_i = \text{conj}\,(Z'_{2*NSCds-i})$ for i = NSCds+1 to 2*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, Δf = 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.

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

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,

$$(2 + 0.125)\text{*NSCds} \times 69 = (2 + 0.15625)\text{*NSCds} \times 68 \quad (7\text{-}24)$$

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

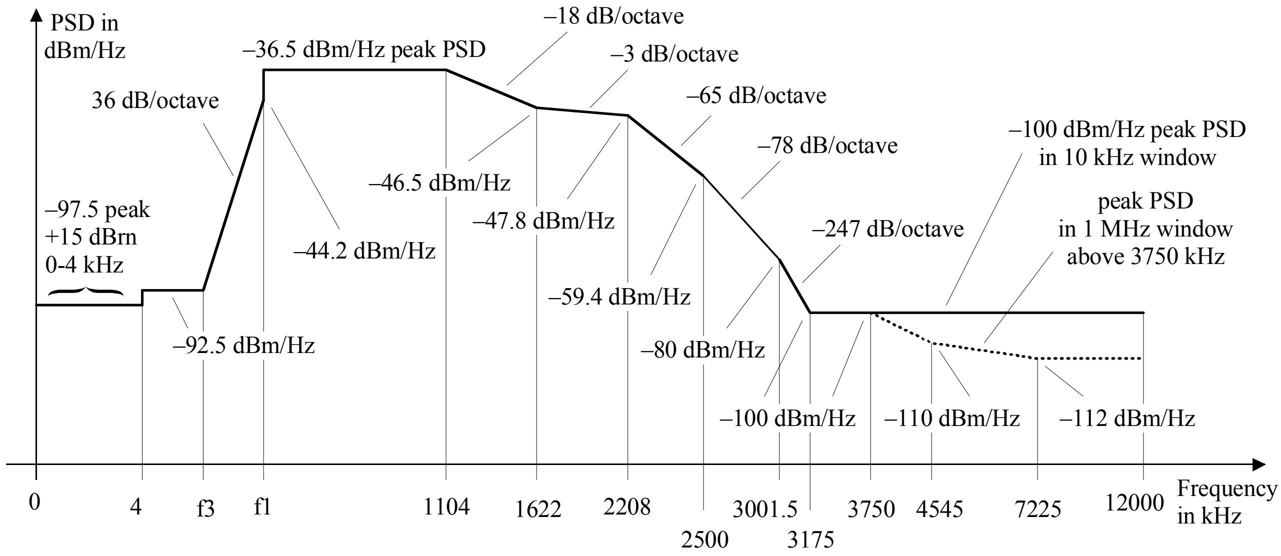
The cyclic prefix shall be used for all symbols beginning with the C-RATES1 segment of the initialization sequence, as defined in 10.6.2.

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*log2(f/f3)
f1 < 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*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
f1	-44.2	10 kHz
f1	-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< f ≤ 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.

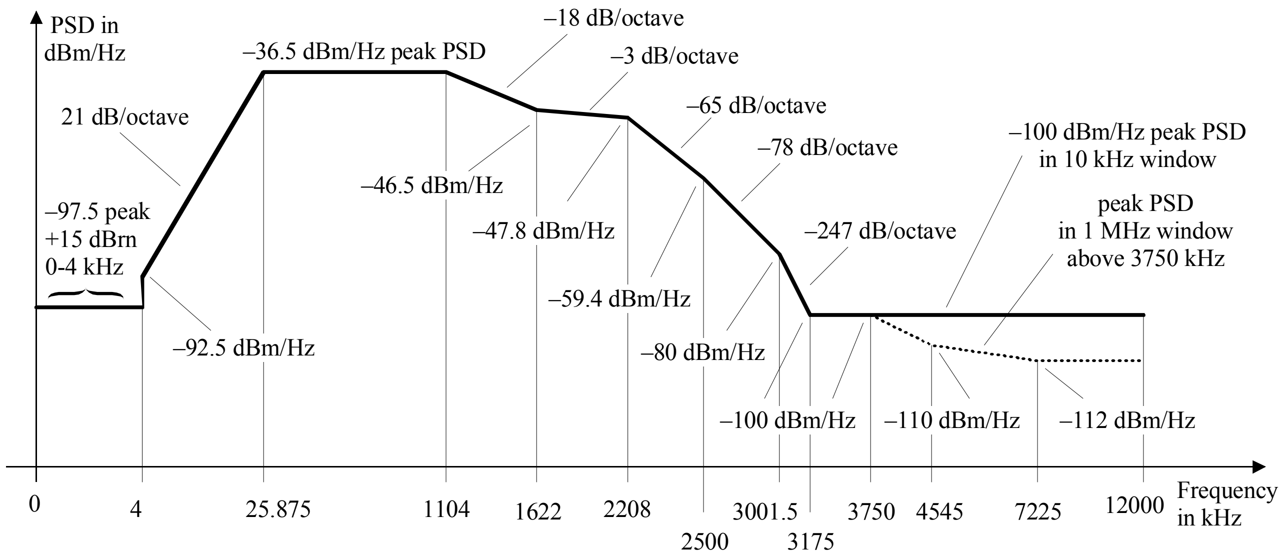
NOTE 6 – All PSD and power measurements shall be made at the U-C interface.

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*log2(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*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 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 ≤ 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:

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

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.

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

Tone Index	Log_ssv$_i$ (dB)	Comments
n1	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.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)
511	–11.3	2208 kHz (–11.3 = -51.3 - 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.

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 $n \geq 1$, 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.

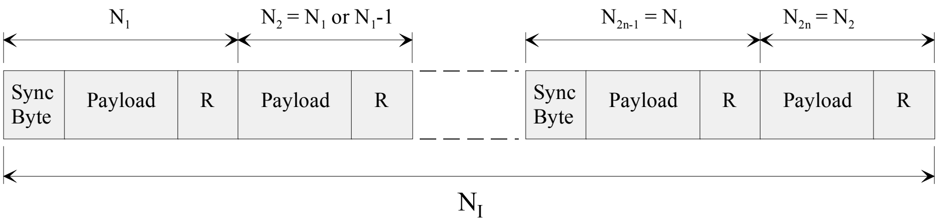


Figure I.15 – Data frame for S = 1/2n mode

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.

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

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 $N_{dmt} = 0, 1, \ldots, 344$

$S = 272 \times N_{dmt} \bmod 2760$

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:

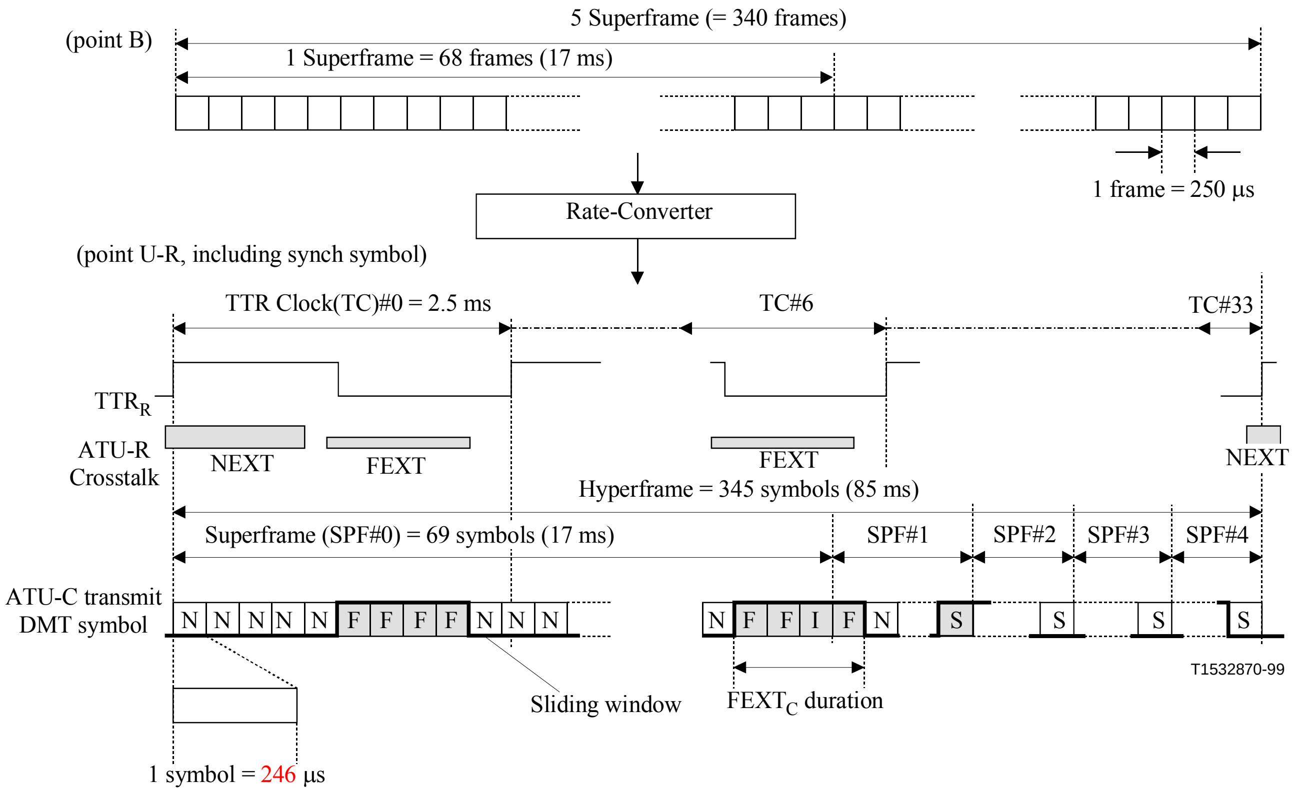
$FEXT_C$ symbol:

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.



I	Inverse synch symbol
S	$NEXT_C$ Synch symbol
F	Symbol using Bitmap-F_C ($FEXT_C$ duration bitmap)
N	Symbol using Bitmap-N_C ($NEXT_C$ duration bitmap)
S	$FEXT_C$ Synch symbol

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

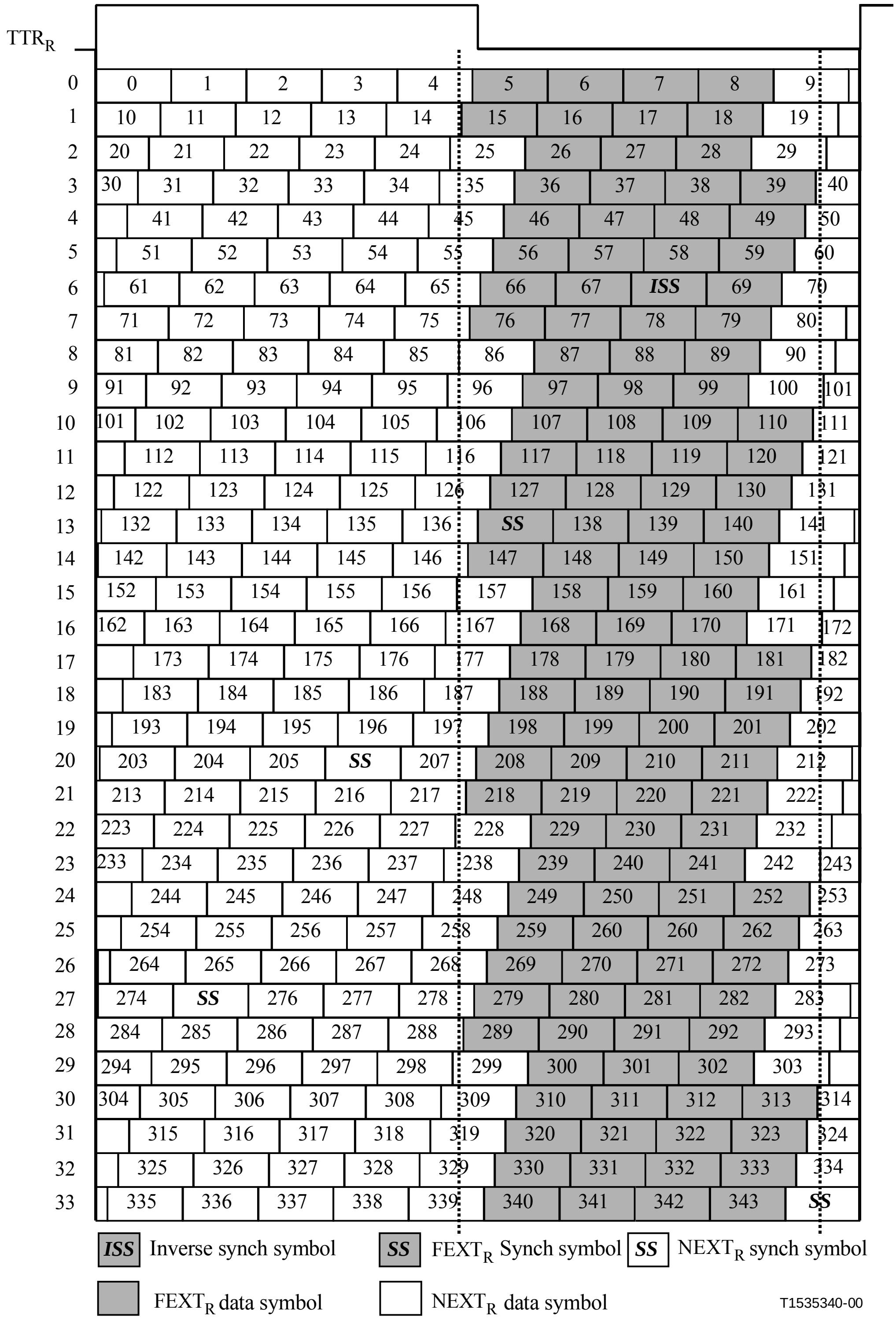


Figure I.17/G.992.1 – Symbol pattern in a hyperframe with cyclic prefix – Upstream

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.

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

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

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 $t_{Cf} \le n_{C\max}$:

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

If $t_{Cf} > n_{C\max}$:

$$n_{Cf} = n_{C\max}$$
$$n_{Ci} = 0$$
$$f_{Cf} = \begin{cases} f_{Cf4} = \left\lceil \dfrac{t_{Cf} \times 10 - n_{Cf} \times 6}{4} \right\rceil \\ f_{Cf3} = \left\lceil \dfrac{t_{Cf} \times 10 - n_{Cf} \times 7}{3} \right\rceil \end{cases}$$
$$f_{Ci} = \begin{cases} f_{Ci4} = f_C - f_{C4} \\ f_{Ci3} = f_C - f_{Cf3} \end{cases}$$

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 for synch symbols.
f_{Cf4}	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.
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 $t_{Cf} \leq n_{C\max}$:

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

If $t_{Cf} > n_{C\max}$:

$$dummy_{Cf4} = \left(f_{Cf} \times 4 + n_{Cf} \times 6\right) - t_{Cf} \times 10$$
$$dummy_{Cf3} = \left(f_{Cf} \times 3 + n_{Cf} \times 7\right) - t_{Cf} \times 10$$
$$dummy_{Ci} = \left(f_{Ci4} \times 96 + f_{Ci3} \times 30\right) - t_{Ci} \times 340$$

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)

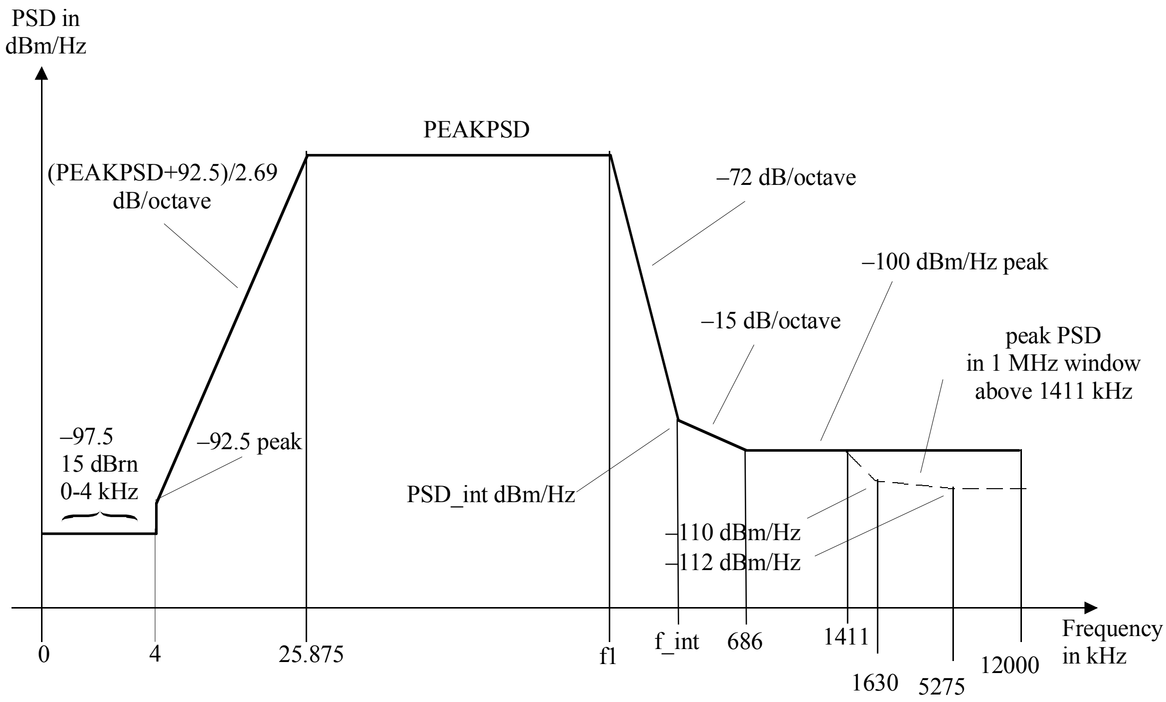
For Annex I-EU, see A.2.2.

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 bitmap for mode 1, both bitmaps for mode 2 (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	-38.5	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 ≤ 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-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, …344

S = 256 x 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 x 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 x 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 I.17).

For N_{dmt} = 0, 1, ..., 344

$S = 272 \times N_{dmt} \bmod 2760$

if { (S > a) and (S + 271 < a + b) } then $FEXT_C$ symbols

else then $NEXT_C$ symbols

where a = 1315, b = 1293

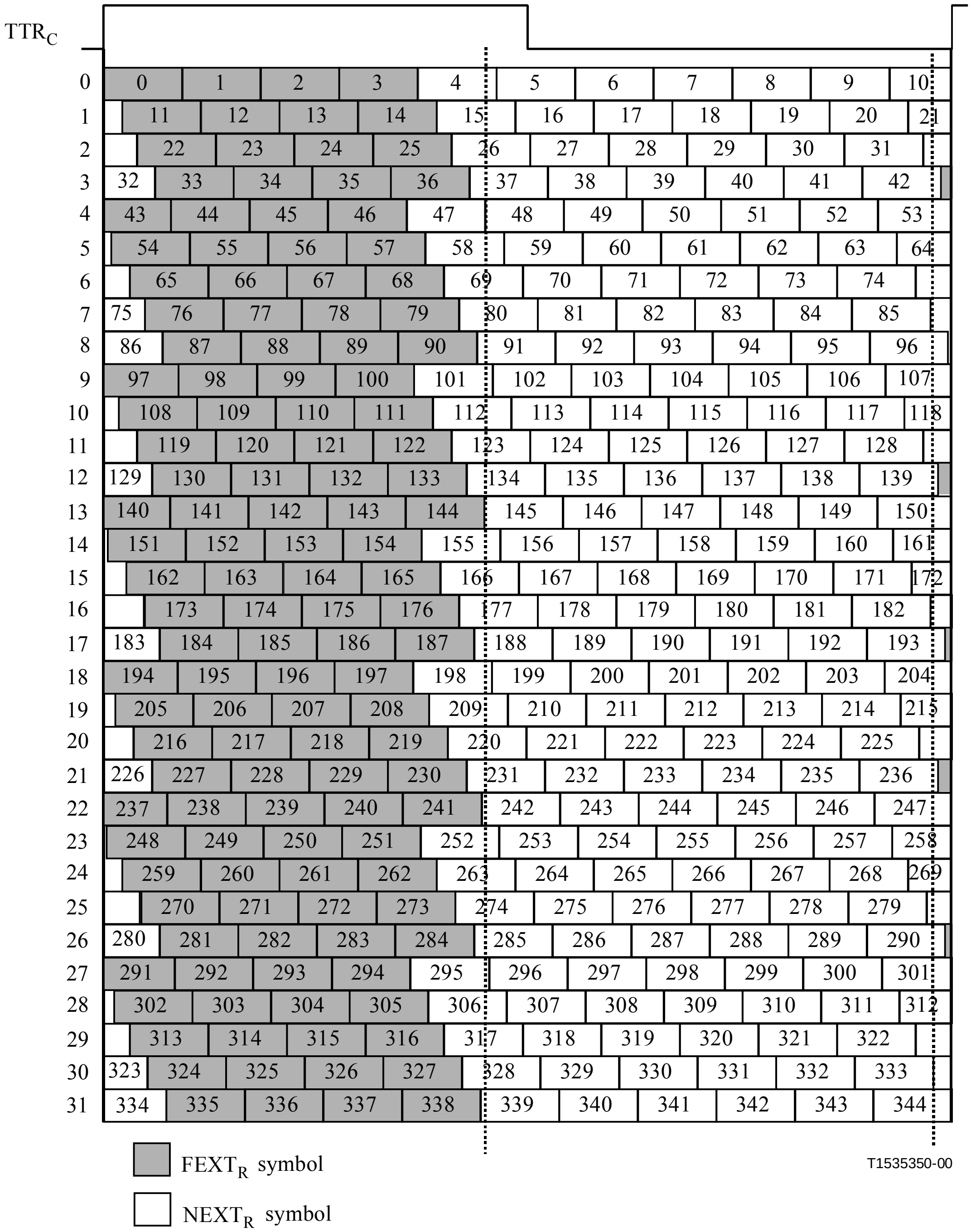


Figure I.19/G.992.1 – Symbol pattern in a hyperframe without cyclic prefix – Downstream

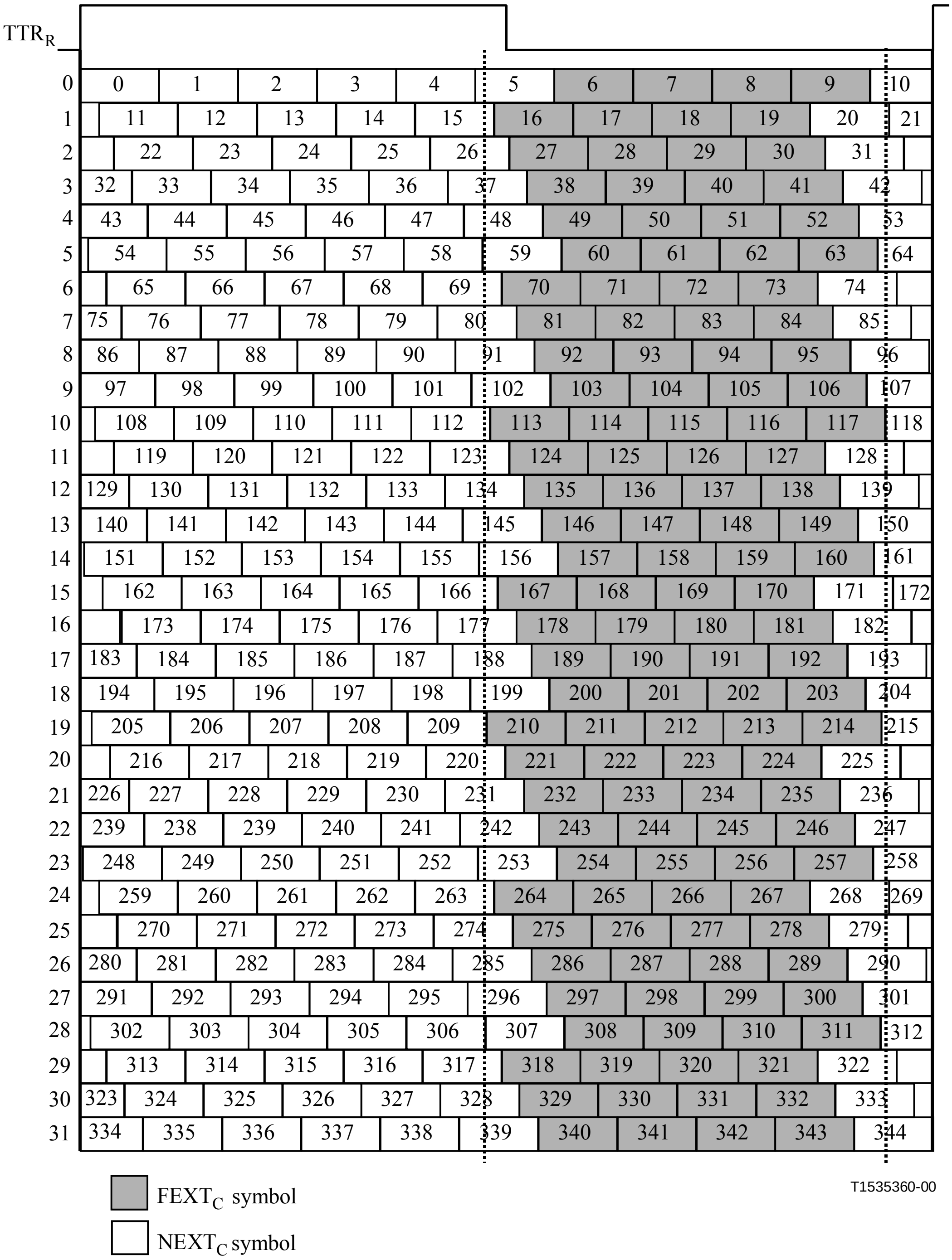


Figure I.20/G.992.1 – Symbol pattern in a hyperframe without cyclic prefix – Upstream

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 §I.7.3 and §I.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 §I.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".

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

Bits 8	7	6	5	4	3	2	1	**NPar(1)s**
x	x	x	x	x	x	x	1	Reserved for future use
x	x	x	x	x	x	1	x	Reserved for future use
x	x	x	x	x	1	x	x	Reserved for future use
x	x	x	x	1	x	x	x	Reserved for future use
x	x	x	1	x	x	x	x	Reserved for future use
x	x	1	x	x	x	x	x	Reserved for future use
x	1	x	x	x	x	x	x	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

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

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	x	x	x	x	x	x	1	$n_{\text{C-PILOT1}} = 64$
x	x	x	x	x	x	1	x	$n_{\text{C-PILOT1}} = 128$
x	x	x	x	x	1	x	x	$n_{\text{C-PILOT1}} = 256$
x	x	x	x	1	x	x	x	Amateur radio notch – 1.8 MHz band
x	x	x	1	x	x	x	x	Reserved for future use
x	x	1	x	x	x	x	x	$n_{\text{C-PILOT1}} = 96$
x	x	0	0	0	0	0	0	No parameters in this octet
Since A48 is the only TTR indication signal specified 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
x	x	x	x	x	x	x	1	R-ACK1
x	x	x	x	x	x	1	x	R-ACK2
x	x	x	x	x	1	x	x	DBM
x	x	x	x	1	x	x	x	Reserved for future use
x	x	x	1	x	x	x	x	Reserved for future use
x	x	1	x	x	x	x	x	G.997.1 – Clear EOC OAM
x	x	0	0	0	0	0	0	No parameters in this octet
Since Annex I-EU only supports ATM transport, STM and ATM parameters are not specified.								

Table I.7.4 – Non-standard information field – G.992.1 Annex I-EU SPar(2) coding

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

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 8	7	6	5	4	3	2	1	G.992.1 Annex I-EU Additional inband spectral shaping Npar(3)s Octet 1
x	x					x	x	NOMINAL_PSD_lowband (bits 8 & 7)
x	x	x	x	x	x			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 8	7	6	5	4	3	2	1	G.992.1 Annex I-EU Additional inband spectral shaping Npar(3)s Octet 2
x	x	x	x	x	x	x	x	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 8	7	6	5	4	3	2	1	G.992.1 Annex I-EU Additional inband spectral shaping Npar(3)s Octet 3
x	x					x	x	PSD level at 1622 kHz (bits 8 & 7)
x	x	x	x	x	x			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 8	7	6	5	4	3	2	1	**G.992.1 Annex I-EU Additional inband spectral shaping Npar(3)s Octet 4**
x	x	x	x	x	x	x	x	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 8	7	6	5	4	3	2	1	**G.992.1 Annex I-EU Additional inband spectral shaping Npar(3)s Octet 5**
x	x					x	x	PSD level at 2208 kHz (bits 8 & 7)
x	x	x	x	x	x			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 8	7	6	5	4	3	2	1	**G.992.1 Annex I-EU Additional inband spectral shaping Npar(3)s Octet 6**
x	x	x	x	x	x	x	x	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**
x	x	x	x	x	x	x	1	Mode 1 upstream mask
x	x	x	x	x	x	1	x	Mode 2 upstream mask
x	x	x	x	x	1	x	x	Optional upstream masks for non-overlapped spectrum
x	x	x	x	1	x	x	x	EU-64
x	x	x	1	x	x	x	x	EU-32
x	x	1	x	x	x	x	x	EU-36
x	x	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

Bits 8	7	6	5	4	3	2	1	**G.992.1 Annex I-EU Extended upstream NPar(3)s Octet 2**
x	x	x	x	x	x	x	1	EU-40
x	x	x	x	x	x	1	x	EU-44
x	x	x	x	x	1	x	x	EU-48
x	x	x	x	1	x	x	x	EU-52
x	x	x	1	x	x	x	x	EU-56
x	x	1	x	x	x	x	x	EU-60
x	x	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.

Table I.8/G.992.1 – ATU-C CL 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 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.
$n_{C\text{-PILOT1}}=64$	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 64.
$n_{C\text{-PILOT1}}=96$	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 96.
$n_{C\text{-PILOT1}}=128$	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 128.
$n_{C\text{-PILOT1}}=256$	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 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.

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.
$n_{C\text{-}PILOT1}=64$	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 64 (Note 1).
$n_{C\text{-}PILOT1}=96$	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 96 (Note 1).
$n_{C\text{-}PILOT1}=128$	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 128 (Note 1).
$n_{C\text{-}PILOT1}=256$	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 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 2208 kHz
REDUCED_PSD_low band	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 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 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 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.	

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.

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

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.
$n_{C\text{-}PILOT1}$=64	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 64.
$n_{C\text{-}PILOT1}$=96	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 96.
$n_{C\text{-}PILOT1}$=128	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 128.
$n_{C\text{-}PILOT1}$=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.

I.7.3.2.2 MS messages (supplements 10.3.2)

Table I.11.

Table I.11/G.992.1 – ATU-R 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-R is selecting G.992.1 Annex I-EU.
$n_{C\text{-}PILOT1}$=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).
$n_{C\text{-}PILOT1}$=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).

$n_{C\text{-}PILOT1}$=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).
$n_{C\text{-}PILOT1}$=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 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 2208 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 2208 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-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 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.	

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

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.
$n_{C\text{-}PILOT1}$=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).
$n_{C\text{-}PILOT1}$=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).

$n_{C\text{-}PILOT1}$=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).
$n_{C\text{-}PILOT1}$=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.
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 2208 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 2208 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-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 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 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.	

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 $f_{C\text{-}PILOT1}$ defined as:

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

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

16. $f_{\text{C-PILOT1}}$ = 276 kHz ($n_{\text{C-PILOT1}}$ = 64).
17. $f_{\text{C-PILOT1}}$ = 414 kHz ($n_{\text{C-PILOT1}}$ = 96).
18. $f_{\text{C-PILOT1}}$ = 552 kHz ($n_{\text{C-PILOT1}}$ = 128).
19. $f_{\text{C-PILOT1}}$ = 1104 kHz ($n_{\text{C-PILOT1}}$ = 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:

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.

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.

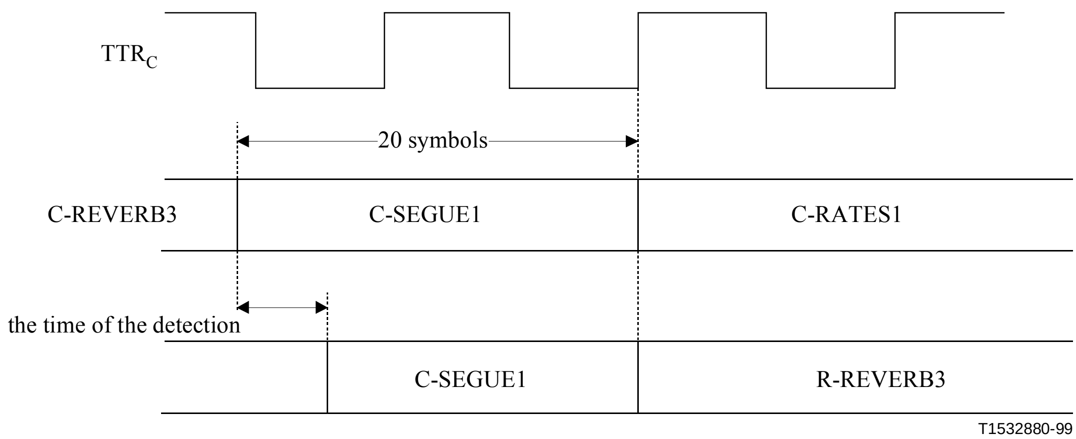


Figure I.22/G.992.1 – Timing diagram from C-SEGUE1 to C-RATES1

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:

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

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.

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:

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

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:

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

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 2^{14}-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 x 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).

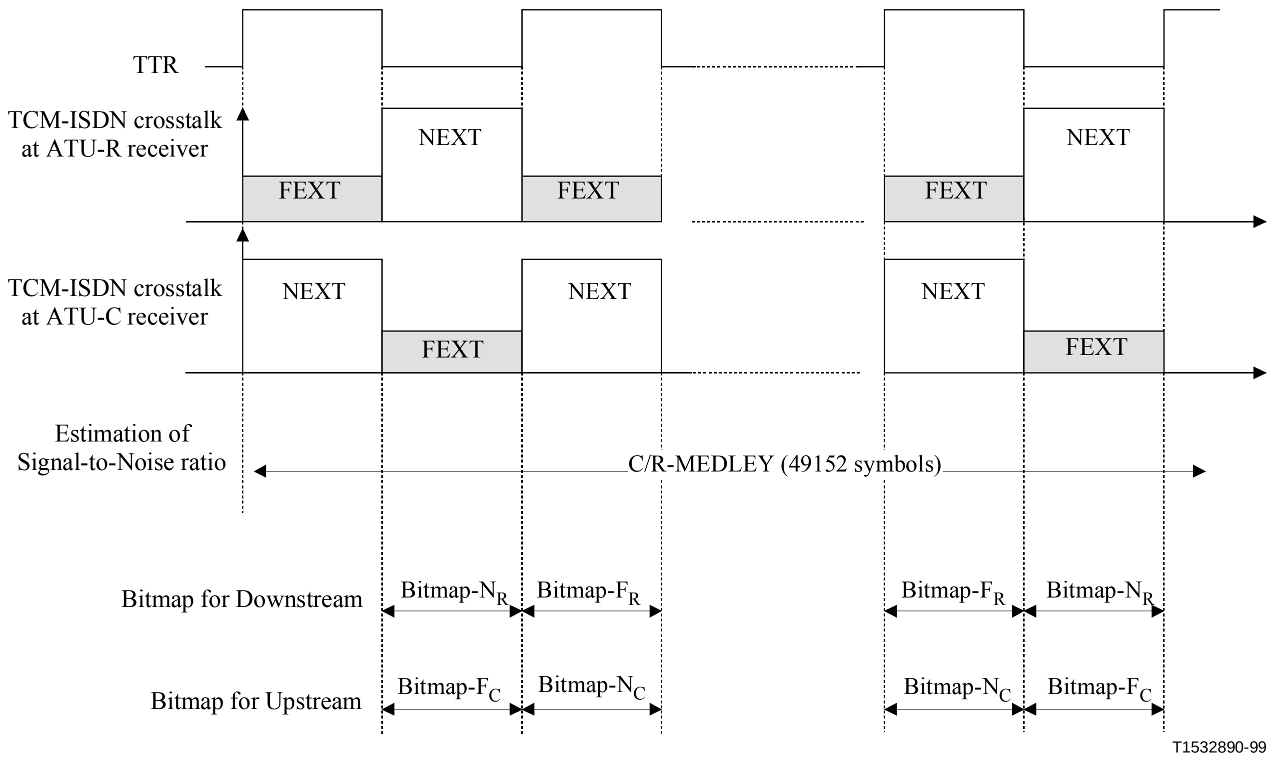


Figure I.23/G.992.1 – Estimation of periodic Signal-to-Noise Ratio

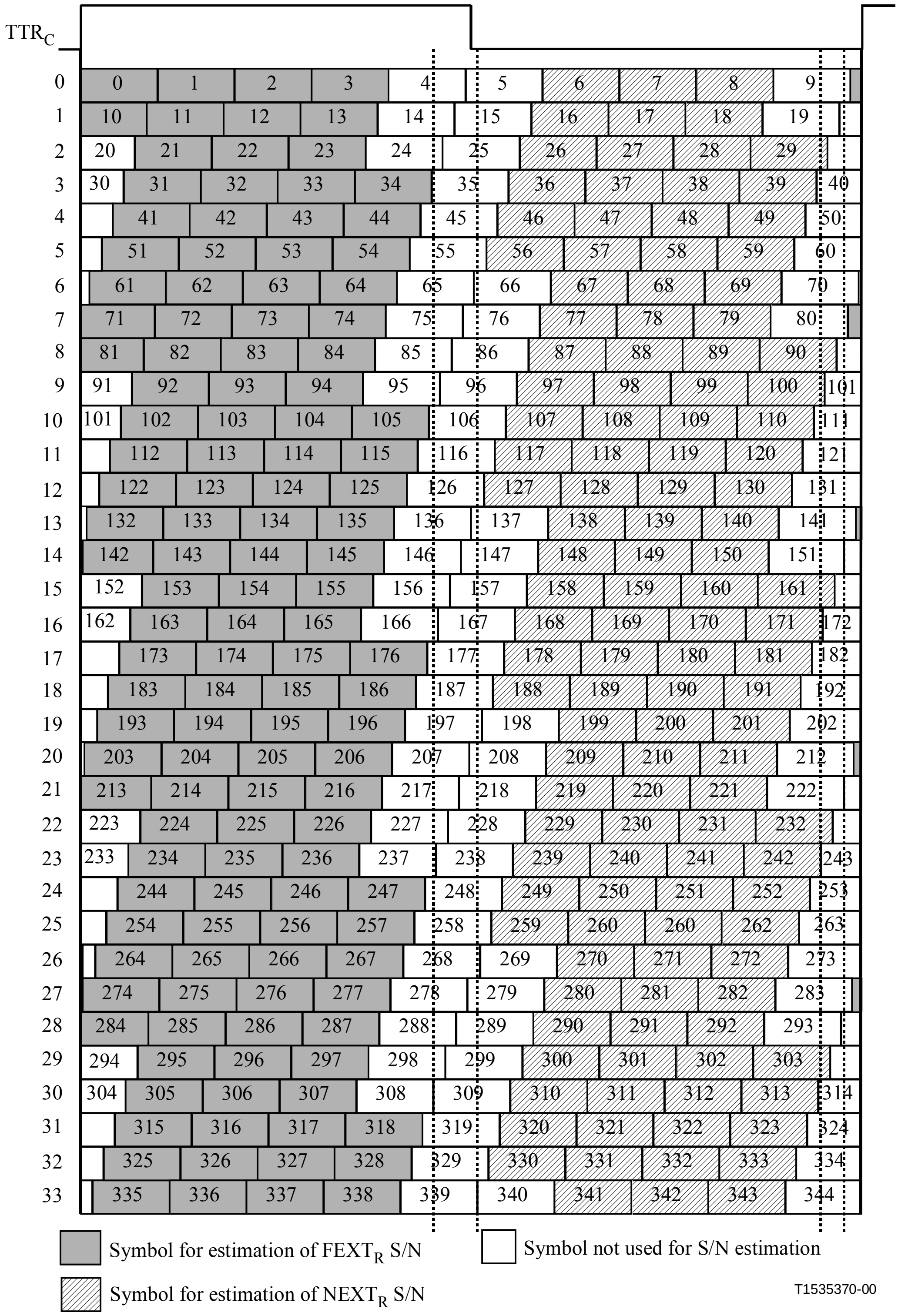


Figure I.24/G.992.1 – Symbol pattern in a hyperframe for S/N estimation – Downstream

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.,

$RS_I = R_I/(n*S)$.

I.7.6.4 C-MSG1 (supplements 10.6.4)

Table I.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; binary coded 0-15 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 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:

$$d_n = 1 \text{ for } n = 1 \text{ to } 23 \text{ and } d_n = d_{n-18} \oplus d_{n-23} \text{ for } n > 23.$$

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 $N_{dmt} = 0, 1, \ldots, 344$

$S = 272 \times N_{dmt} \bmod 2760$

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).

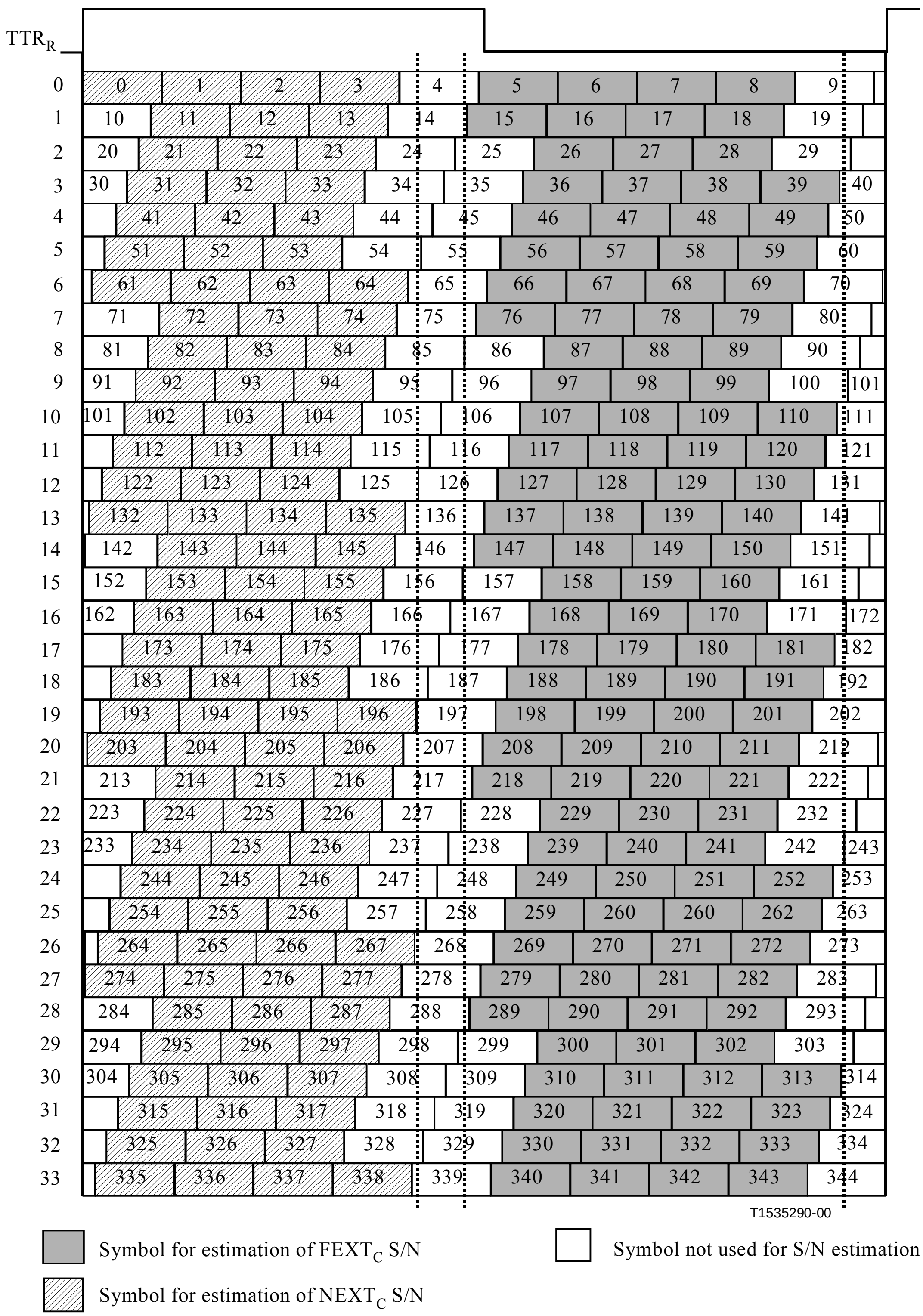


Figure I.25/G.992.1 – Symbol pattern in a hyperframe for S/N estimation – Upstream

I.7.8.4 R-MSG1 (supplements 10.7.6)

Table I.14/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 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.

Table I.15/G.992.1 – Assignment of 32 bits of C-MSG2

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".	

For NSCus=32,

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

Otherwise,

$n_{1C\text{-}MSG2} = 139$
$n_{2C\text{-}MSG2} = 187$

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 x 126 + 88 x 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), $\{m_{10}, ..., m_0\} = 00001111111_2$].

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-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_is 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 (00000_2 and $00000000\ 000_2$, 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 (000.00110000_2 to 001.01010101_2).

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:

$m = \{m_{32*(NSCu-1)-1}, m_{32*(NSCu-1)-2}, \ldots, m_1, m_0\} = \{ g_{2*NSCu-1}, b_{2*NSCu-1}, \ldots, g_{NSCu+1}, b_{NSCu+1}, g_{NSCu-1}, b_{NSCu-1}, \ldots, g_1, b_1\},$ (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)

Table I.16/G.992.1 – RRSI fields of C-RATES-RA

	←bits→							
fields	7	6	5	4	3	2	1	0
RS_F	0	0	value of RS_F MSB … LSB					
RS_I	B_8 (AS0)	B_9 (AS0)	value of RS_I MSB … LSB					
S	I_9	I_8	value of S MSB … LSB					
I	I_7	I_6	I_5	I_4	I_3	I_2	I_1	I_0
FS(LS2)	value of FS(LS2) *set to* $\{00000000_2\}$							

The RS_I field has been extended to include the most significant bit B_9 of B_I (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.

Table I.17/G.992.1 – Assignment of 80 bits of R-MSG-RA (Annex I-EU)

Suffix(ces) of m_i (Note)	Parameter 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	$B_{fast\text{-}max}$
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, B_{max}
13-12	Maximum Interleave Depth downstream
11-0	Total number of bits per DMT symbol, B_{max}
NOTE – Within the separate fields the least significant bits have the lowest subscripts.	

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 $B_{fast\text{-}max}$ (new)

$B_{fast\text{-}max}$ 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 $B_{fast\text{-}max}$ is t_f.

I.7.10.2 R-MSG2 (supplements 10.9.8)

Table I.18/G.992.1 – Assignment of 32 bits of R-MSG2

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, 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".	

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

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 $g_{NSCds+64}$ 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 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) 001.01000000_2 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 (00000_2 and $00000000\ 000_2$, 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 (000.00110000_2 to 001.01010101_2).

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

$$m = \{m_{(2*NSCds-2)*16-1}, m_{(2*NSCds-2)*16-2}, \ldots, m_1, m_0\} = \{g_{2*NSCds-1}, b_{2*NSCds-1}, \ldots, g_{NSCds+1}, b_{NSCds+1}, g_{NSCds-1}, b_{NSCds-1}, \ldots, g_1, b_1\}, \quad \text{(I.10-3)}$$

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.

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

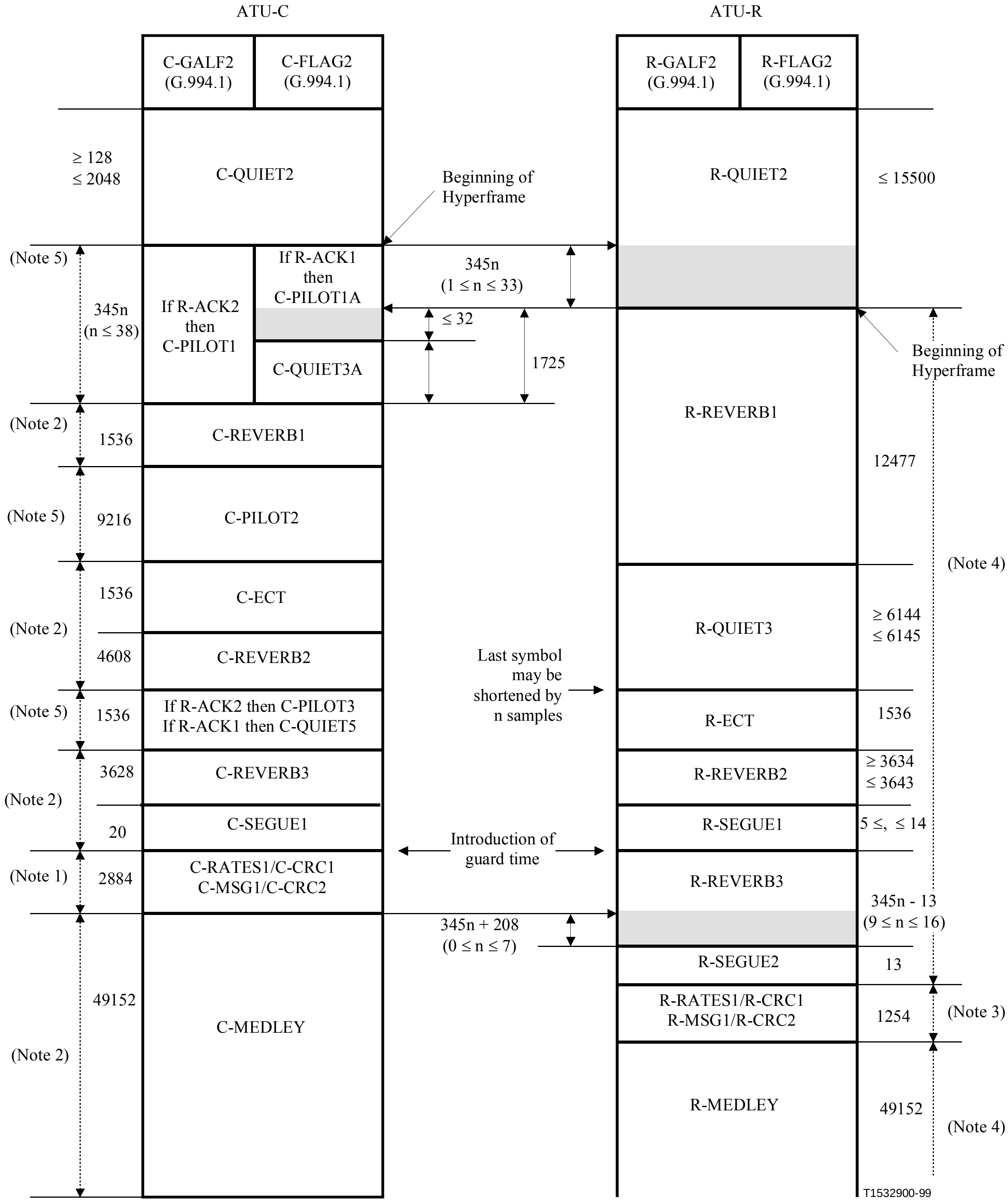
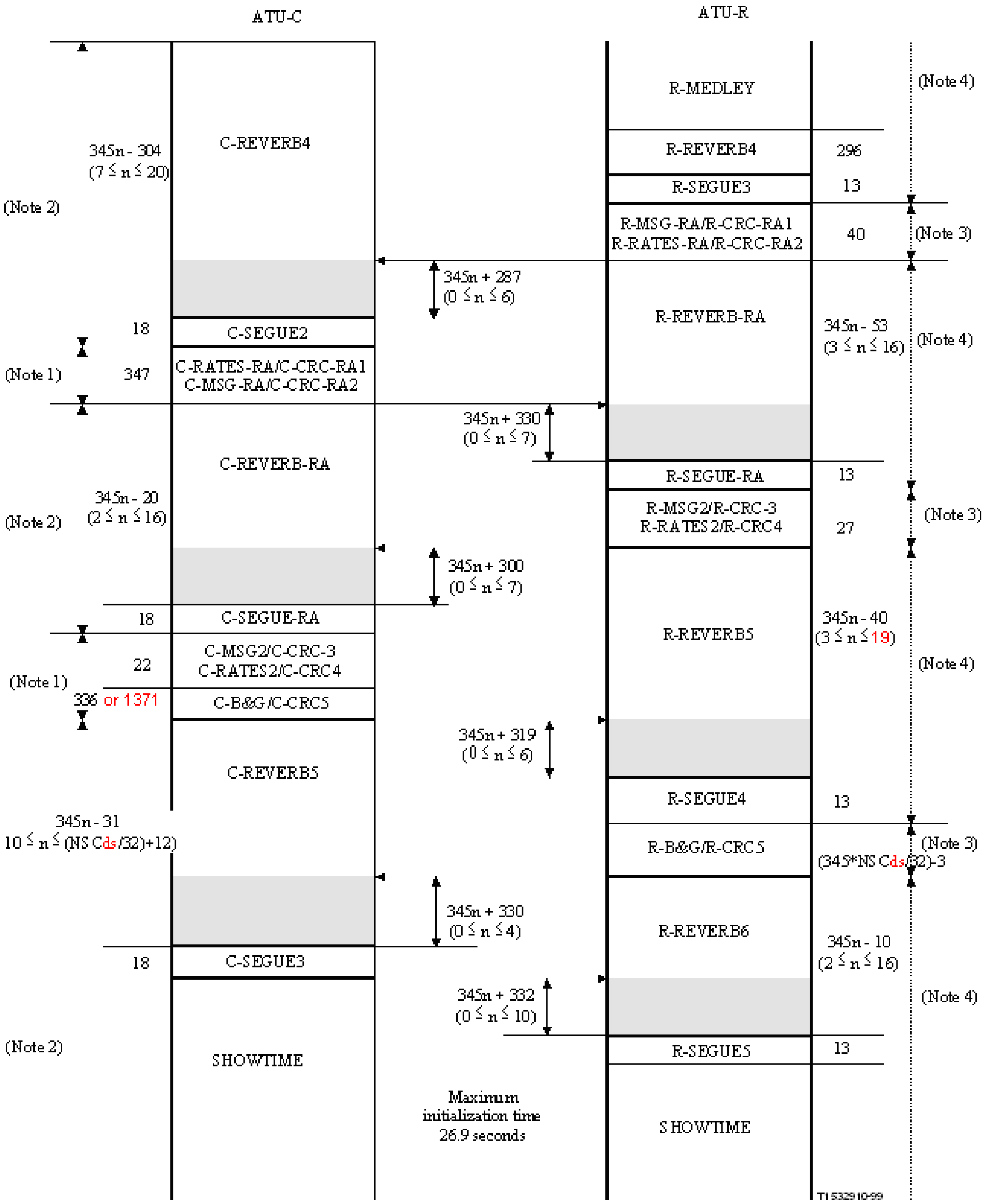


Figure I.26/G.992.1 – Timing diagram of the initialization sequence – Part 1



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 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.

Table I.19/G.992.1 – Format of the bit swap request message

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

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 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.

Table I.20/G.992.1 – Bit swap request command

Value (8 bit)	Interpretation
$yzz00000_2$	Do nothing
$yzz00001_2$	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
$yzz00110_2$	Reduce the transmitted power by 1 dB
$yzz00111_2$	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	

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:

$$g_i' = (1/256) \times round(256 \times g_i \times 10\exp(\Delta/20)) \qquad \text{(I.11-1)}$$

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.

Table I.21/G.992.1 – Format of the bit swap request message

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)

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 → 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 I also implements Annex C.

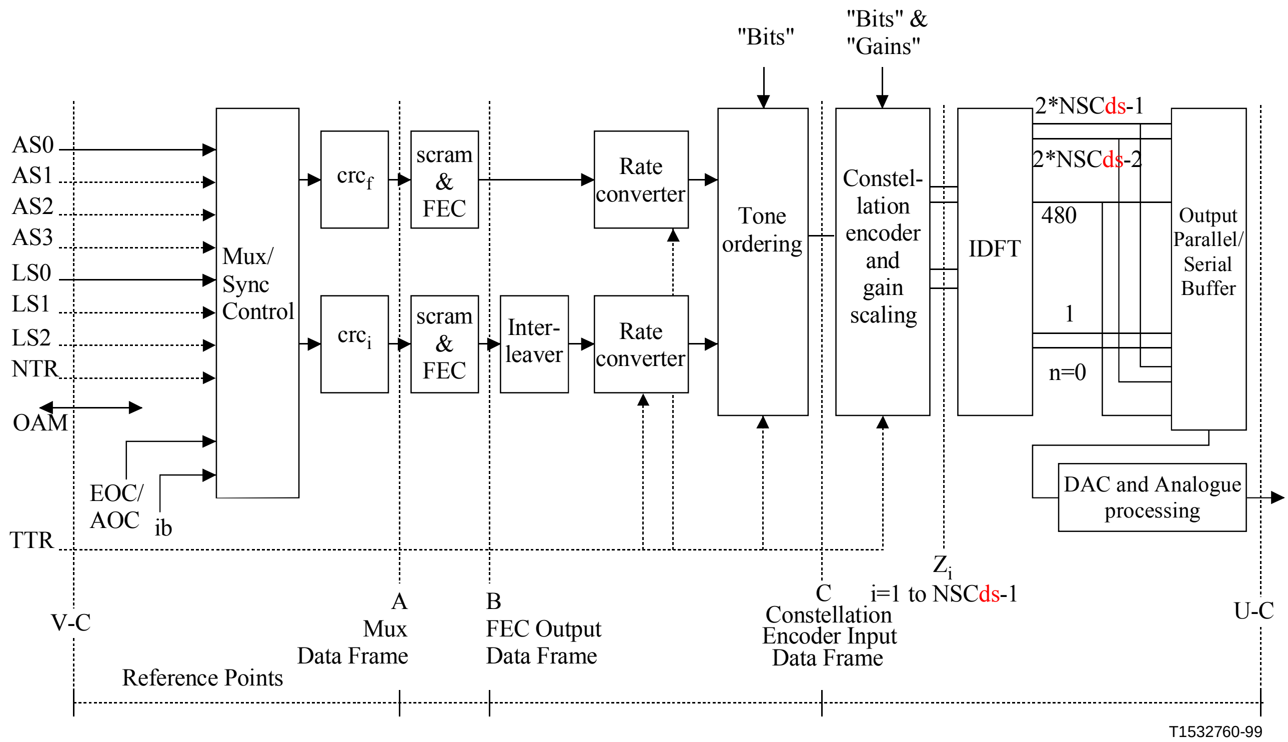
I.2 Definitions

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	The Dual Bitmap method has dual bit rates under the FEXT and NEXT noise from TCM-ISDN
FEXT Bitmap	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	5 Superframes structure which synchronized TTR
$NEXT_C$ duration	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	TCM-ISDN Timing Reference
TTR_C	Timing reference used in ATU-C
TTR_R	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)

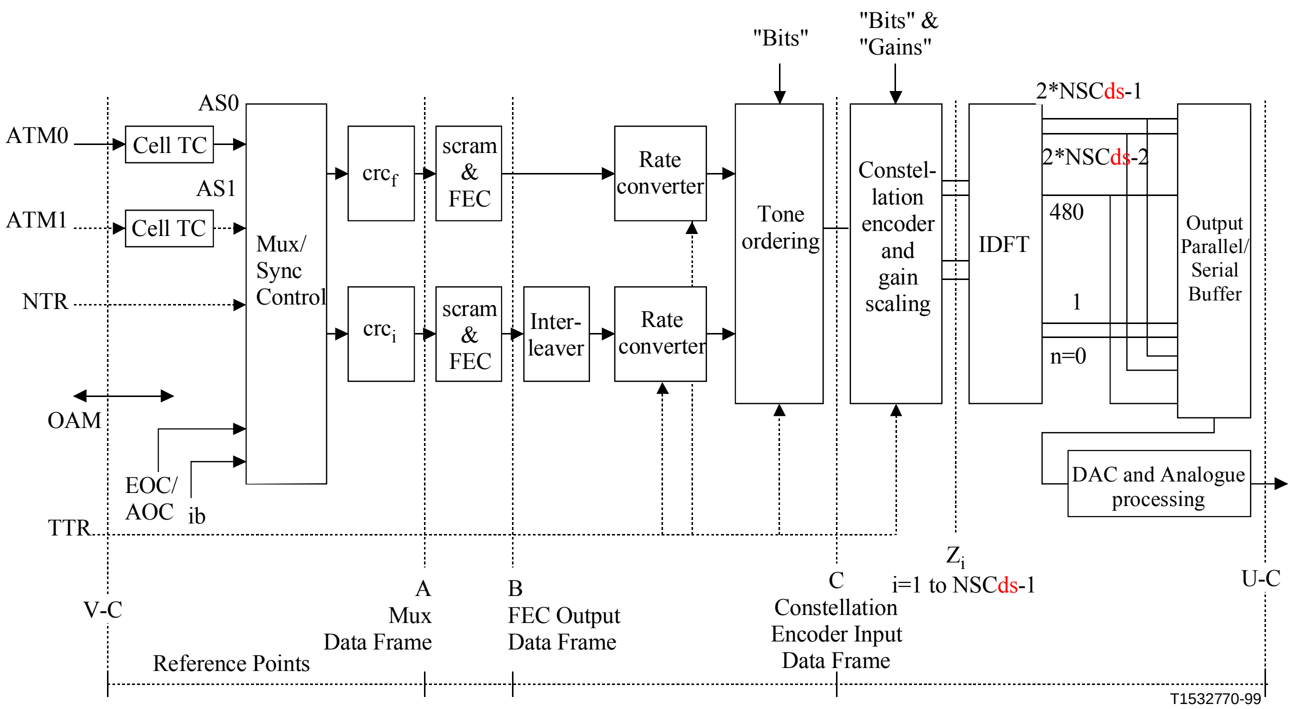
See Figure I.1 and Figure I.2.



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

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

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

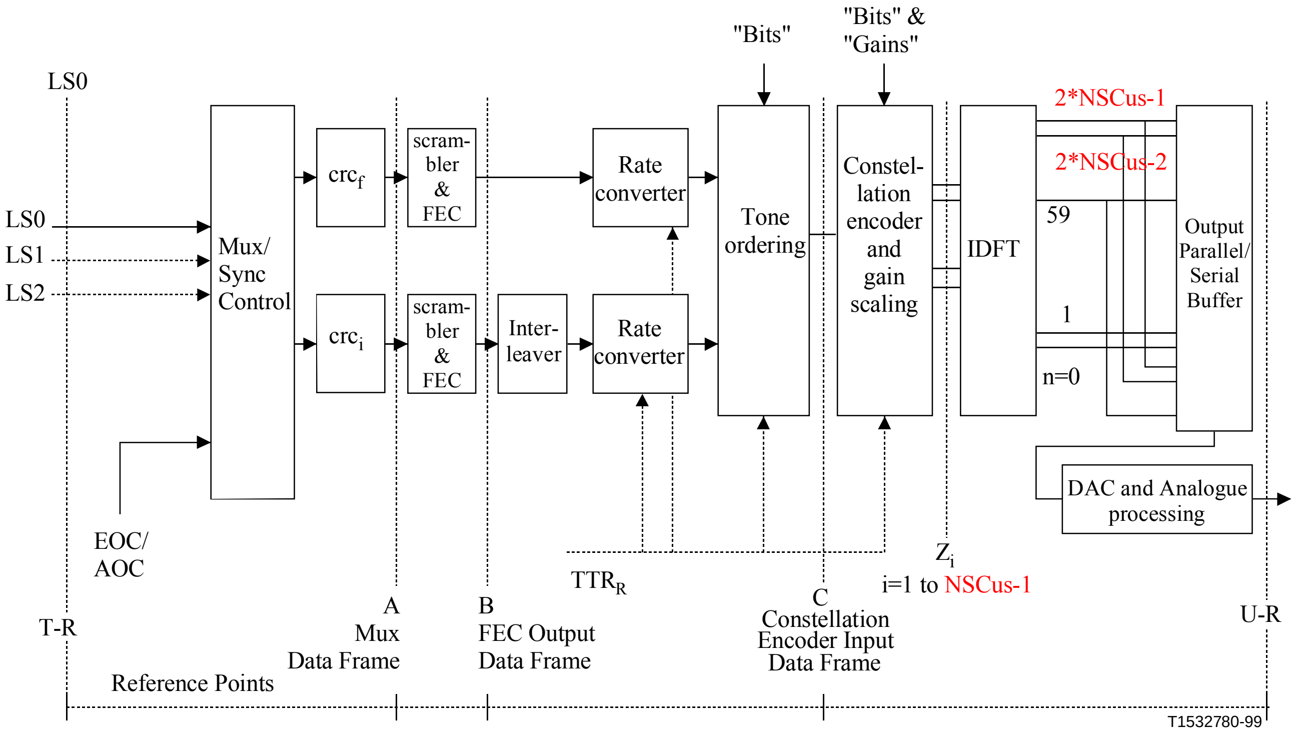


NOTE – The TTR may be generated in ATU-C without being provided from the TCM-ISDN clock.

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)

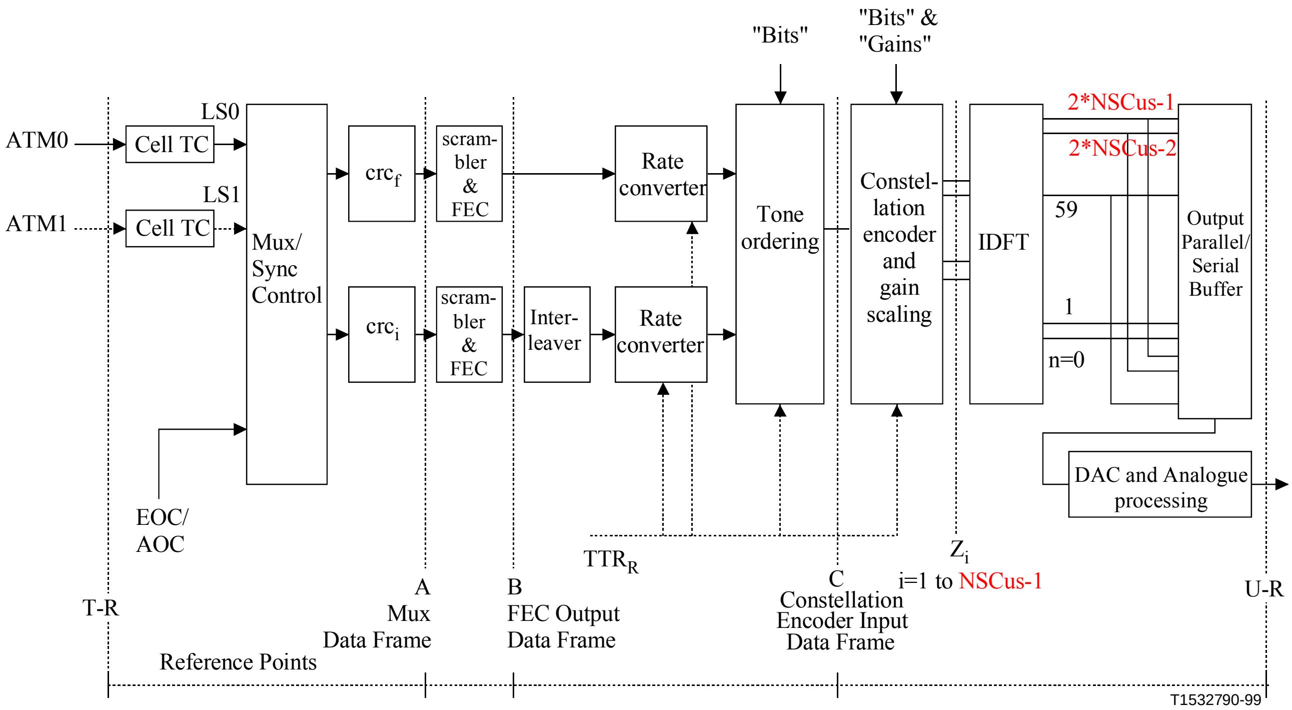
See Figure I.3 and Figure I.4.



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.



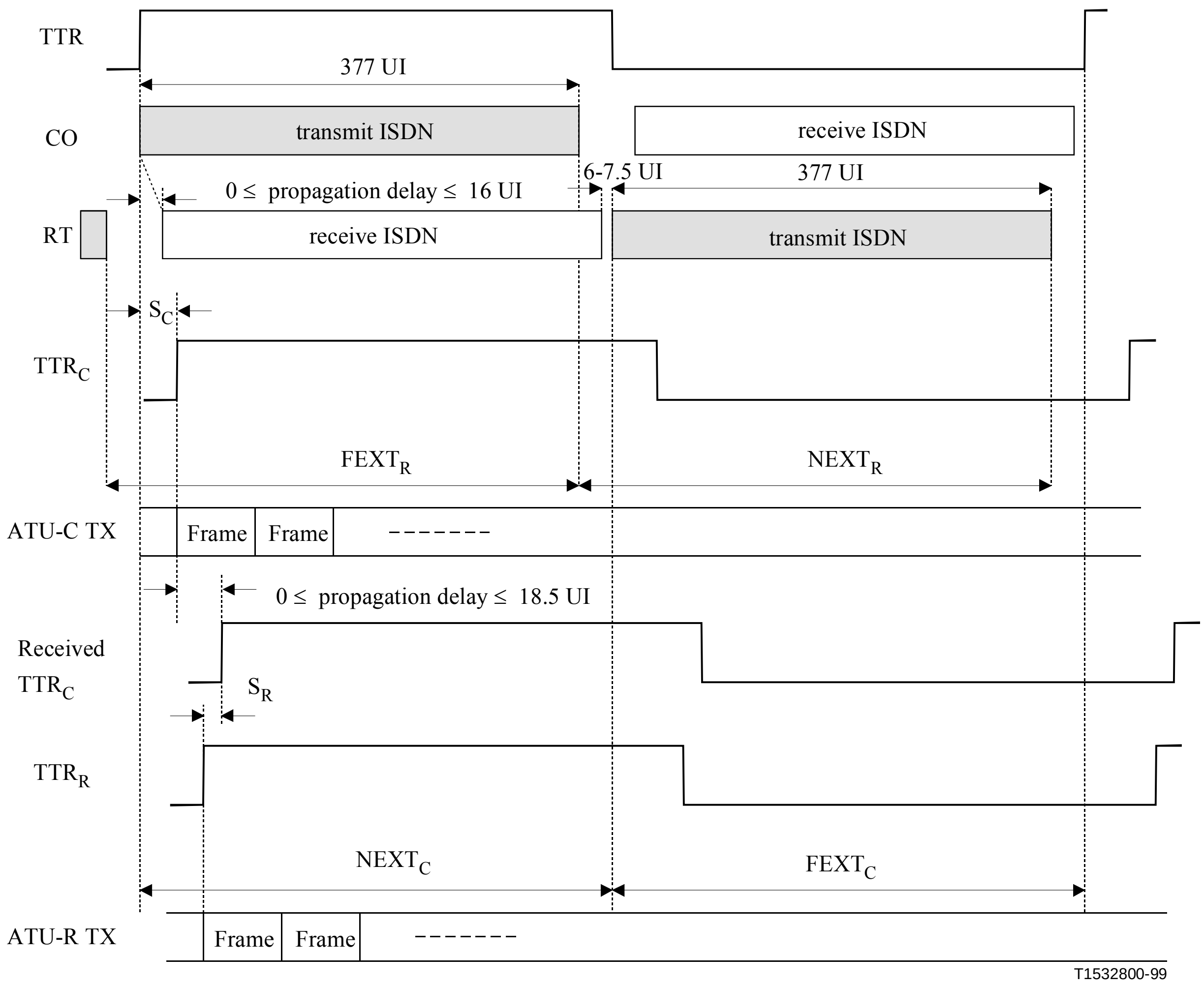
NOTE – The TTR_R shall be generated in ATU-R from the received TTR_C signal, and it is locked to 690 periods of upstream sampling clock (1.104 MHz).

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.



1 UI = 3.125 μs

$FEXT_R$ and **$NEXT_R$** are estimated by ATU-C

$FEXT_C$ and **$NEXT_C$** are estimated by ATU-R

TTR	TCM-ISDN timing reference
TTR_C	Timing reference used in ATU-C
Received TTR_C	Received TTR_C at ATU-R
TTR_R	Timing reference used in ATU-R
S_C	55 × 0.9058 μs: Offset from TTR to TTR_C
S_R	–42 × 0.9058 μs: Offset from received TTR_C to TTR_R

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.

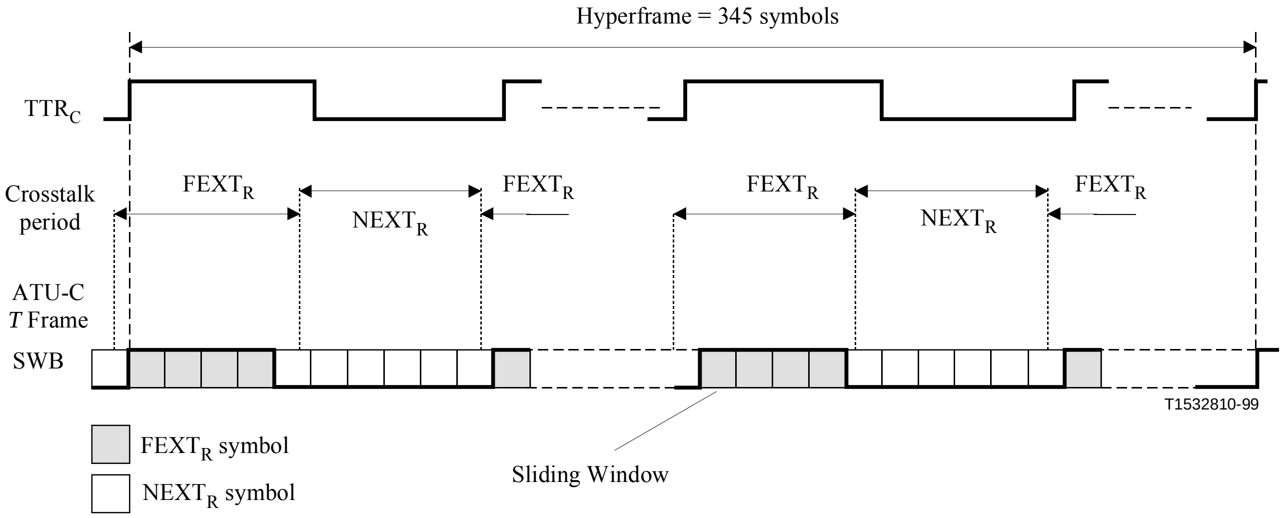


Figure I.6/G.992.1 – Sliding window for downstream symbols

The Sliding Window defines the transmission symbols under the crosstalk noise environment synchronized to the period of TTR. The $FEXT_{C/R}$ symbol represents the symbol completely inside the $FEXT_{C/R}$ duration. The $NEXT_{C/R}$ symbol represents any symbol containing the $NEXT_{C/R}$ duration. Thus, there are more $NEXT_{C/R}$ symbols than $FEXT_{C/R}$ 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-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.

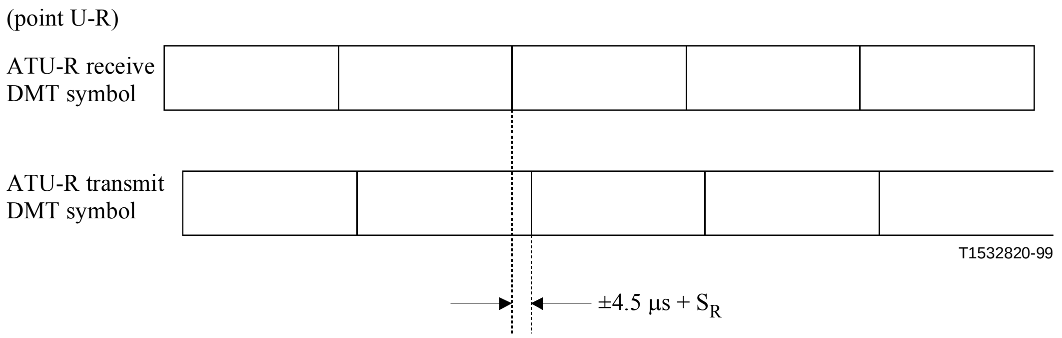


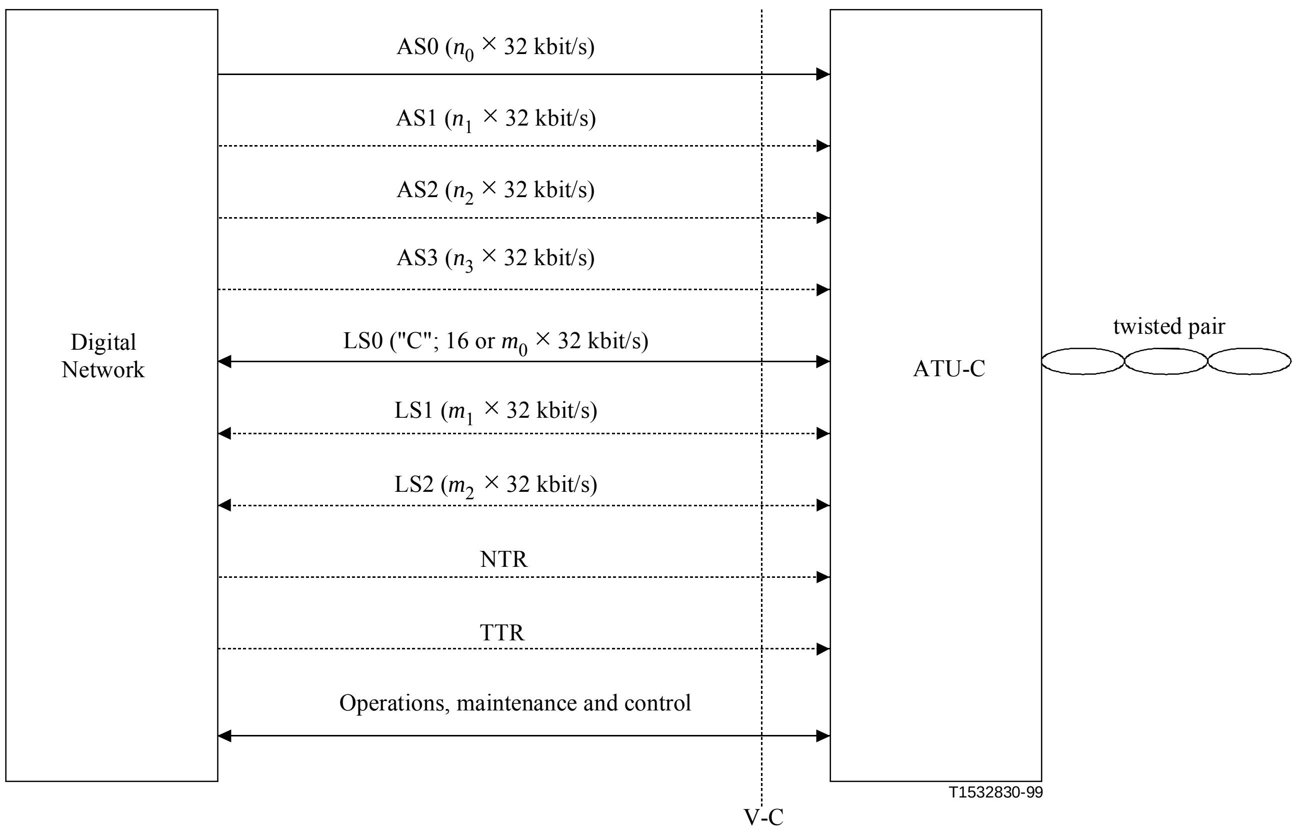
Figure I.7/G.992.1 – Loop timing for ATU-R

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

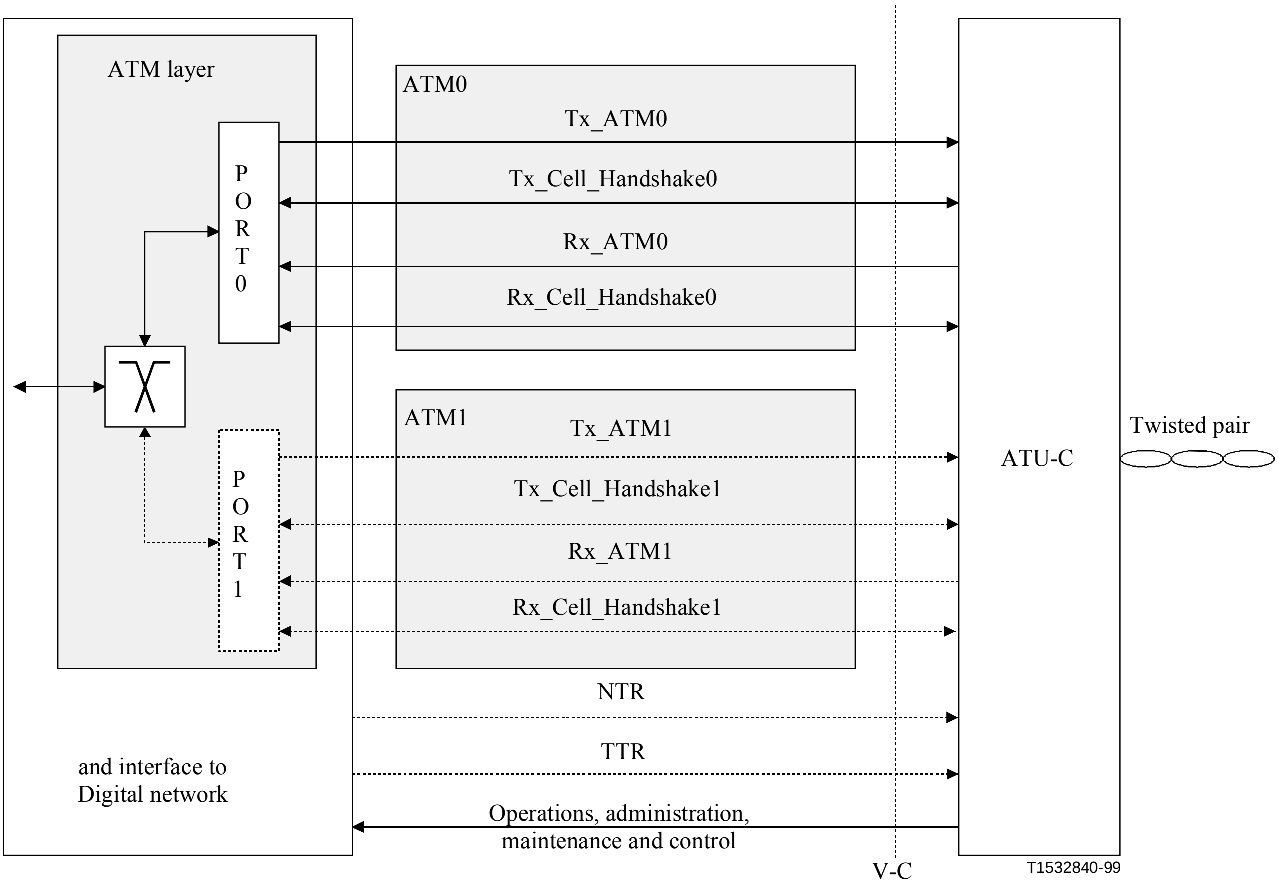
I.4.1.2 Payload transfer delay (supplements 7.1.4)

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 $N_{dmt} = 0, 1, ..., 344$

$S = 272 \times N_{dmt} \bmod 2760$

if { $(S + 271 < a)$ 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.

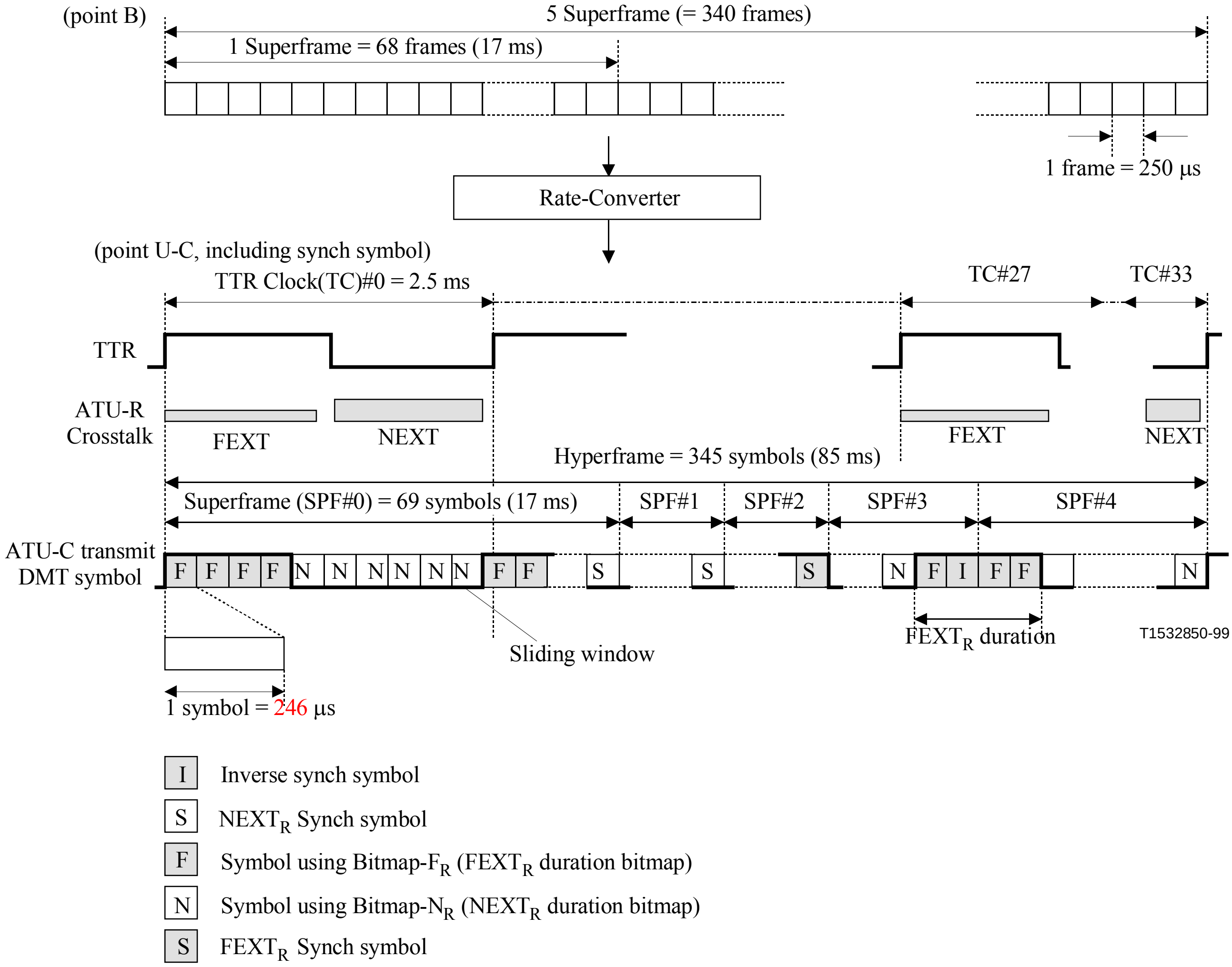


Figure I.10/G.992.1 – Hyperframe structure for downstream

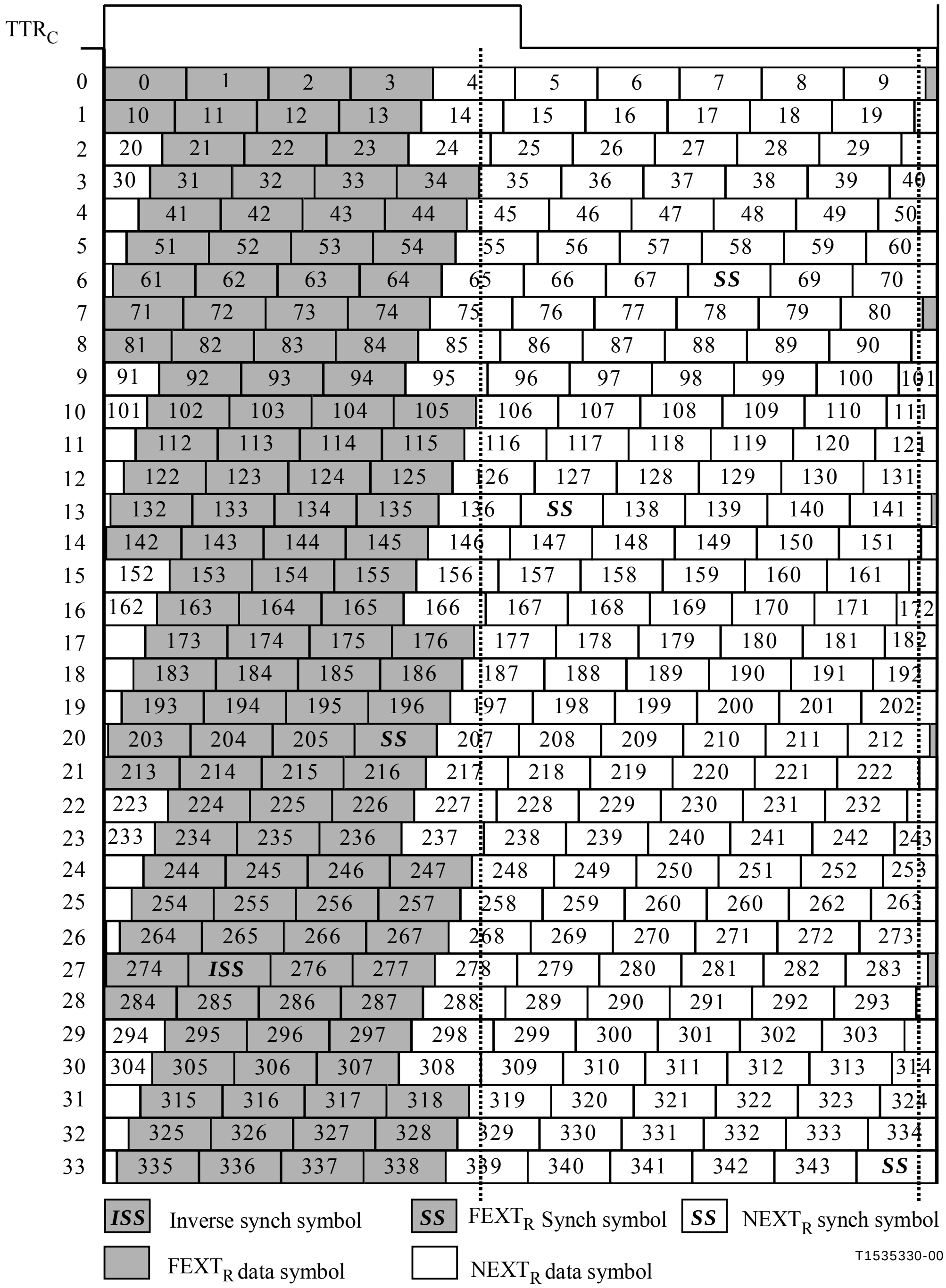


Figure I.11/G.992.1 – Symbol pattern in a hyperframe with cyclic prefix – Downstream

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.

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

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

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 $t_{Rf} \le n_{R\max}$:

$$n_{Rf} = t_{Rf}$$
$$n_{Ri} = n_R - n_{Rf}$$
$$f_{Rf} = t_{Rf}$$
$$f_{Ri} = f_R - f_{Rf}$$

If $t_{Rf} > n_{R\max}$:

$$n_{Rf} = n_{R\max}$$
$$n_{Ri} = 0$$
$$f_{Rf} = \begin{cases} f_{Rf4} = \left\lceil \dfrac{t_{Rf} \times 10 - n_{Rf} \times 6}{4} \right\rceil \\ f_{Rf3} = \left\lceil \dfrac{t_{Rf} \times 10 - n_{Rf} \times 7}{3} \right\rceil \end{cases}$$
$$f_{Ri} = \begin{cases} f_{Ri4} = f_R = f_{Rf4} \\ f_{Ri3} = f_R - f_{Rf3} \end{cases}$$

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 synch symbols.
f_{Rf4}	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.
n_R	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 $t_{Rf} \le n_{R\max}$:

$$dummy_{Rf} = 0$$

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

If $t_{Rf} > n_{R\max}$:

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

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

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

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:

$$dummy_{SRf} = f_{Rf\,3} - f_{Rf\,4}$$

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.

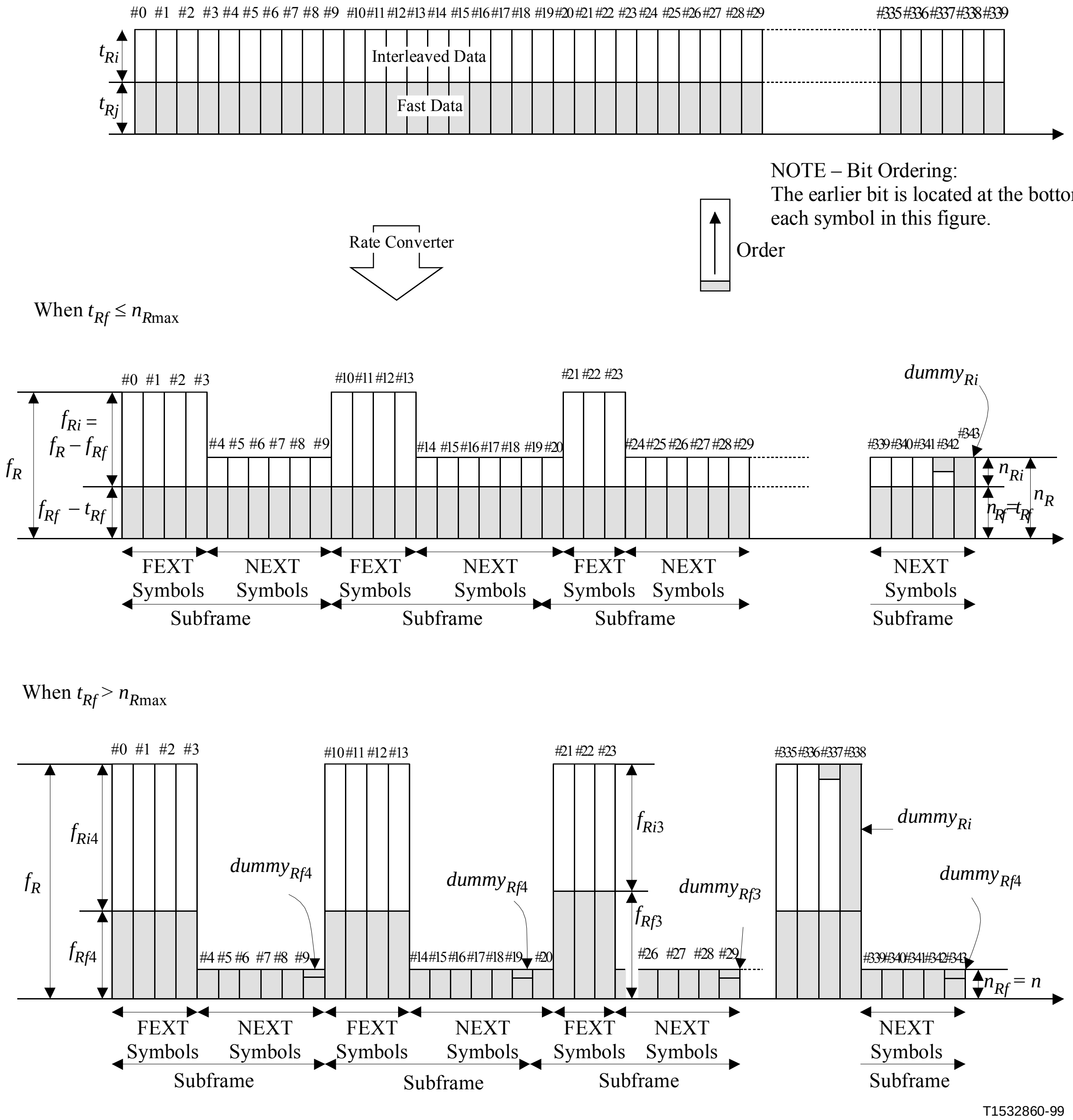


Figure I.12/G.992.1 – Bit distribution for Rate Converter under Dual latency and Dual Bitmap mode

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:

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

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,

$Z_i = \text{conj}\ (Z'_{2*NSCds-i})$ for i = NSCds+1 to 2*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, Δf = 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.

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

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,

$$(2 + 0.125)*\text{NSCds} \times 69 = (2 + 0.15625)*\text{NSCds} \times 68 \quad (7\text{-}24)$$

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

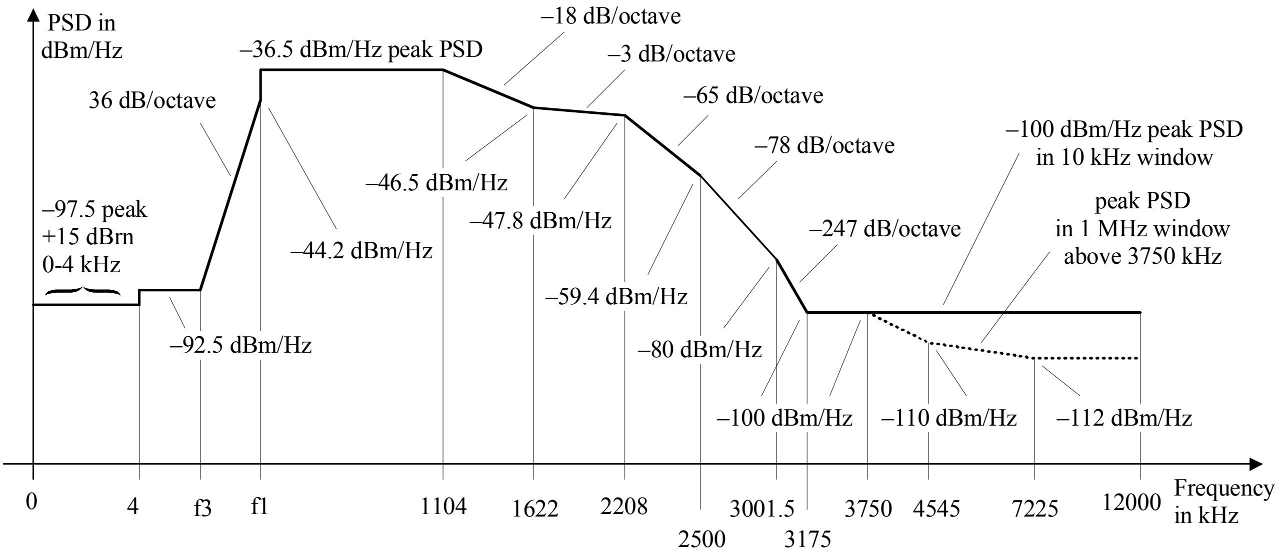
The cyclic prefix shall be used for all symbols beginning with the C-RATES1 segment of the initialization sequence, as defined in 10.6.2.

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*log2(f/f3)
f1 < 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*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
f1	-44.2	10 kHz
f1	-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
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 ≤ 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.

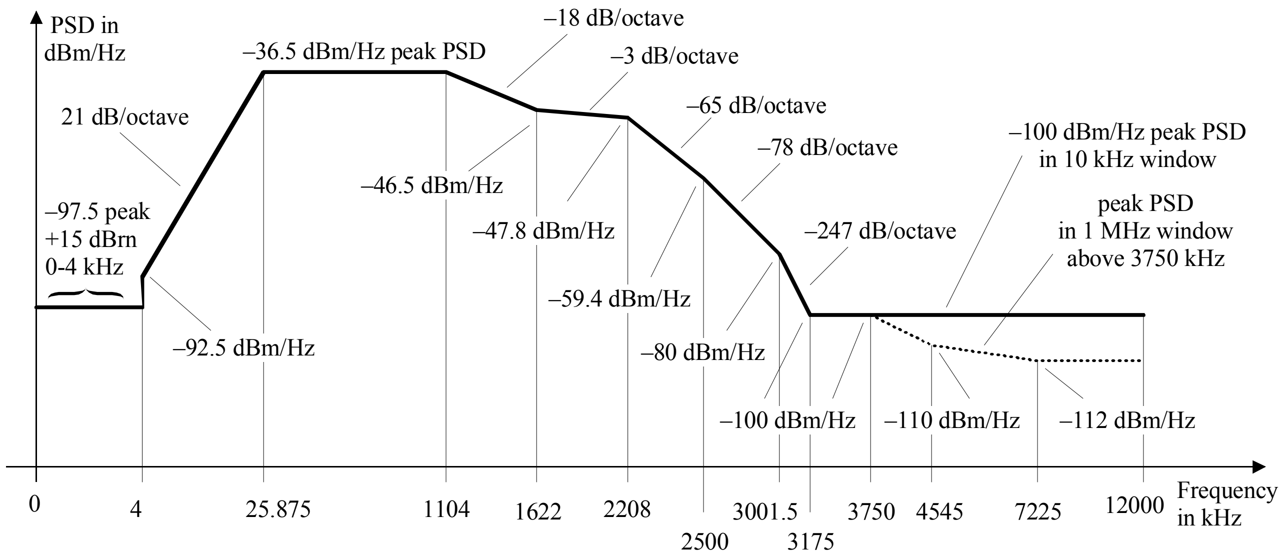
NOTE 6 – All PSD and power measurements shall be made at the U-C interface.

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*log2(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*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 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 ≤ 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:

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

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.

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

Tone Index	Log_ssv_i (dB)	Comments
n1	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.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)
511	–11.3	2208 kHz (–11.3 = -51.3 - 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.

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 $n \geq 1$, 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.

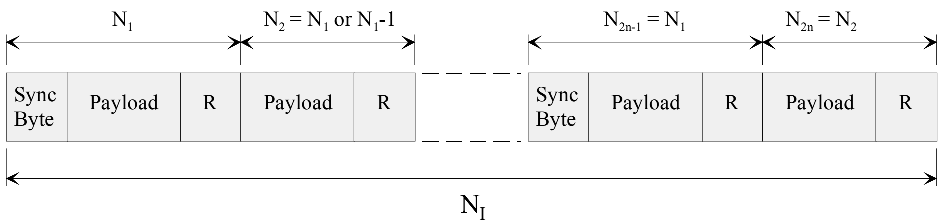


Figure I.15 – Data frame for S = 1/2n mode

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.

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

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

$S = 272 \times N_{dmt} \bmod 2760$

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:

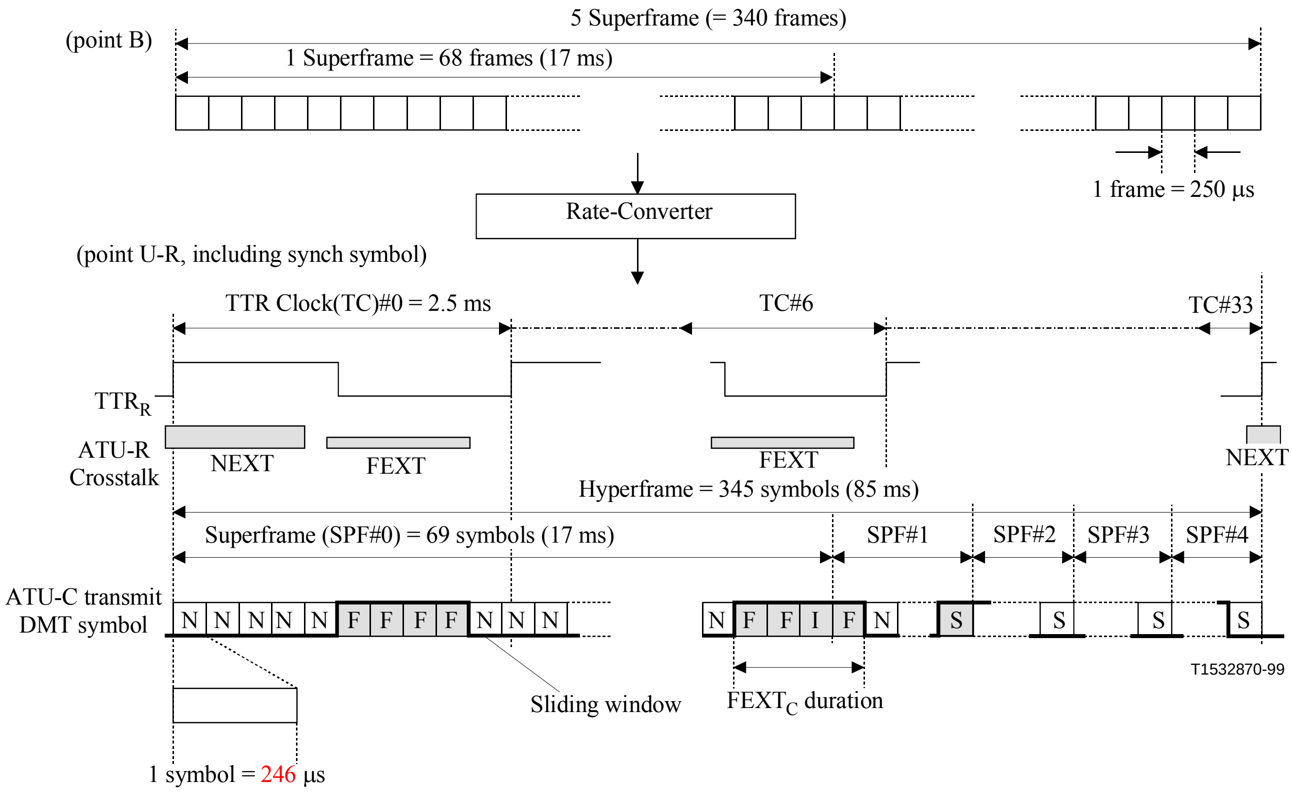
$FEXT_C$ symbol:

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.



I	Inverse synch symbol
S	NEXT$_C$ Synch symbol
F	Symbol using Bitmap-F$_C$ (FEXT$_C$ duration bitmap)
N	Symbol using Bitmap-N$_C$ (NEXT$_C$ duration bitmap)
S	FEXT$_C$ Synch symbol

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

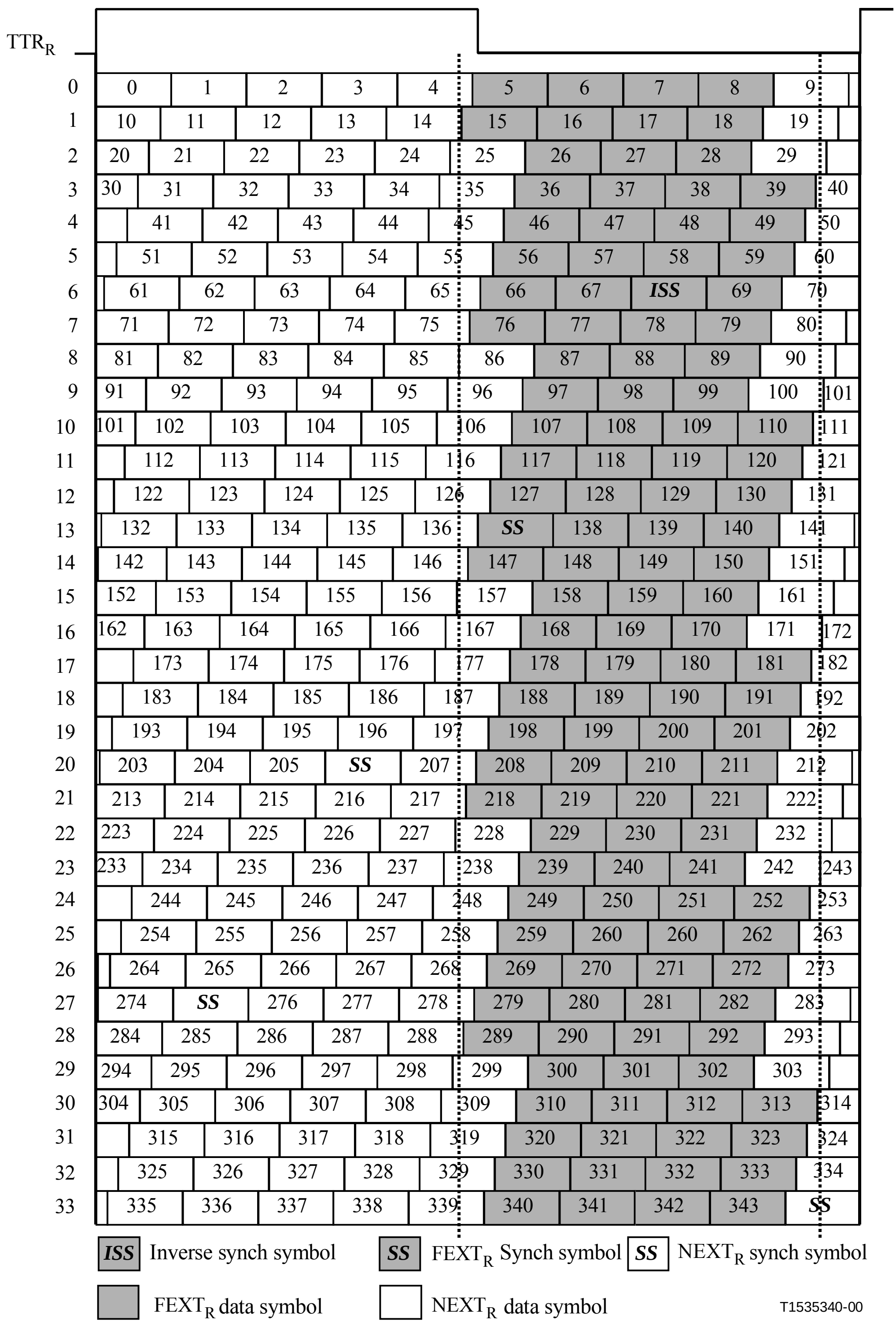


Figure I.17/G.992.1 – Symbol pattern in a hyperframe with cyclic prefix – Upstream

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.

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

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

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 $t_{Cf} \leq n_{C\max}$:

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

If $t_{Cf} > n_{C\max}$:

$$n_{Cf} = n_{C\max}$$
$$n_{Ci} = 0$$
$$f_{Cf} = \begin{cases} f_{Cf4} = \left\lceil \dfrac{t_{Cf} \times 10 - n_{Cf} \times 6}{4} \right\rceil \\ f_{Cf3} = \left\lceil \dfrac{t_{Cf} \times 10 - n_{Cf} \times 7}{3} \right\rceil \end{cases}$$
$$f_{Ci} = \begin{cases} f_{Ci4} = f_C - f_{C4} \\ f_{Ci3} = f_C - f_{Cf3} \end{cases}$$

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 for synch symbols.
f_{Cf4}	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.
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 $t_{Cf} \le n_{C\max}$:

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

If $t_{Cf} > n_{C\max}$:

$$dummy_{Cf4} = \left(f_{Cf} \times 4 + n_{Cf} \times 6\right) - t_{Cf} \times 10$$
$$dummy_{Cf3} = \left(f_{Cf} \times 3 + n_{Cf} \times 7\right) - t_{Cf} \times 10$$
$$dummy_{Ci} = \left(f_{Ci4} \times 96 + f_{Ci3} \times 30\right) - t_{Ci} \times 340$$

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)

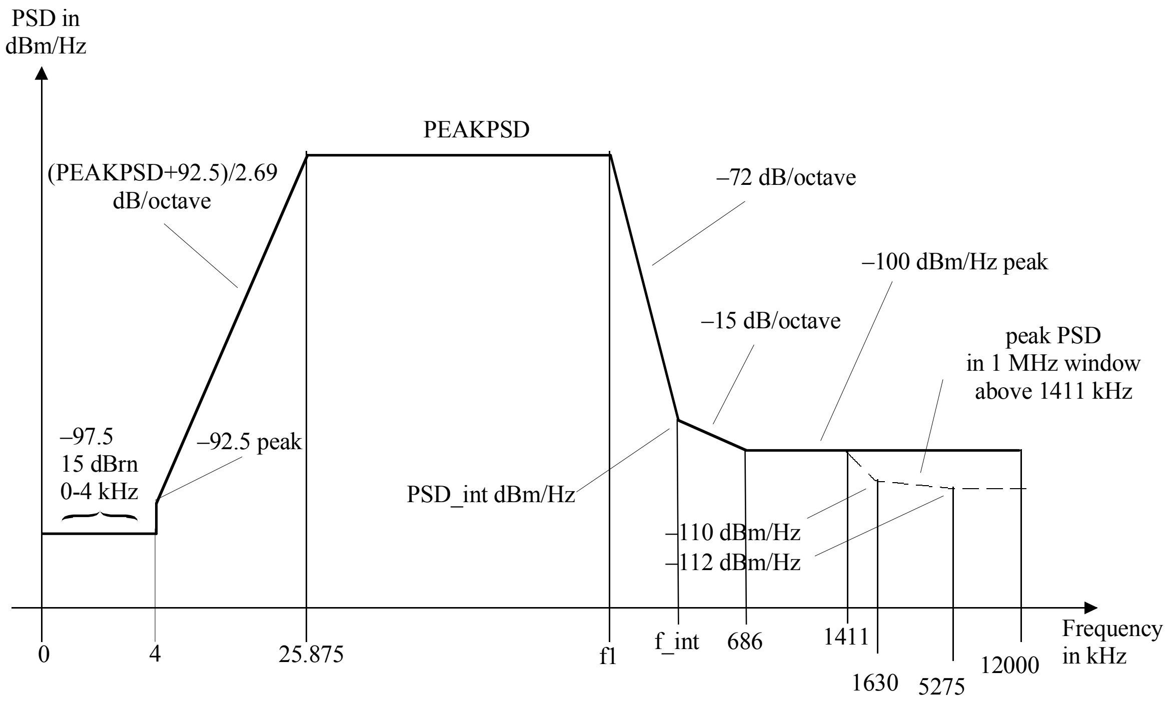
For Annex I-EU, see A.2.2.

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 bitmap for mode 1, both bitmaps for mode 2 (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	-38.5	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 ≤ fj, where fj is the frequency of the next specified breakpoint.

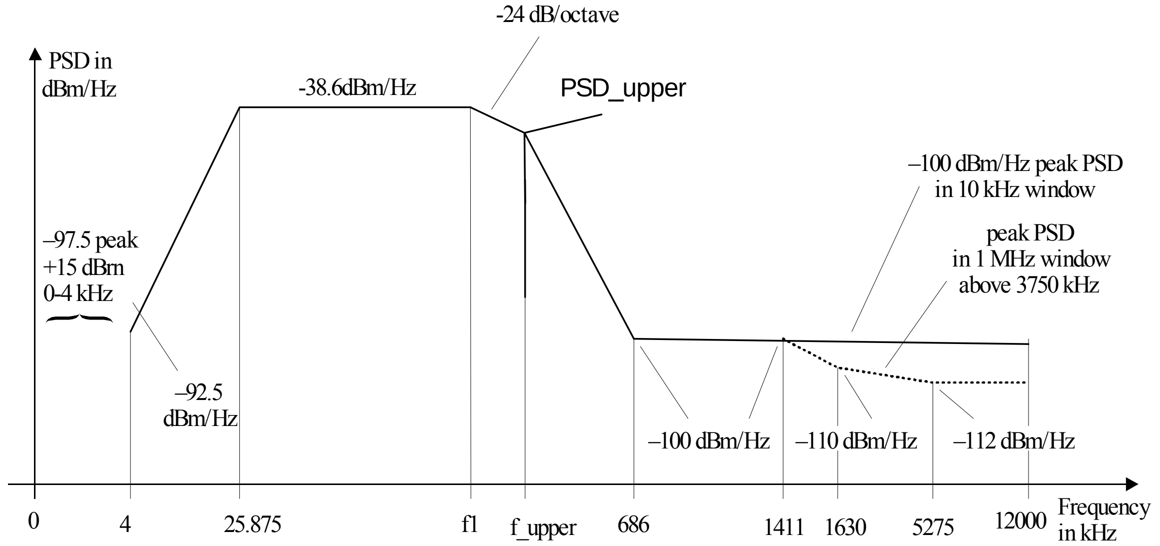
NOTE 4 – The power in a 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency i.e. power in the [f, f + 1 MHz] window shall conform to the specification at frequency f.

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.



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_upper	$PEAKPSD-24^*\log_2(f/f1)$
f_upper < f < 686	PSD_upper-((PSD_upper+100)/log2(686/f_upper))*log2(f/f_upper)
f > 686	-100

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 *f_upper* (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-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, …344
  $S = 256 \times N_{dmt} \bmod 2760$
  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,
  $S = 256 \times N_{dmt} \bmod 2760$
  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
  $S = 272 \times N_{dmt} \bmod 2760$

if { $(S + 271 \geq a)$ and $(S \leq a + b)$ } 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 I.17).

For $N_{dmt} = 0, 1, ..., 344$

$S = 272 \times N_{dmt} \bmod 2760$

if { $(S > a)$ and $(S + 271 < a + b)$ } then $FEXT_C$ symbols

else then $NEXT_C$ symbols

where a = 1315, b = 1293

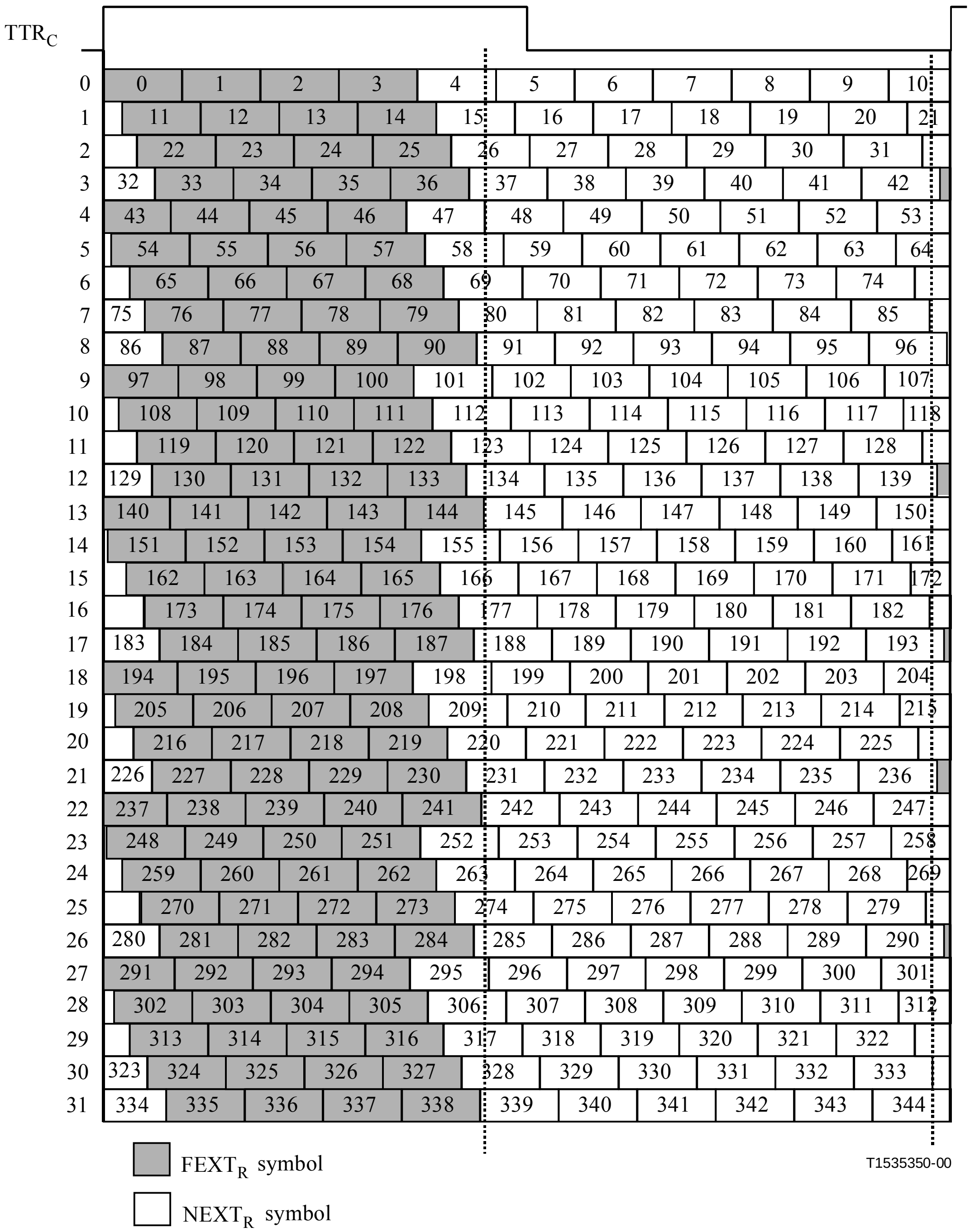


Figure I.19/G.992.1 – Symbol pattern in a hyperframe without cyclic prefix – Downstream

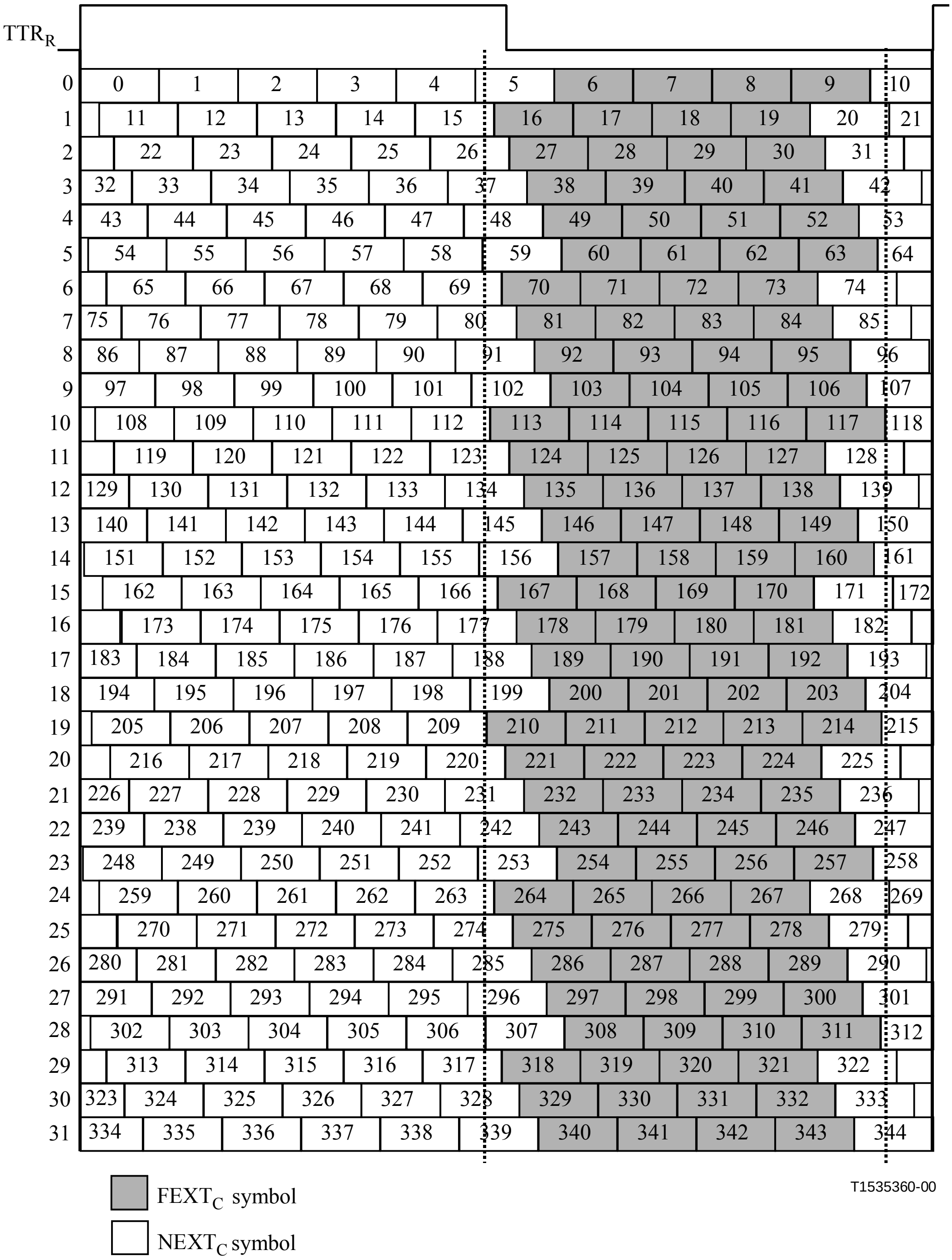


Figure I.20/G.992.1 – Symbol pattern in a hyperframe without cyclic prefix – Upstream

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 §I.7.3 and §I.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 §I.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”.

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

Bits 8	7	6	5	4	3	2	1	**NPar(1)s**
x	x	x	x	x	x	x	1	Reserved for future use
x	x	x	x	x	x	1	x	Reserved for future use
x	x	x	x	x	1	x	x	Reserved for future use
x	x	x	x	1	x	x	x	Reserved for future use
x	x	x	1	x	x	x	x	Reserved for future use
x	x	1	x	x	x	x	x	Reserved for future use
x	1	x	x	x	x	x	x	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

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

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	x	x	x	x	x	x	1	$n_{\text{C-PILOT1}} = 64$
x	x	x	x	x	x	1	x	$n_{\text{C-PILOT1}} = 128$
x	x	x	x	x	1	x	x	$n_{\text{C-PILOT1}} = 256$
x	x	x	x	1	x	x	x	Amateur radio notch – 1.8 MHz band
x	x	x	1	x	x	x	x	Reserved for future use
x	x	1	x	x	x	x	x	$n_{\text{C-PILOT1}} = 96$
x	x	0	0	0	0	0	0	No parameters in this octet
Since A48 is the only TTR indication signal specified 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**
x	x	x	x	x	x	x	1	R-ACK1
x	x	x	x	x	x	1	x	R-ACK2
x	x	x	x	x	1	x	x	DBM
x	x	x	x	1	x	x	x	Reserved for future use
x	x	x	1	x	x	x	x	Reserved for future use
x	x	1	x	x	x	x	x	G.997.1 – Clear EOC OAM
x	x	0	0	0	0	0	0	No parameters in this octet
Since Annex I-EU only supports ATM transport, STM and ATM parameters are not specified.								

Table I.7.4 – Non-standard information field – G.992.1 Annex I-EU SPar(2) coding

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

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 8	7	6	5	4	3	2	1	G.992.1 Annex I-EU Additional inband spectral shaping Npar(3)s Octet 1
x	x					x	x	NOMINAL_PSD_lowband (bits 8 & 7)
x	x	x	x	x	x			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 8	7	6	5	4	3	2	1	G.992.1 Annex I-EU Additional inband spectral shaping Npar(3)s Octet 2
x	x	x	x	x	x	x	x	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 8	7	6	5	4	3	2	1	G.992.1 Annex I-EU Additional inband spectral shaping Npar(3)s Octet 3
x	x					x	x	PSD level at 1622 kHz (bits 8 & 7)
x	x	x	x	x	x			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 8	7	6	5	4	3	2	1	G.992.1 Annex I-EU Additional inband spectral shaping Npar(3)s Octet 4
x	x	x	x	x	x	x	x	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 8	7	6	5	4	3	2	1	G.992.1 Annex I-EU Additional inband spectral shaping Npar(3)s Octet 5
x	x					x	x	PSD level at 2208 kHz (bits 8 & 7)
x	x	x	x	x	x			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 8	7	6	5	4	3	2	1	G.992.1 Annex I-EU Additional inband spectral shaping Npar(3)s Octet 6
x	x	x	x	x	x	x	x	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
x	x	x	x	x	x	x	1	Mode 1 upstream mask
x	x	x	x	x	x	1	x	Mode 2 upstream mask
x	x	x	x	x	1	x	x	Optional upstream masks for non-overlapped spectrum
x	x	x	x	1	x	x	x	EU-64
x	x	x	1	x	x	x	x	EU-32
x	x	1	x	x	x	x	x	EU-36
x	x	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

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

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	x	x	x	x	x	x	1	EU-S68
x	x	x	x	x	x	1	x	EU-S72
x	x	x	x	x	1	x	x	EU-S76
x	x	x	x	1	x	x	x	EU-S80
x	x	x	1	x	x	x	x	EU-S84
x	x	1	x	x	x	x	x	EU-S88
x	x	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	x	x	x	x	x	x	1	EU-S92
x	x	x	x	x	x	1	x	EU-S96
x	x	x	x	x	1	x	x	Reserved for future use
x	x	x	x	1	x	x	x	Reserved for future use
x	x	x	1	x	x	x	x	Reserved for future use
x	x	1	x	x	x	x	x	Reserved for future use
x	x	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.

Table I.8/G.992.1 – ATU-C CL 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 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.
$n_{C\text{-PILOT1}}$=64	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 64.
$n_{C\text{-PILOT1}}$=96	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 96.
$n_{C\text{-PILOT1}}$=128	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 128.
$n_{C\text{-PILOT1}}$=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 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.

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.
$n_{C\text{-}PILOT1}=64$	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 64 (Note 1).
$n_{C\text{-}PILOT1}=96$	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 96 (Note 1).
$n_{C\text{-}PILOT1}=128$	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 128 (Note 1).
$n_{C\text{-}PILOT1}=256$	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 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 2208 kHz
REDUCED_PSD_low band	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 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 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 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.	

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.

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

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.
$n_{C\text{-}PILOT1}$=64	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 64.
$n_{C\text{-}PILOT1}$=96	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 96.
$n_{C\text{-}PILOT1}$=128	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 128.
$n_{C\text{-}PILOT1}$=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.

I.7.3.2.2 MS messages (supplements 10.3.2)

Table I.11.

Table I.11/G.992.1 – ATU-R 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-R is selecting G.992.1 Annex I-EU.
$n_{C\text{-}PILOT1}$=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).
$n_{C\text{-}PILOT1}$=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).

$n_{C\text{-}PILOT1}$=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).
$n_{C\text{-}PILOT1}$=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 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 2208 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 2208 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-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 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.	

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

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.
$n_{C\text{-}PILOT1}$=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).
$n_{C\text{-}PILOT1}$=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).

$n_{C\text{-}PILOT1}=128$	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the pilot tone on subcarrier 128 (Note 1).
$n_{C\text{-}PILOT1}=256$	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.
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 2208 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 2208 kHz	This 8 bit Npar(3) parameter indicates the relative downstream PSD level that the ATU-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 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 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.	

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 $f_{C\text{-}PILOT1}$ 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. $f_{\text{C-PILOT1}}$ = 276 kHz ($n_{\text{C-PILOT1}}$ = 64).
21. $f_{\text{C-PILOT1}}$ = 414 kHz ($n_{\text{C-PILOT1}}$ = 96).
22. $f_{\text{C-PILOT1}}$ = 552 kHz ($n_{\text{C-PILOT1}}$ = 128).
23. $f_{\text{C-PILOT1}}$ = 1104 kHz ($n_{\text{C-PILOT1}}$ = 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:

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.

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.

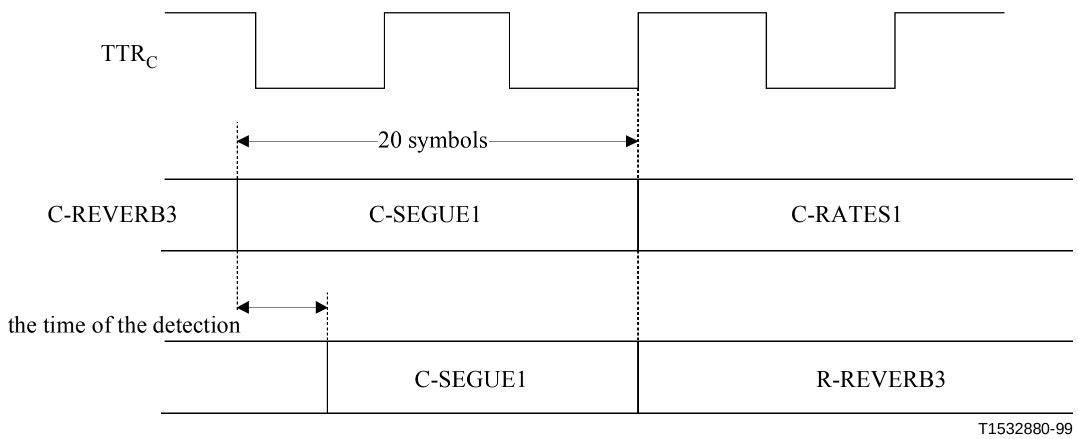


Figure I.22/G.992.1 – Timing diagram from C-SEGUE1 to C-RATES1

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:

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

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.

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:

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

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:

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

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 2^{14}-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 x 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).

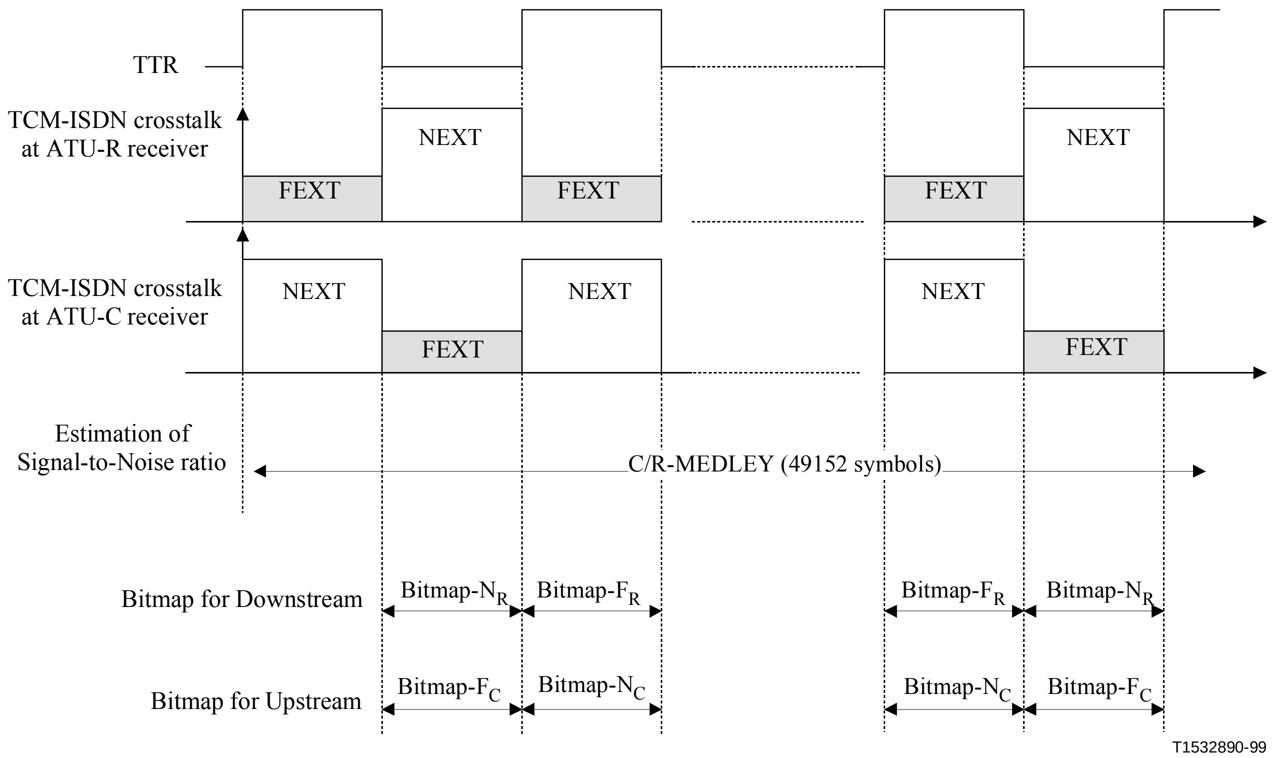


Figure I.23/G.992.1 – Estimation of periodic Signal-to-Noise Ratio

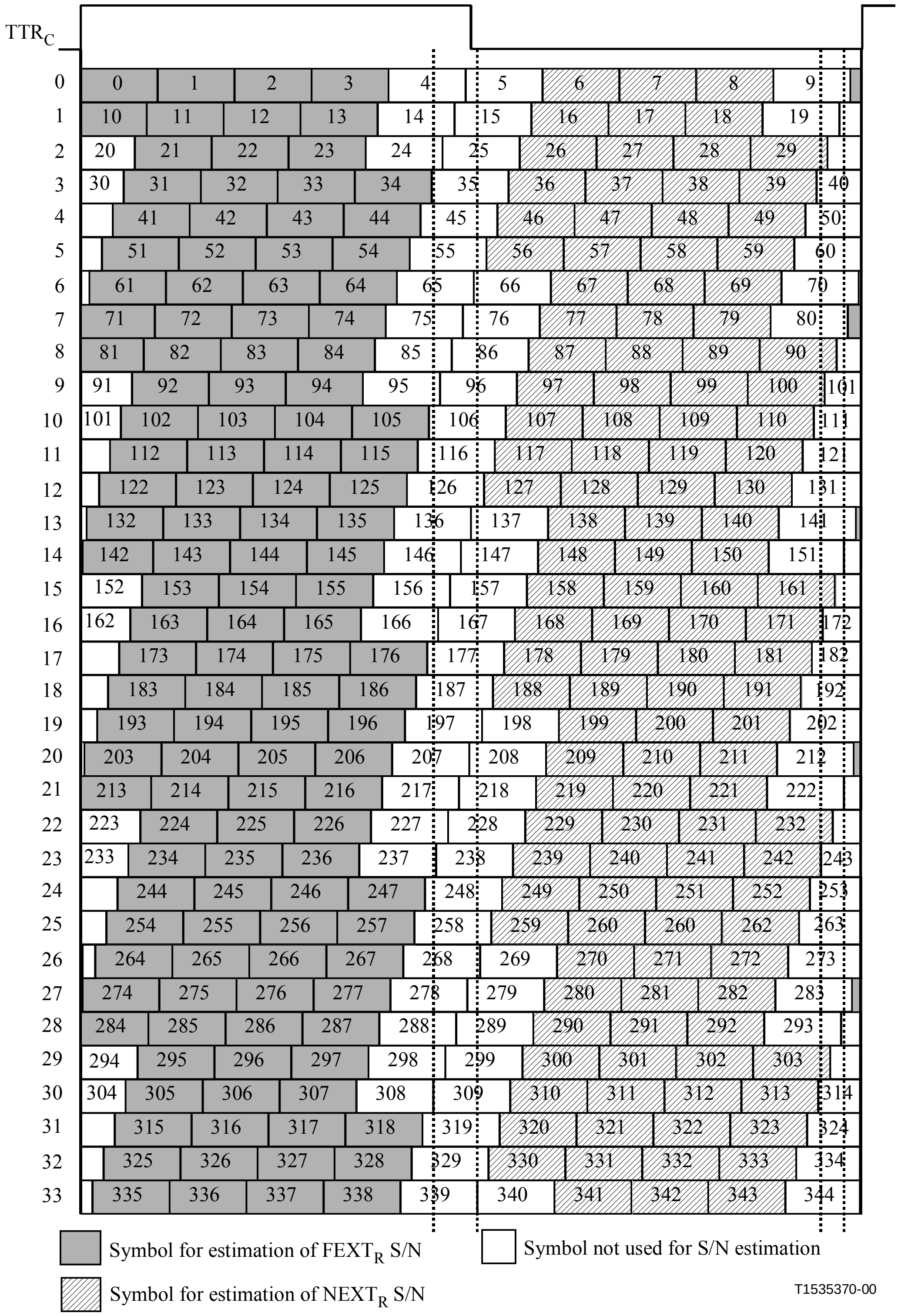


Figure I.24/G.992.1 – Symbol pattern in a hyperframe for S/N estimation – Downstream

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.,

$RS_I = R_I/(n*S)$.

I.7.6.4 C-MSG1 (supplements 10.6.4)

Table I.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; binary coded 0-15 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 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:

$$d_n = 1 \text{ for } n = 1 \text{ to } 23 \text{ and } d_n = d_{n-18} \oplus d_{n-23} \text{ for } n > 23.$$

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 $N_{dmt} = 0, 1, \ldots, 344$
  $S = 272 \times N_{dmt} \bmod 2760$
  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).

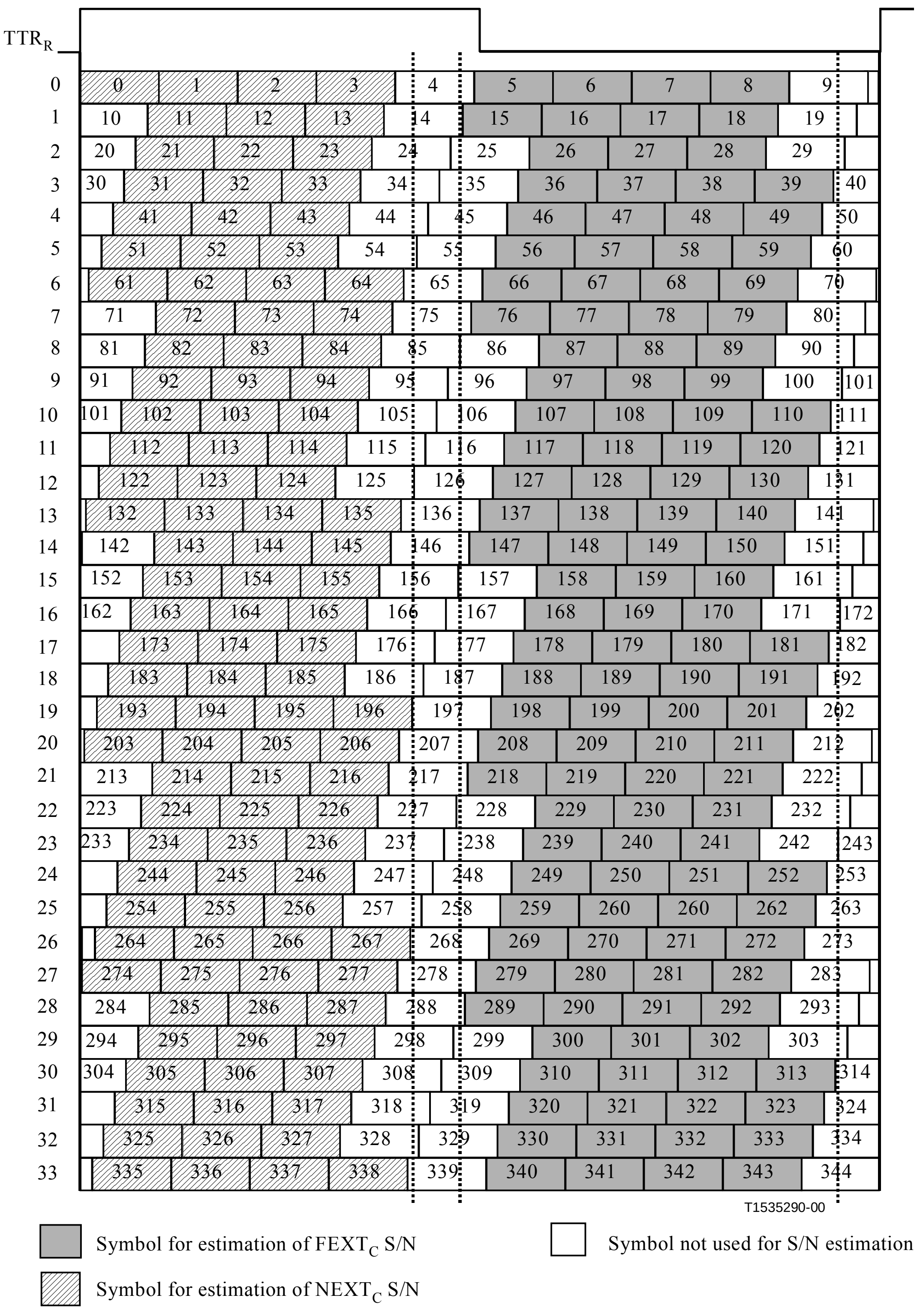


Figure I.25/G.992.1 – Symbol pattern in a hyperframe for S/N estimation – Upstream

I.7.8.4 R-MSG1 (supplements 10.7.6)

Table I.14/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 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.

Table I.15/G.992.1 – Assignment of 32 bits of C-MSG2

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".	

For NSCus=32,

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

Otherwise,

$n_{1C\text{-}MSG2} = 139$
$n_{2C\text{-}MSG2} = 187$

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 x 126 + 88 x 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), $\{m_{10}, ..., m_0\} = 00001111111_2$].

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-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_is 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 (00000_2 and $00000000\ 000_2$, 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 (000.00110000_2 to 001.01010101_2).

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:

$m = \{m_{32*(NSCu-1)-1}, m_{32*(NSCu-1)-2}, \ldots, m_1, m_0\} = \{ g_{2*NSCu-1}, b_{2*NSCu-1}, \ldots, g_{NSCu+1}, b_{NSCu+1}, g_{NSCu-1}, b_{NSCu-1}, \ldots, g_1, b_1\}$, (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)

Table I.16/G.992.1 – RRSI fields of C-RATES-RA

	←——— bits ———→							
fields	7	6	5	4	3	2	1	0
RS_F	0	0	value of RS_F MSB … LSB					
RS_I	B_8 (AS0)	B_9 (AS0)	value of RS_I MSB … LSB					
S	I_9	I_8	value of S MSB … LSB					
I	I_7	I_6	I_5	I_4	I_3	I_2	I_1	I_0
FS(LS2)	value of FS(LS2) *set to* $\{00000000_2\}$							

The RS_I field has been extended to include the most significant bit B_9 of B_I (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.

Table I.17/G.992.1 – Assignment of 80 bits of R-MSG-RA (Annex I-EU)

Suffix(ces) of m_i (Note)	Parameter 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	$B_{fast\text{-}max}$
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, B_{max}
13-12	Maximum Interleave Depth downstream
11-0	Total number of bits per DMT symbol, B_{max}
NOTE – Within the separate fields the least significant bits have the lowest subscripts.	

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 $B_{fast\text{-}max}$ (new)

$B_{fast\text{-}max}$ 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 $B_{fast\text{-}max}$ is t_f.

I.7.10.2 R-MSG2 (supplements 10.9.8)

Table I.18/G.992.1 – Assignment of 32 bits of R-MSG2

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, 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".	

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

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 $g_{NSCds+64}$ 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 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) 001.01000000_2 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 (00000_2 and $00000000\ 000_2$, 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 (000.00110000_2 to 001.01010101_2).

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

$$m = \{m_{(2*NSCds-2)*16-1}, m_{(2*NSCds-2)*16-2}, \ldots, m_1, m_0\} = \{ g_{2*NSCds-1}, b_{2*NSCds-1}, \ldots, g_{NSCds+1}, b_{NSCds+1}, g_{NSCds-1}, b_{NSCds-1}, \ldots, g_1, b_1\}, \quad \text{(I.10-3)}$$

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.

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

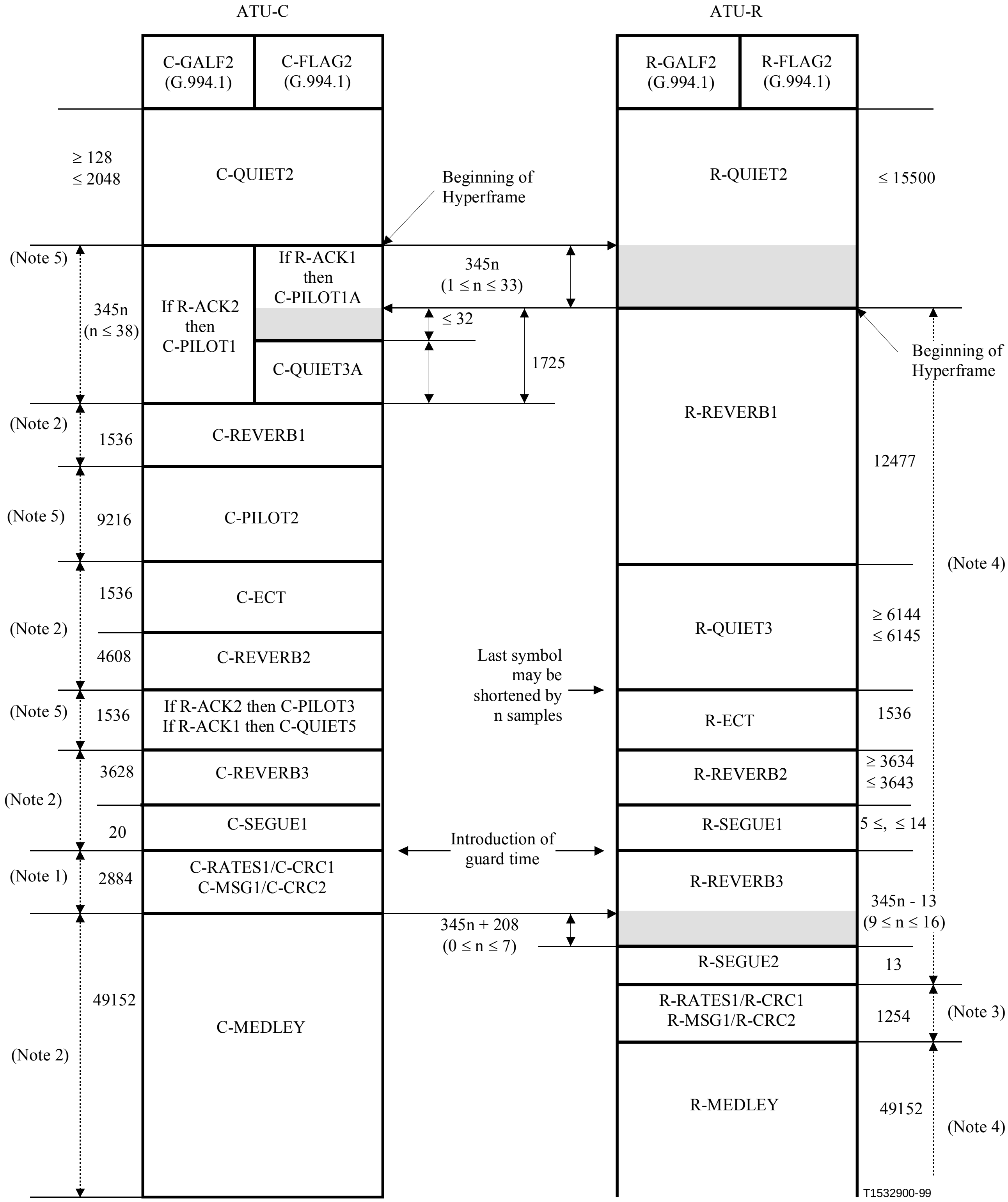
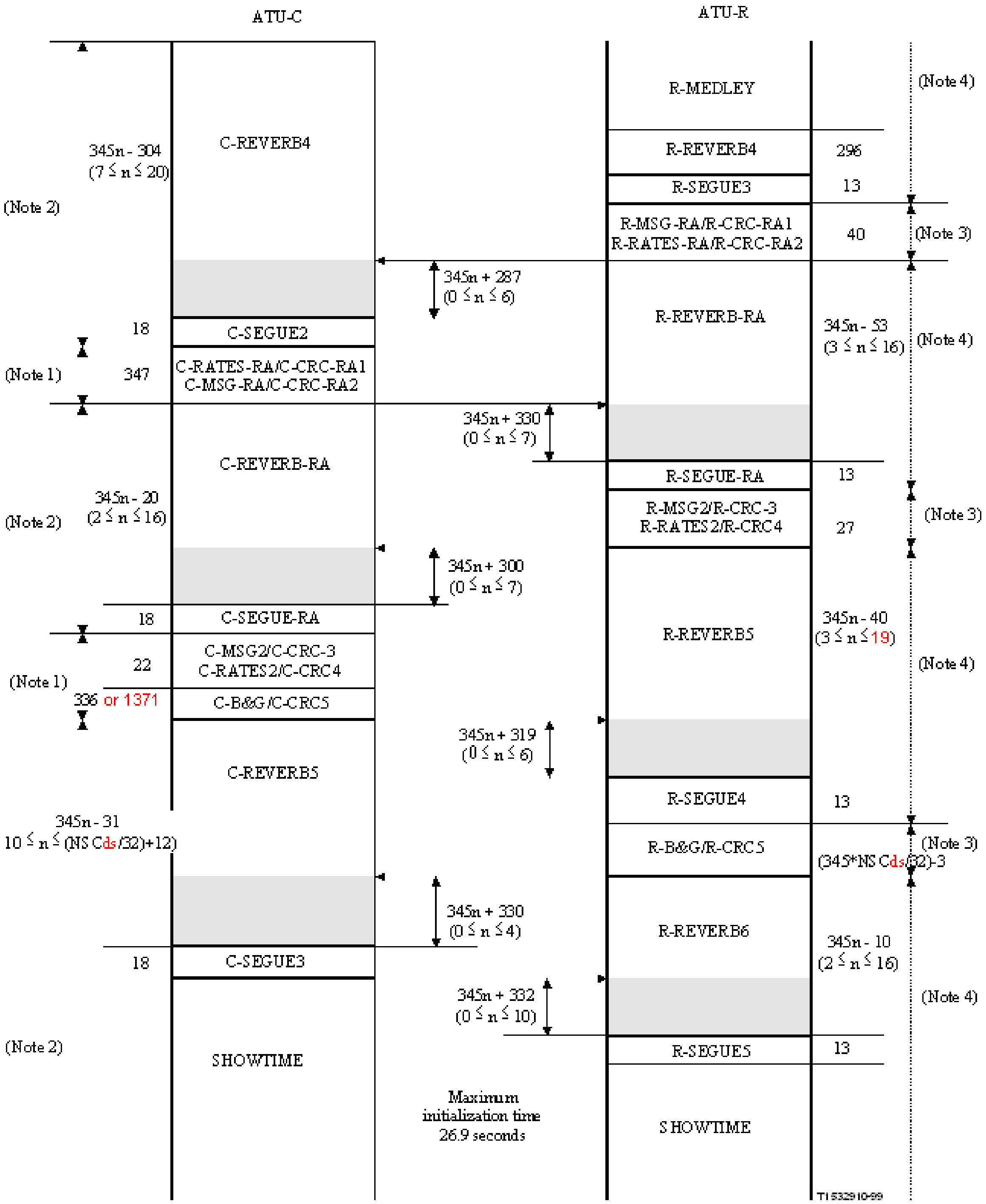


Figure I.26/G.992.1 – Timing diagram of the initialization sequence – Part 1



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 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.

Table I.19/G.992.1 – Format of the bit swap request message

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

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 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.

Table I.20/G.992.1 – Bit swap request command

Value (8 bit)	Interpretation
$yzz00000_2$	Do nothing
$yzz00001_2$	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
$yzz00110_2$	Reduce the transmitted power by 1 dB
$yzz00111_2$	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	

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:

$$g_i' = (1/256) \times round(256 \times g_i \times 10\exp(\Delta/20)) \qquad \text{(I.11-1)}$$

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.

Table I.21/G.992.1 – Format of the bit swap request message

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)

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 → 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 C-EU also implements 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.

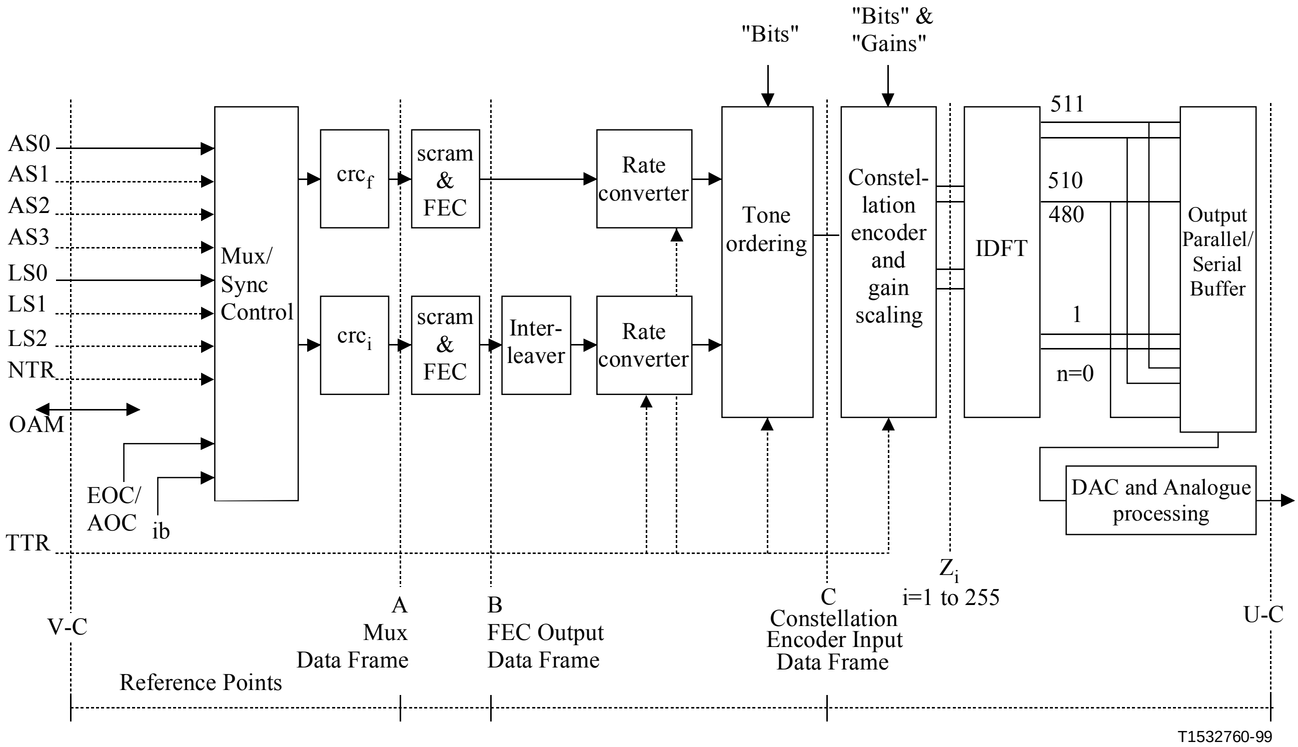
C.2 Definitions

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	The Dual Bitmap method has dual bit rates under the FEXT and NEXT noise from TCM-ISDN
FEXT Bitmap	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	5 Superframes structure which synchronized TTR
$NEXT_C$ duration	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)

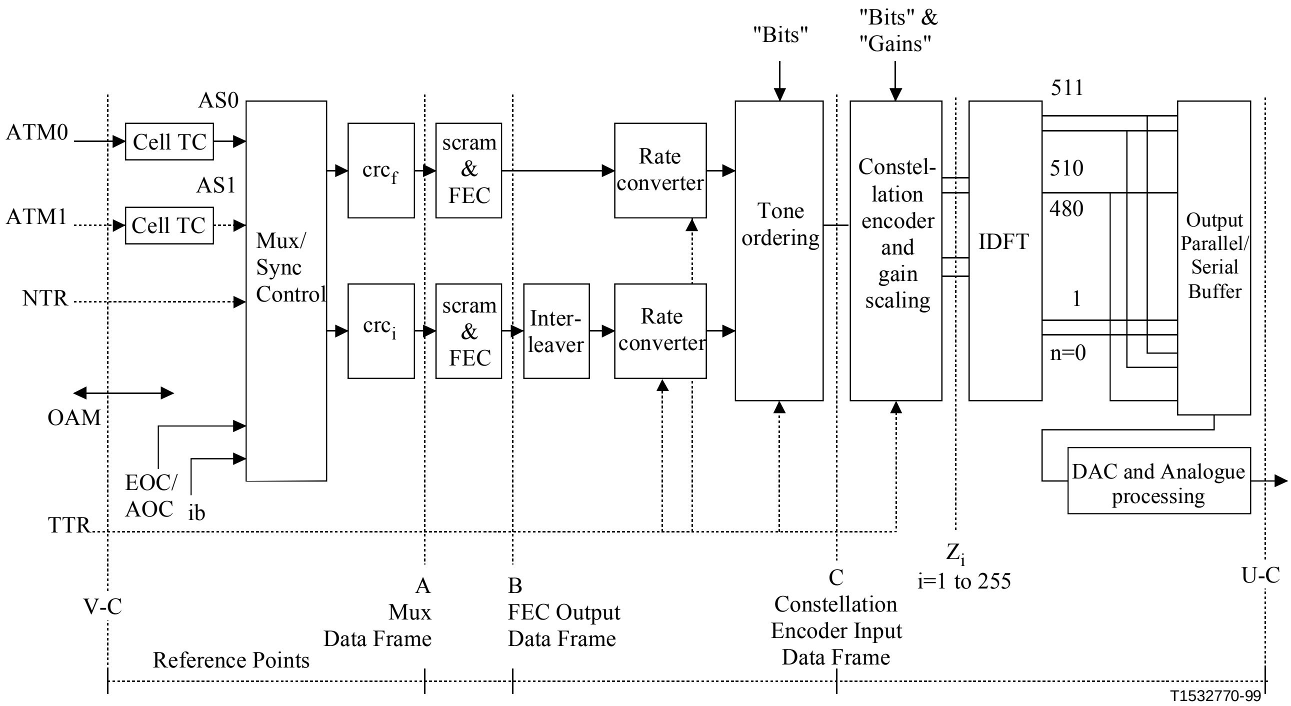
See Figure C.1 and Figure C.2.



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.

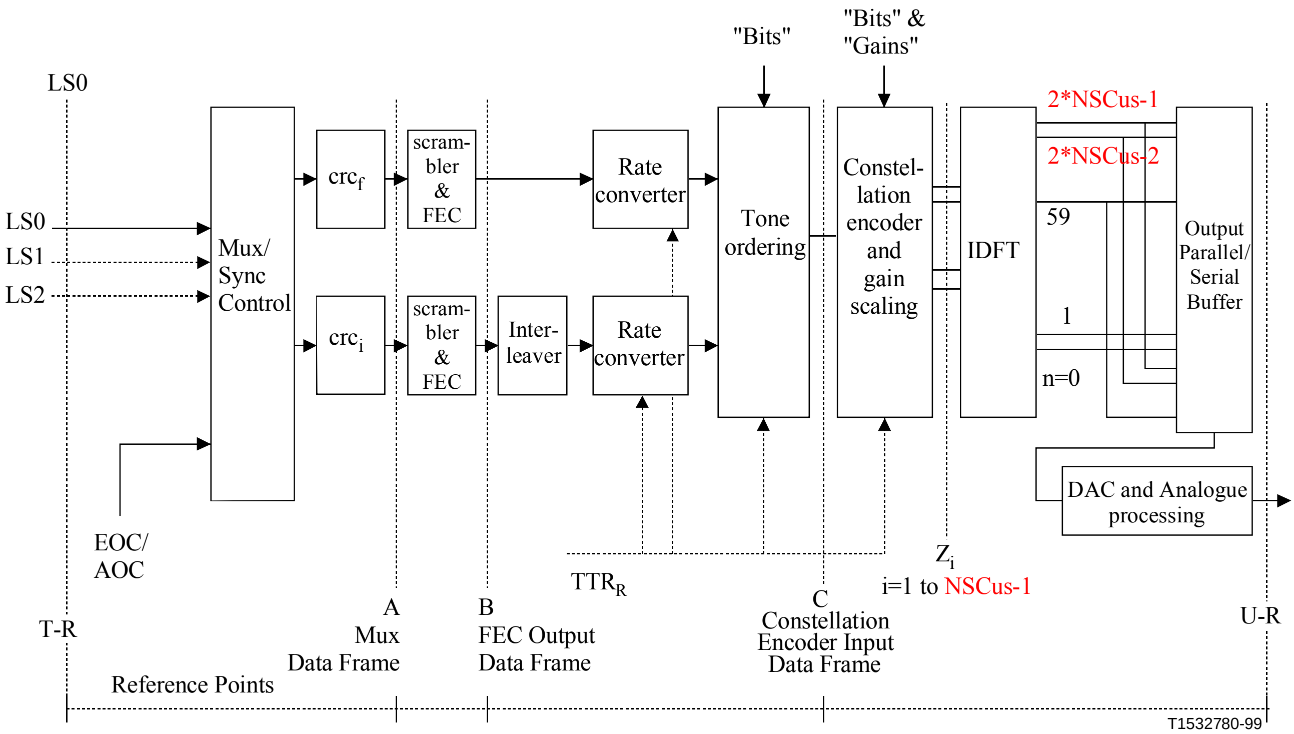


NOTE – The TTR may be generated in ATU-C without being provided from the TCM-ISDN clock.

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)

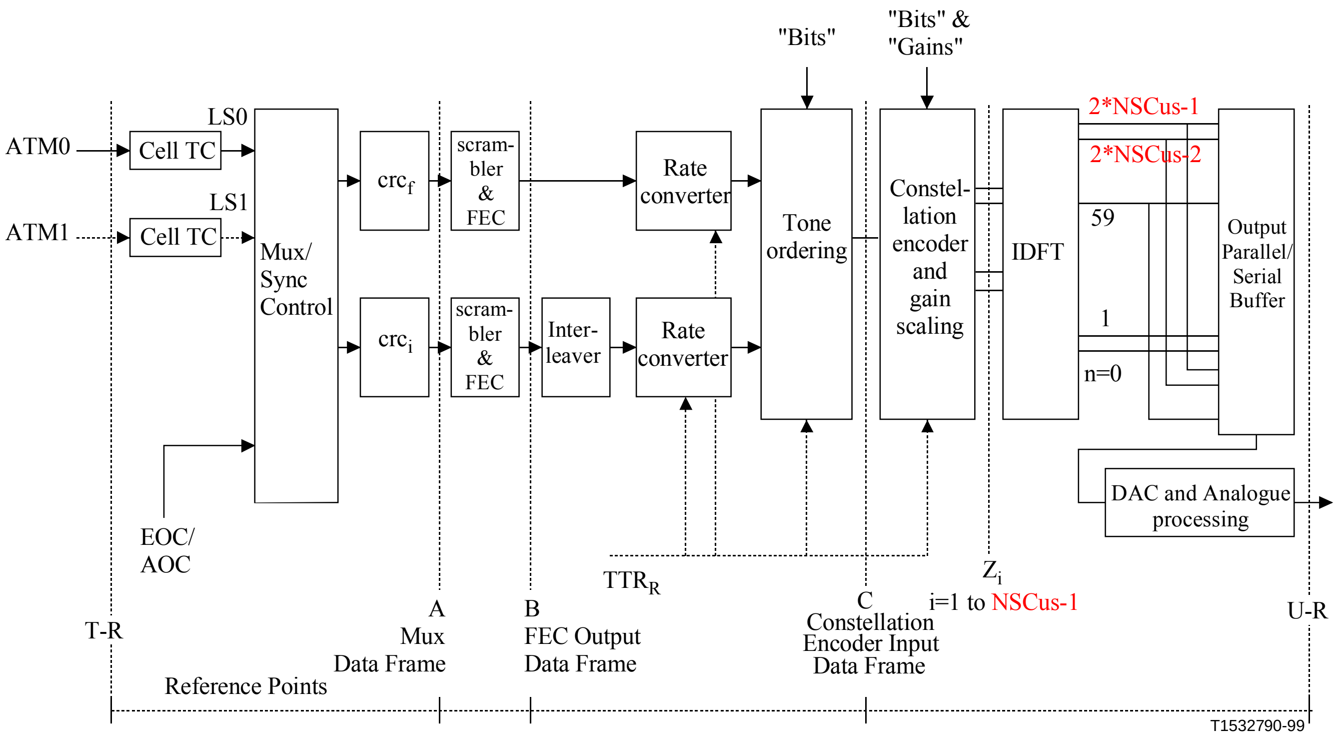
See Figure C.3 and Figure C.4.



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.



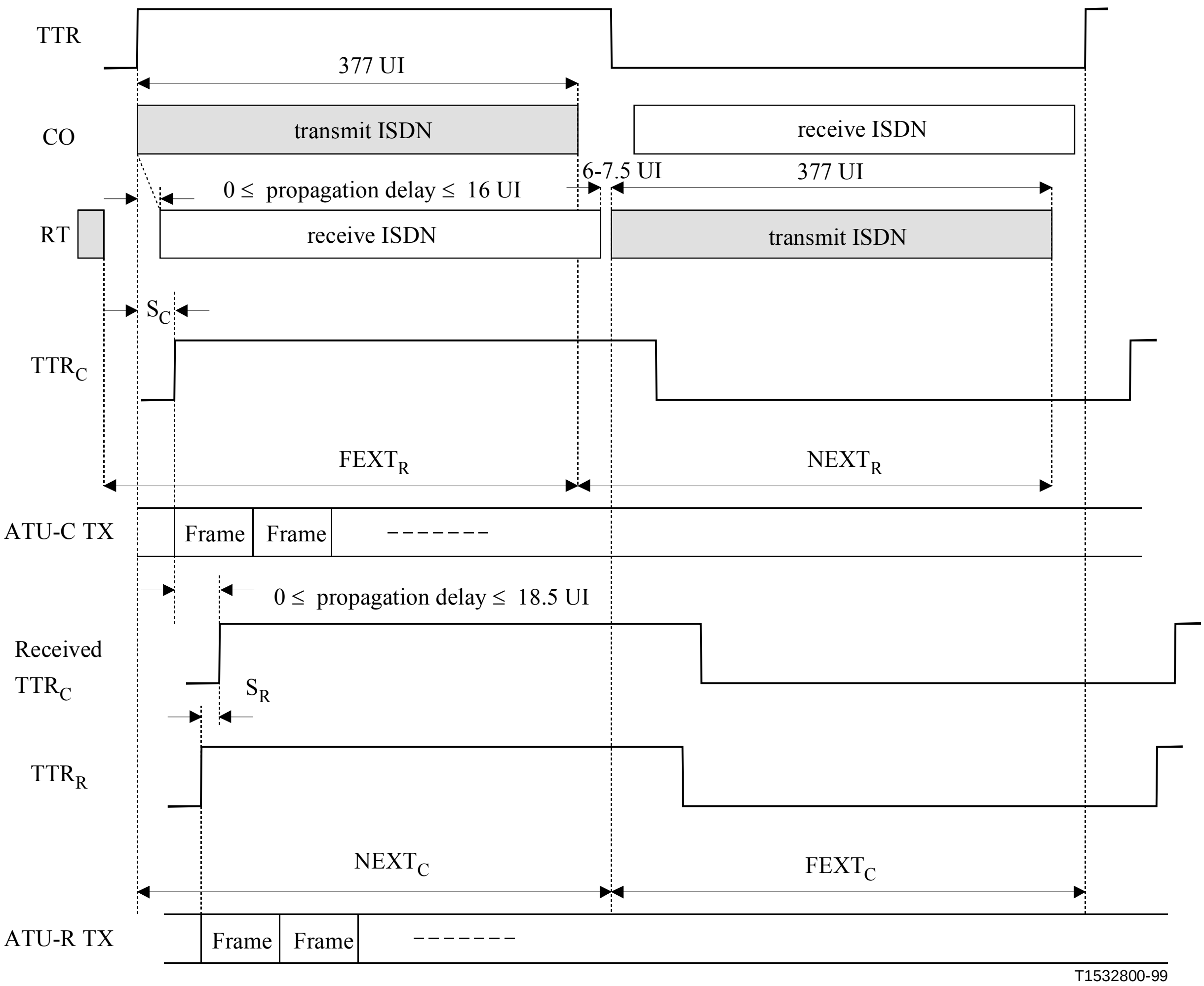
NOTE – The TTR_R shall be generated in ATU-R from the received TTR_C signal, and it is locked to 690 periods of upstream sampling clock (276 kHz).

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.



1 UI = 3.125 µs

$FEXT_R$ and **$NEXT_R$** are estimated by ATU-C

$FEXT_C$ and **$NEXT_C$** are estimated by ATU-R

TTR	TCM-ISDN timing reference
TTR_C	Timing reference used in ATU-C
Received TTR_C	Received TTR_C at ATU-R
TTR_R	Timing reference used in ATU-R
S_C	55 × 0.9058 µs: Offset from TTR to TTR_C
S_R	–42 × 0.9058 µs: Offset from received TTR_C to TTR_R

Figure C.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 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.

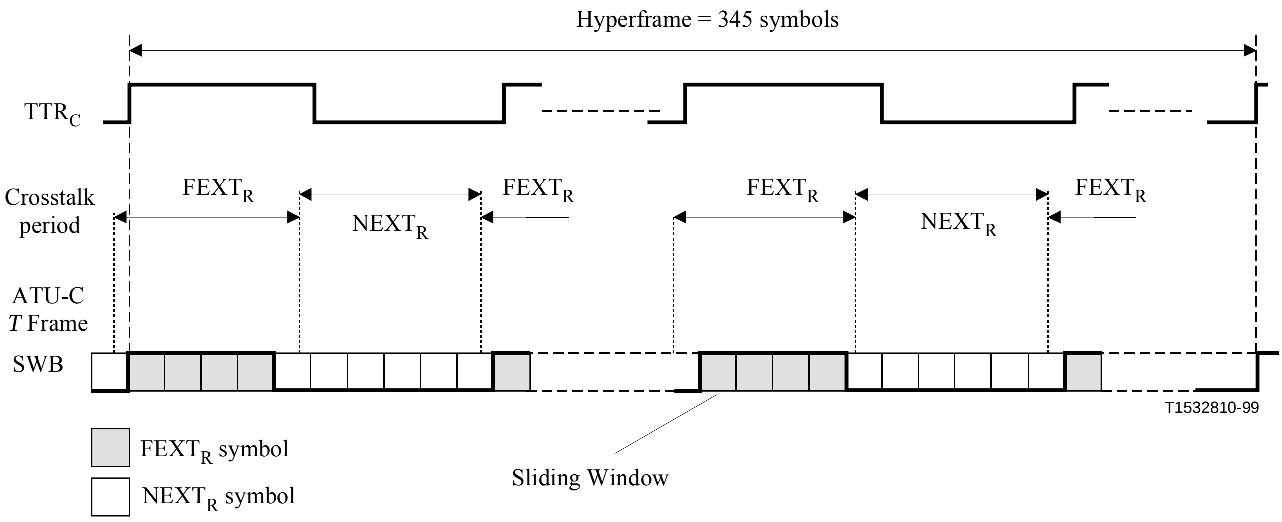


Figure C.6/G.992.1 – Sliding window for downstream symbols

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

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.

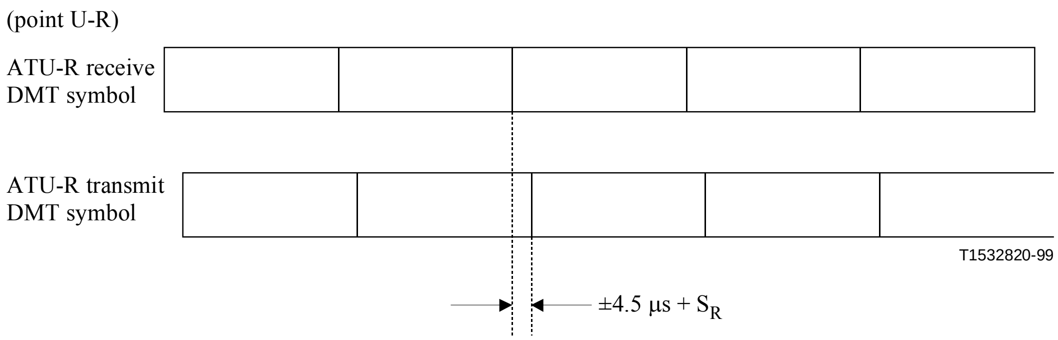


Figure C.7/G.992.1 – Loop timing for ATU-R

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.

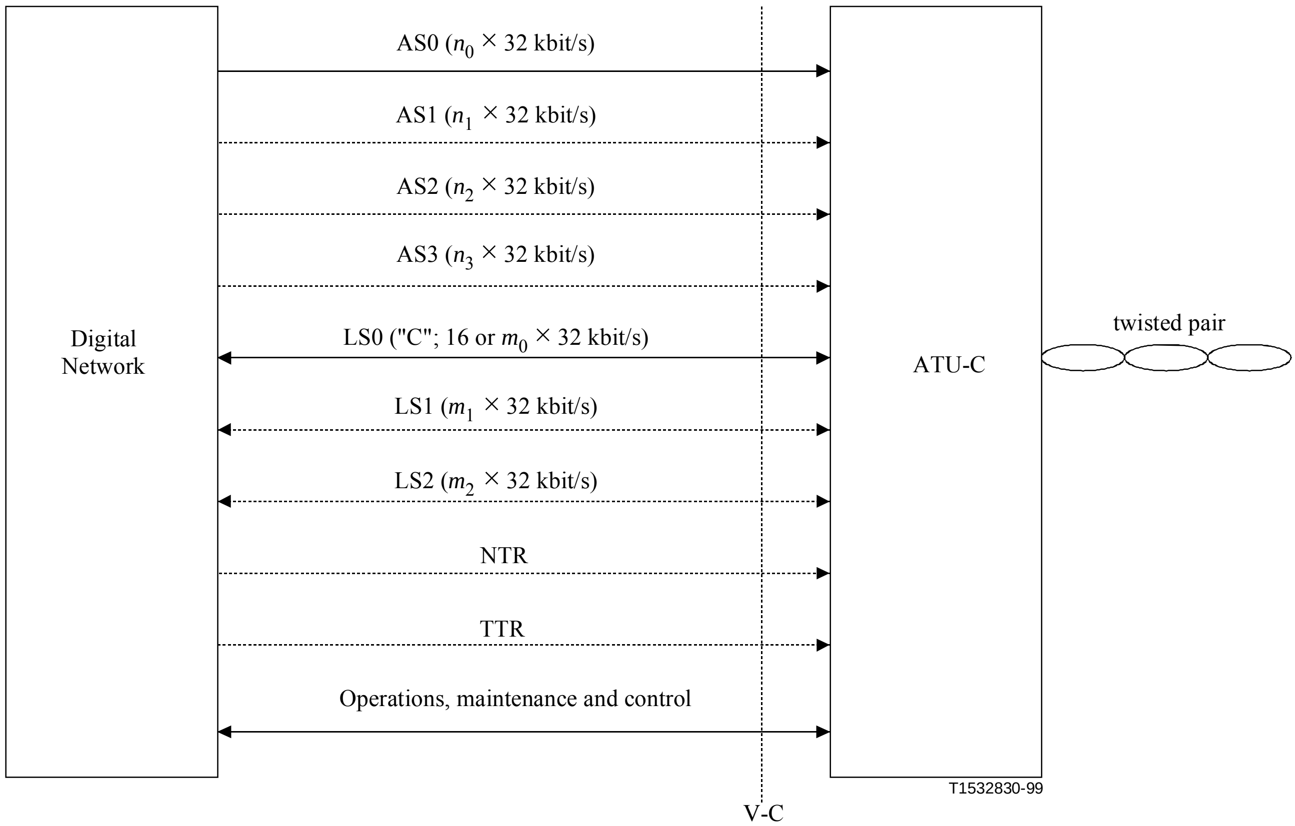
Table 11.5.1/G.994.1 contains the code points to support these profiles.

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

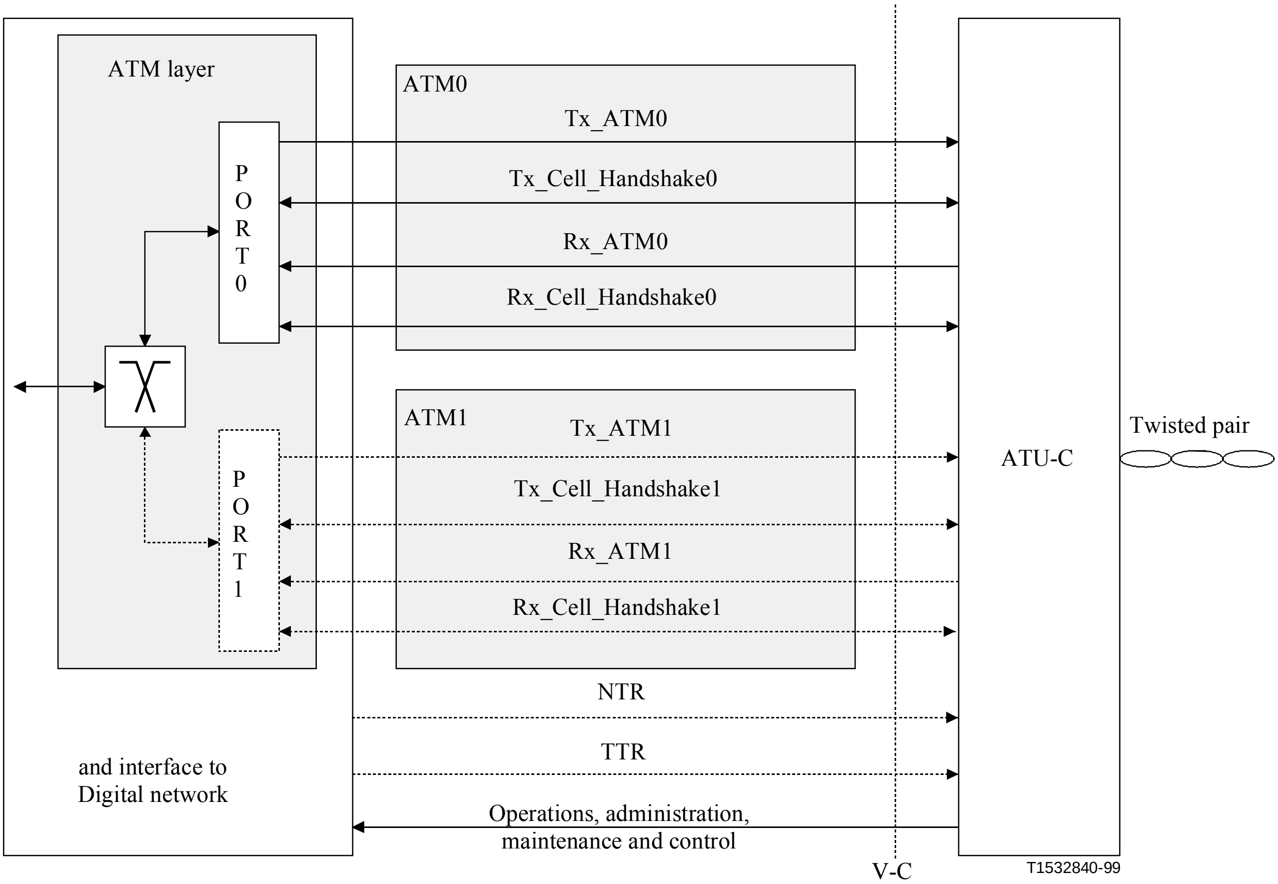
C.4.1.2 Payload transfer delay (supplements 7.1.4)

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).

For N_{dmt} = 0, 1, ..., 344
    $S = 272 \times N_{dmt} \bmod 2760$
    if { $(S + 271 < a)$ 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

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.

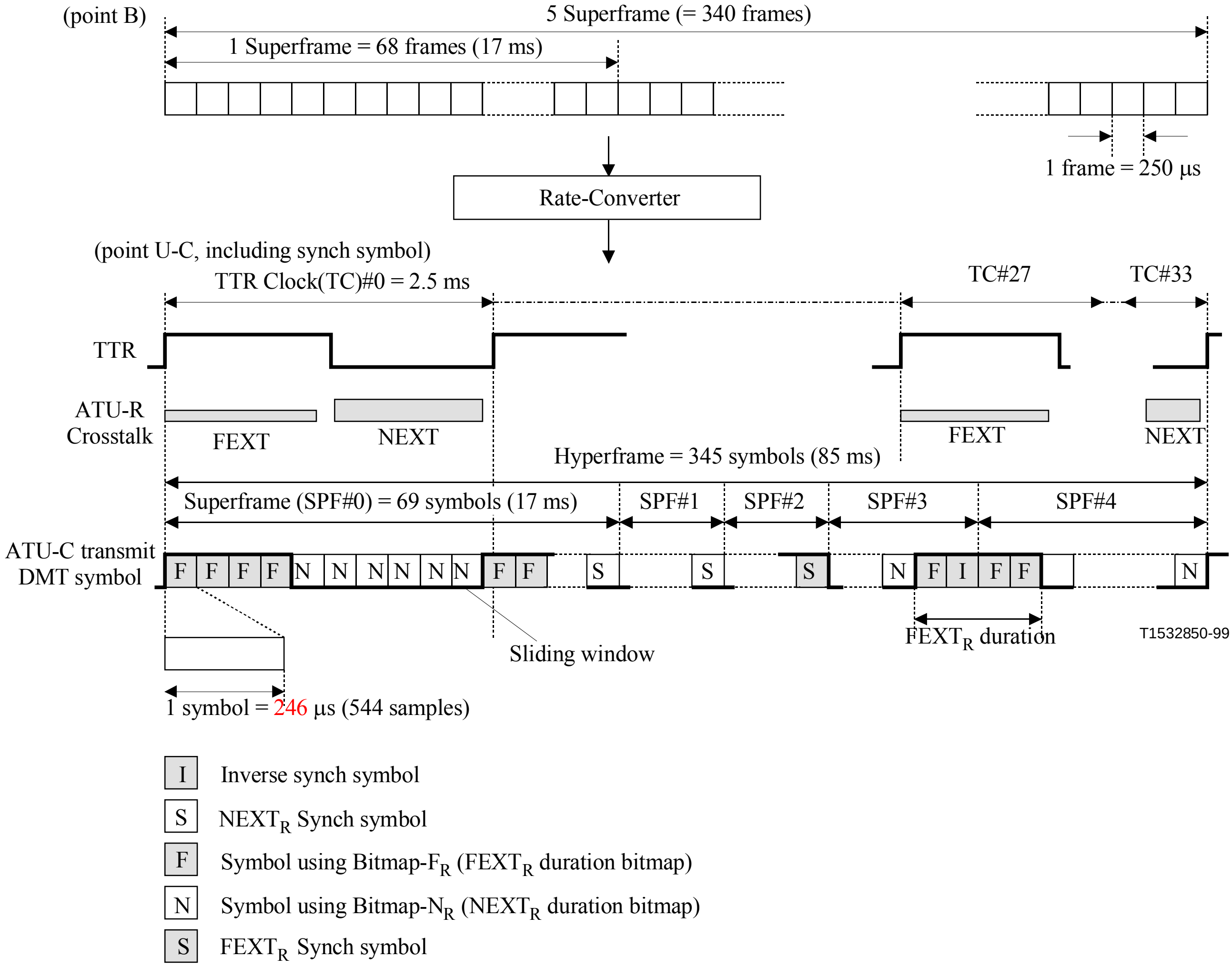


Figure C.10/G.992.1 – Hyperframe structure for downstream

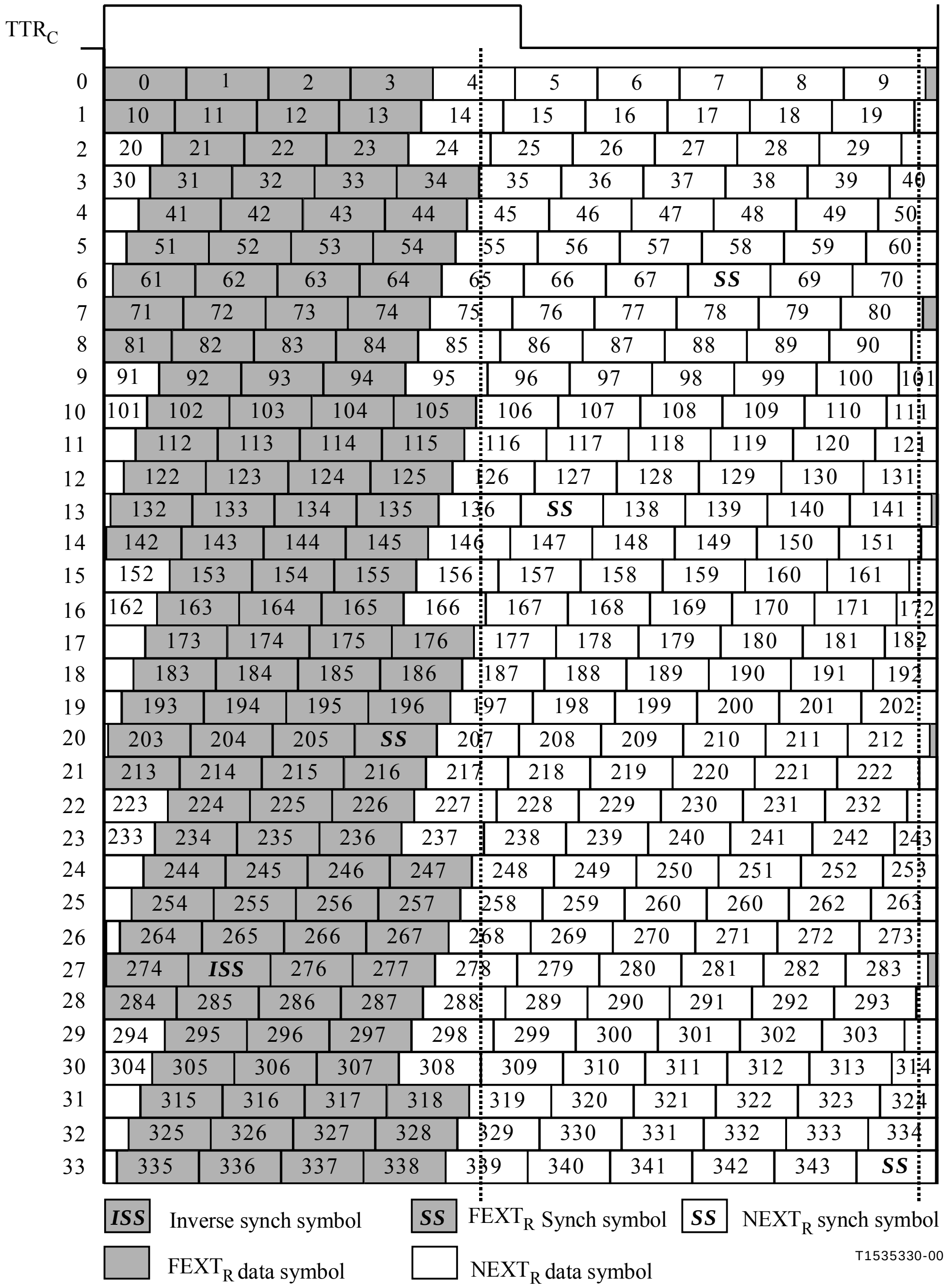


Figure C.11/G.992.1 – Symbol pattern in a hyperframe with cyclic prefix – Downstream

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.

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

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

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 $t_{Rf} \le n_{R\max}$:

$$n_{Rf} = t_{Rf}$$
$$n_{Ri} = n_R - n_{Rf}$$
$$f_{Rf} = t_{Rf}$$
$$f_{Ri} = f_R - f_{Rf}$$

If $t_{Rf} > n_{R\max}$:

$$n_{Rf} = n_{R\max}$$
$$n_{Ri} = 0$$
$$f_{Rf} = \begin{cases} f_{Rf4} = \left\lceil \dfrac{t_{Rf} \times 10 - n_{Rf} \times 6}{4} \right\rceil \\ f_{Rf3} = \left\lceil \dfrac{t_{Rf} \times 10 - n_{Rf} \times 7}{3} \right\rceil \end{cases}$$
$$f_{Ri} = \begin{cases} f_{Ri4} = f_R = f_{Rf4} \\ f_{Ri3} = f_R - f_{Rf3} \end{cases}$$

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 C.4.3.3) contains 3 Bitmap-F_R except for synch symbols.
f_{Rf4}	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.
n_R	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 $t_{Rf} \le n_{R\max}$:

$$dummy_{Rf} = 0$$
$$dummy_{Ri} = \left(f_{Ri} \times 126 + n_{Ri} \times 214\right) - t_{Ri} \times 340$$

If $t_{Rf} > n_{R\max}$:

$$dummy_{Rf4} = \left(f_{Rf} \times 4 + n_{Rf} \times 6\right) - t_{Rf} \times 10$$
$$dummy_{Rf3} = \left(f_{Rf} \times 3 + n_{Rf} \times 7\right) - t_{Rf} \times 10$$
$$dummy_{Ri} = \left(f_{Ri4} \times 96 + f_{Ri3} \times 30\right) - t_{Ri} \times 340$$

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.

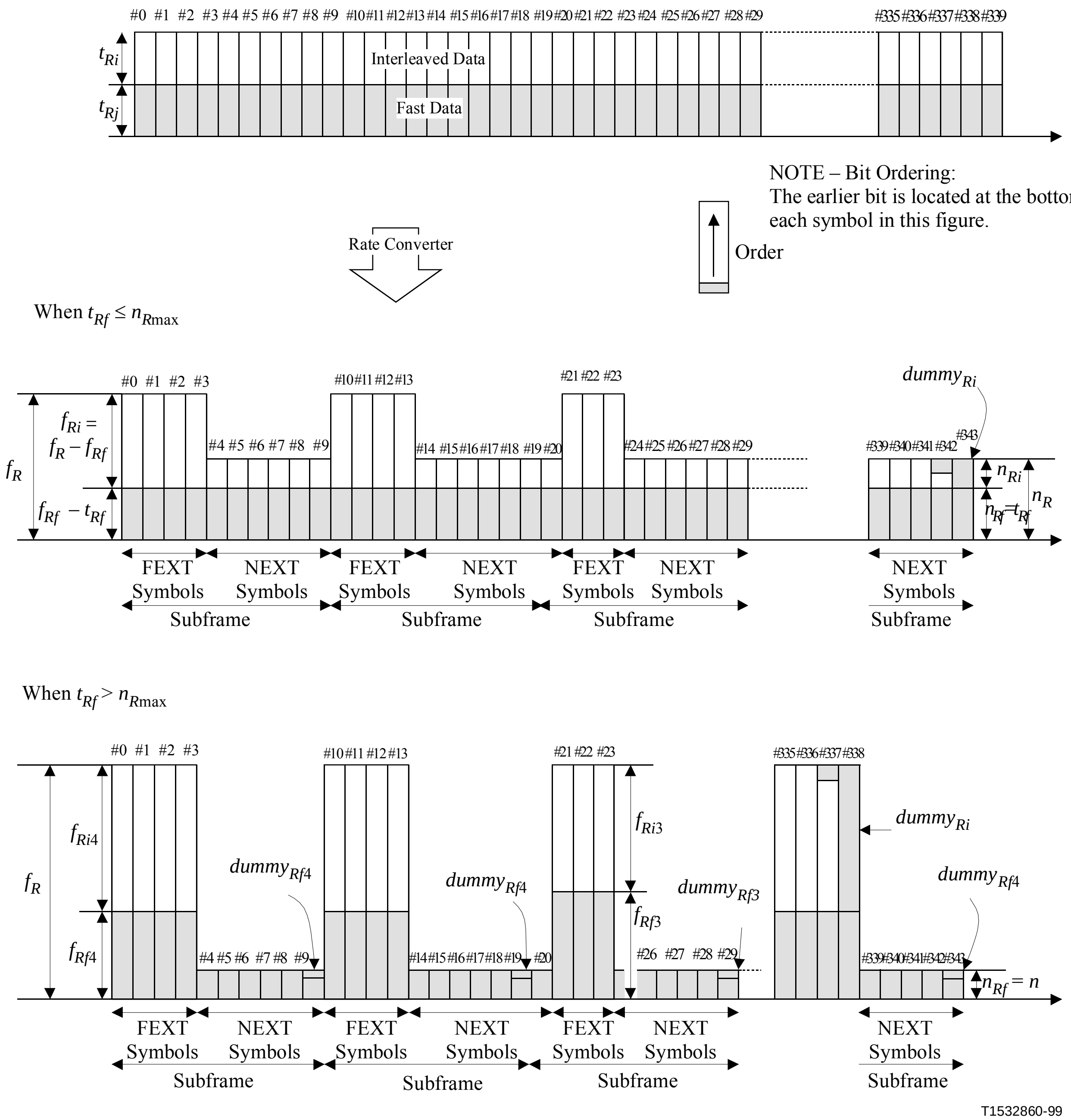


Figure C.12/G.992.1 – Bit distribution for Rate Converter under Dual latency and Dual Bitmap mode

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)

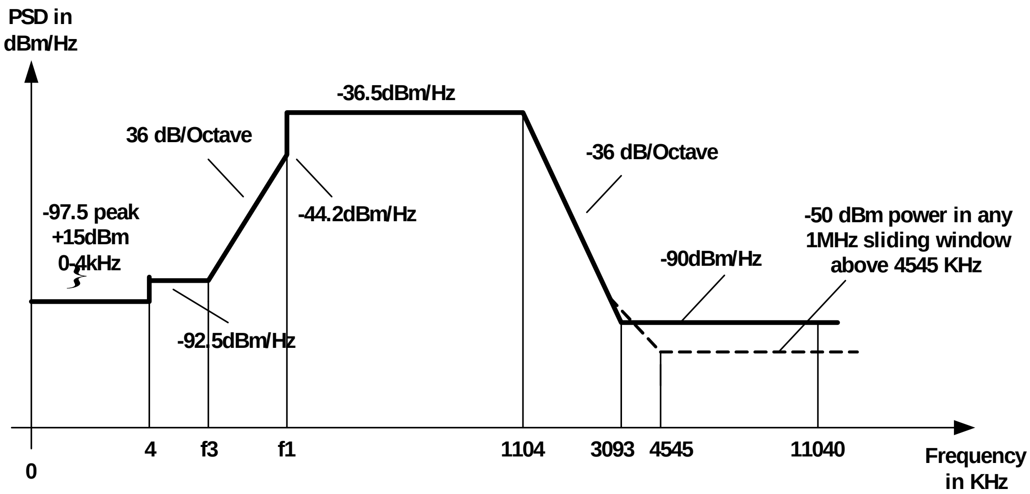
Bits d_{2i+1} and d_{2i+2}, which modulate the pilot carrier that has tone index i, shall be overwritten by {0,0}, generating the (+,+) constellation point.

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.



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*log2(f/f3)
f1 < f < 1104	-36.5
1104 < f < 3093	-36.5 - 36.0*log2(f/1104)
3093 < f < 4545	-90 peak, with max power in the [f, f+1MHz] window of (-36.5-36*log2(f/1104)+60) dBm
4545 < f < 11040	-90 peak, with max power in the [f, f+1MHz] window of –50 dBm

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
f1	-44.2	10 kHz
f1	-36.5	10 kHz
1104	-36.5	10 kHz
3093	-90	10 kHz
11040	-90	10 kHz
4545	-100	1 MHz
11040	-100	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< f ≤ 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.

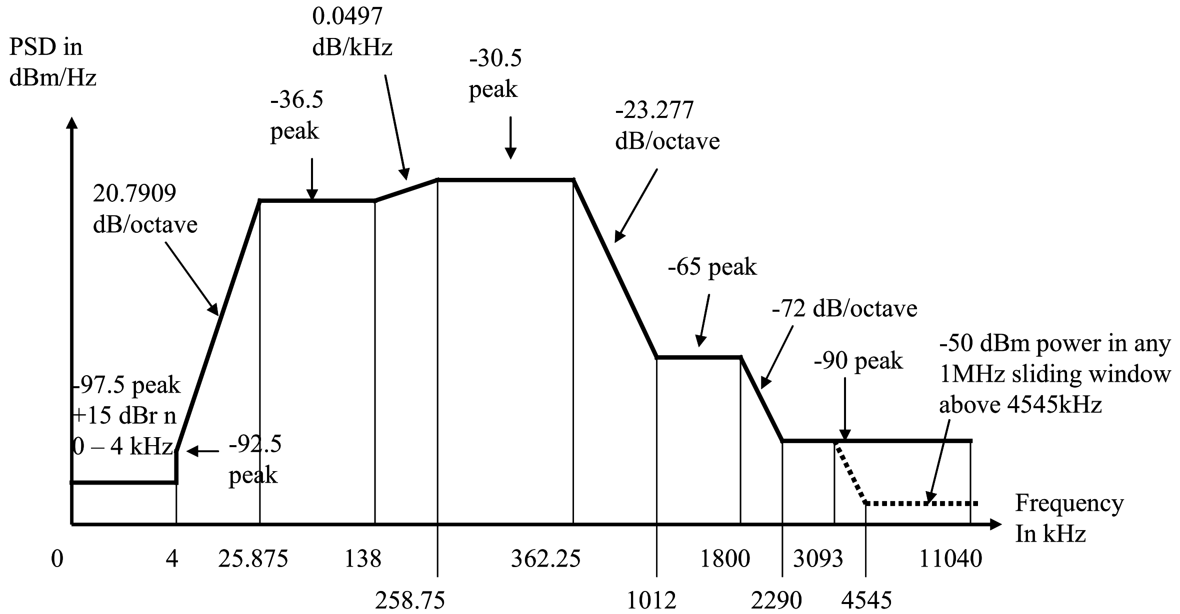
The ATU-C may use different PSD masks during $FEXT_R$ symbols and $NEXT_R$ symbols. These masks may differ from, but shall fall within, the masks defined in Annex A. Example PSD masks can be found in Appendix V.

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

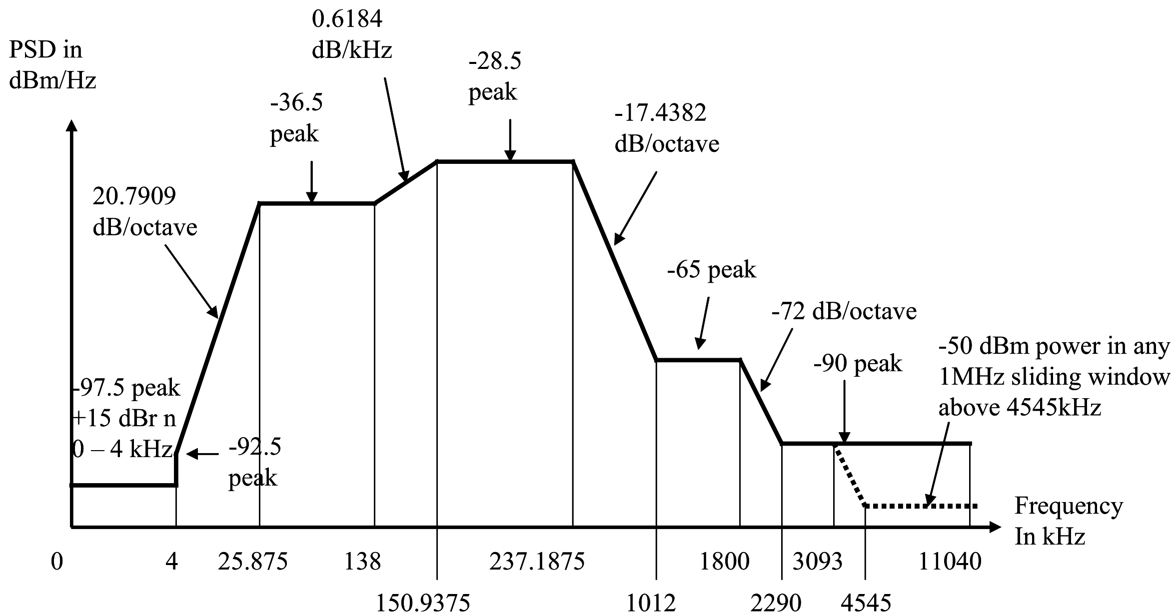


Frequency f (KHz)	PSD (dBm/Hz) Peak values
$0<f\leq 4$	-97.5, with max power in the in 0-4 kHz band of +15 dBrn
$4<f\leq 25.875$	$-92.5+20.7909*\log_2(f/4)$
$25.875<f\leq 138$	-36.5
$138 < f\leq 258.75$	$-43.3571+0.0497*f$
$258.75< f\leq 362.25$	-30.5
$362.25< f\leq 1012$	$-30.5-23.277*\log_2(f/362.25)$
$1012< f\leq 1800$	-65
$1800 < f\leq 2290$	$-65 - 72 \times \log_2 (f/1800)$
$2290 < f\leq 3093$	–90
$3093 < f\leq 4545$	–90 peak, with max power in the $[f, f + 1$ MHz$]$ window of $(-36.5 - 36 \times \log_2 (f/1104) + 60)$ dBm
$4545 < f\leq 11\,040$	–90 peak, with max power in the $[f, f + 1$ MHz$]$ window of –50 dBm

C.4.8.3.2 LD-TIF2

LD-TIF2 is defined in Figure C.TIF2.

Figure C.TIF2 The PSD mask for LD-TIF2



Frequency f (KHz)	PSD (dBm/Hz) Peak values
$0<f \le 4$	-97.5, with max power in the in 0-4 kHz band of +15 dBrn
$4<f \le 25.875$	$-92.5+20.7909*\log_2(f/4)$
$25.875<f \le 138$	-36.5
$138 < f \le 150.9375$	$-121.8333+0.6184*f$
$150.9375< f \le 237.1875$	-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 $N_{dmt} = 0, 1, \ldots, 344$

$S = 272 \times N_{dmt} \bmod 2760$

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.

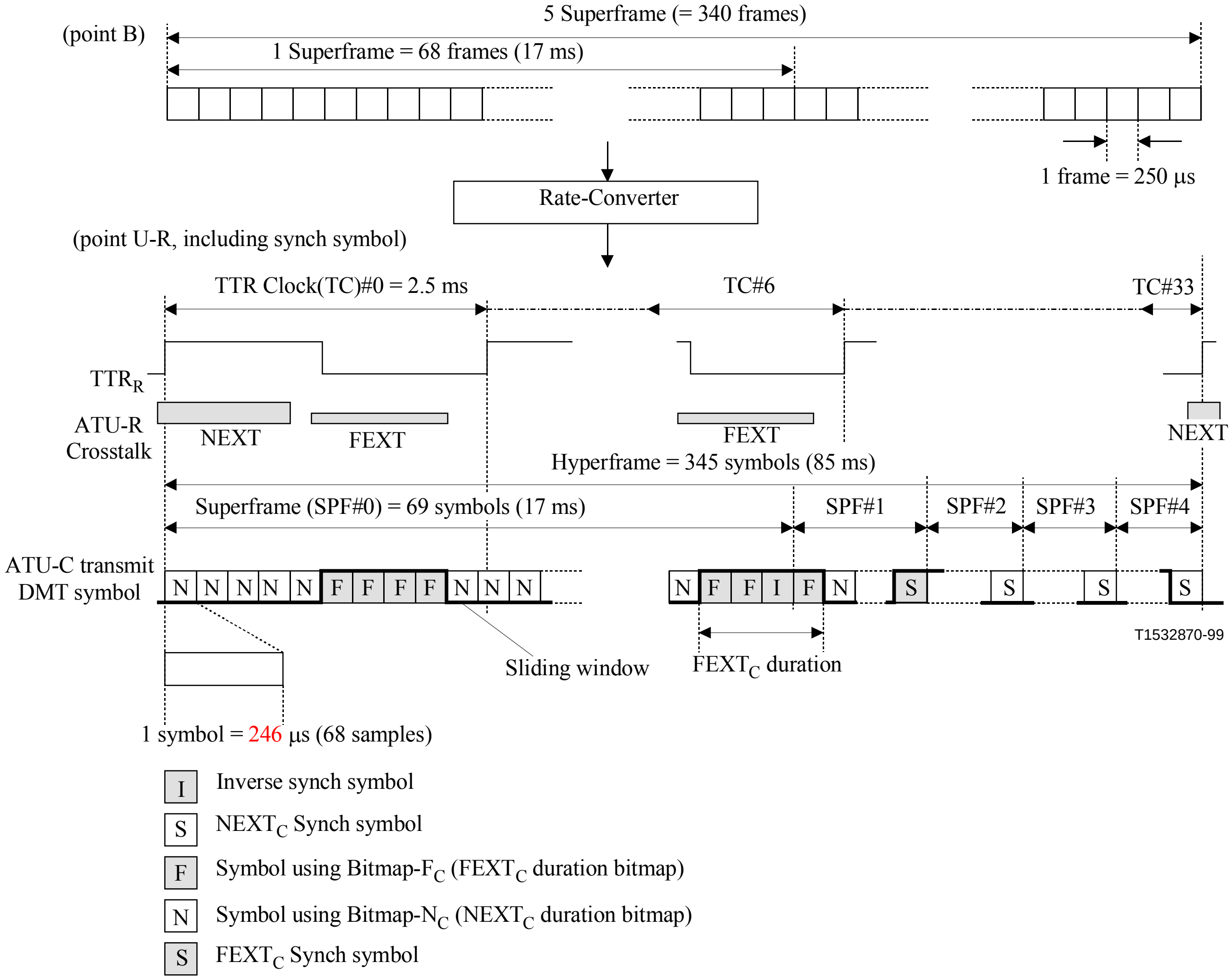


Figure C.13/G.992.1 – Hyperframe structure for upstream

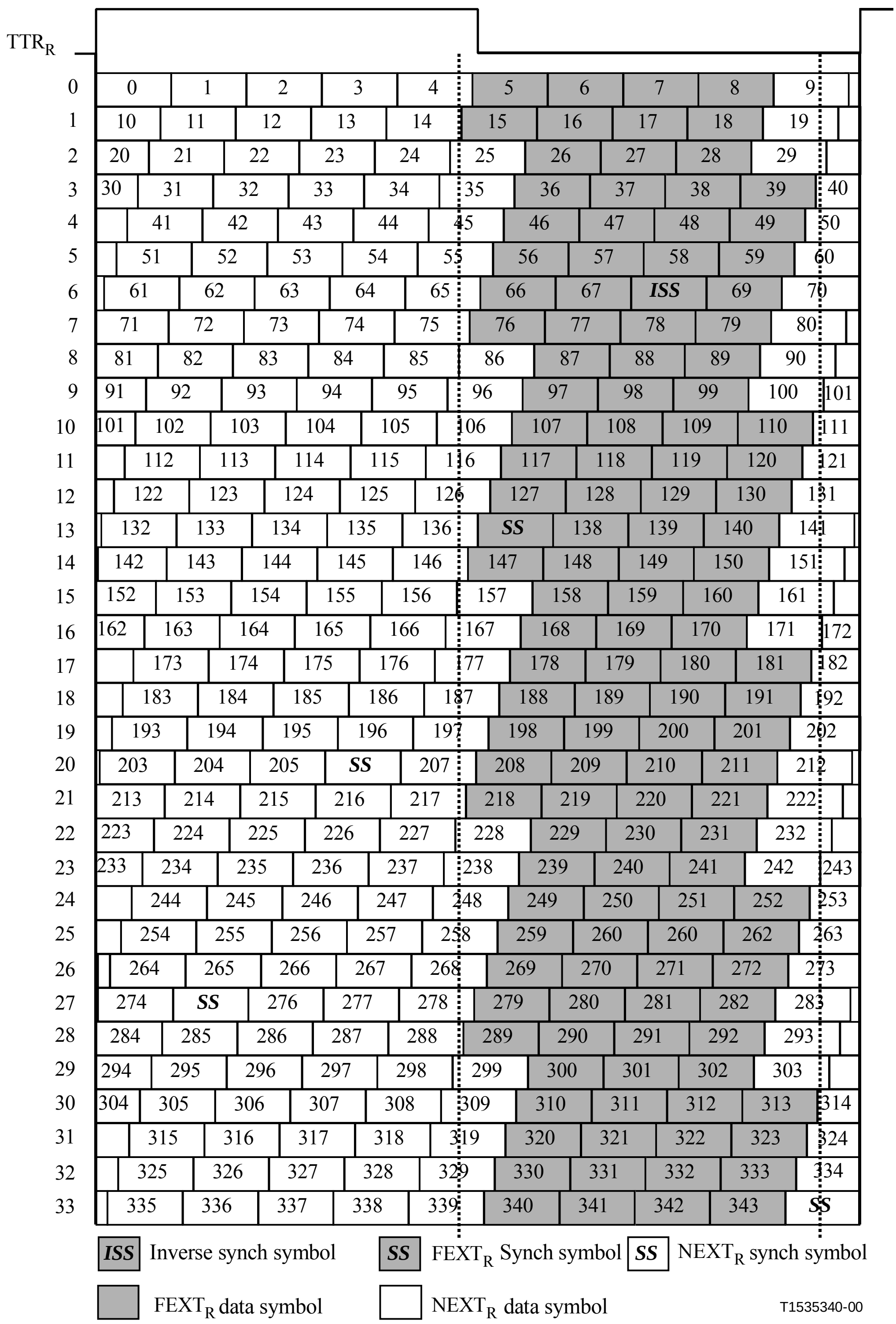


Figure C.14/G.992.1 – Symbol pattern in a hyperframe with cyclic prefix – Upstream

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.

Table C.2/G.992.1 – Subframe (upstream)

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

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 $t_{Cf} \leq n_{C\max}$:

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

If $t_{Cf} > n_{C\max}$:

$$n_{Cf} = n_{C\max}$$
$$n_{Ci} = 0$$
$$f_{Cf} = \begin{cases} f_{Cf4} = \left\lceil \dfrac{t_{Cf} \times 10 - n_{Cf} \times 6}{4} \right\rceil \\ f_{Cf3} = \left\lceil \dfrac{t_{Cf} \times 10 - n_{Cf} \times 7}{3} \right\rceil \end{cases}$$
$$f_{Ci} = \begin{cases} f_{Ci4} = f_C - f_{C4} \\ f_{Ci3} = f_C - f_{Cf3} \end{cases}$$

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 C.5.1.3) contains 3 Bitmap-F_C except for synch symbols.
f_{Cf4}	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.
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 $t_{Cf} \leq n_{C\max}$:

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

If $t_{Cf} > n_{C\max}$:

$$dummy_{Cf4} = \left(f_{Cf} \times 4 + n_{Cf} \times 6 \right) - t_{Cf} \times 10$$
$$dummy_{Cf3} = \left(f_{Cf} \times 3 + n_{Cf} \times 7 \right) - t_{Cf} \times 10$$
$$dummy_{Ci} = \left(f_{Ci4} \times 96 + f_{Ci3} \times 30 \right) - t_{Ci} \times 340$$

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 +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.

C.5.5.3 Nyquist frequency (supplements 8.11.1.2)

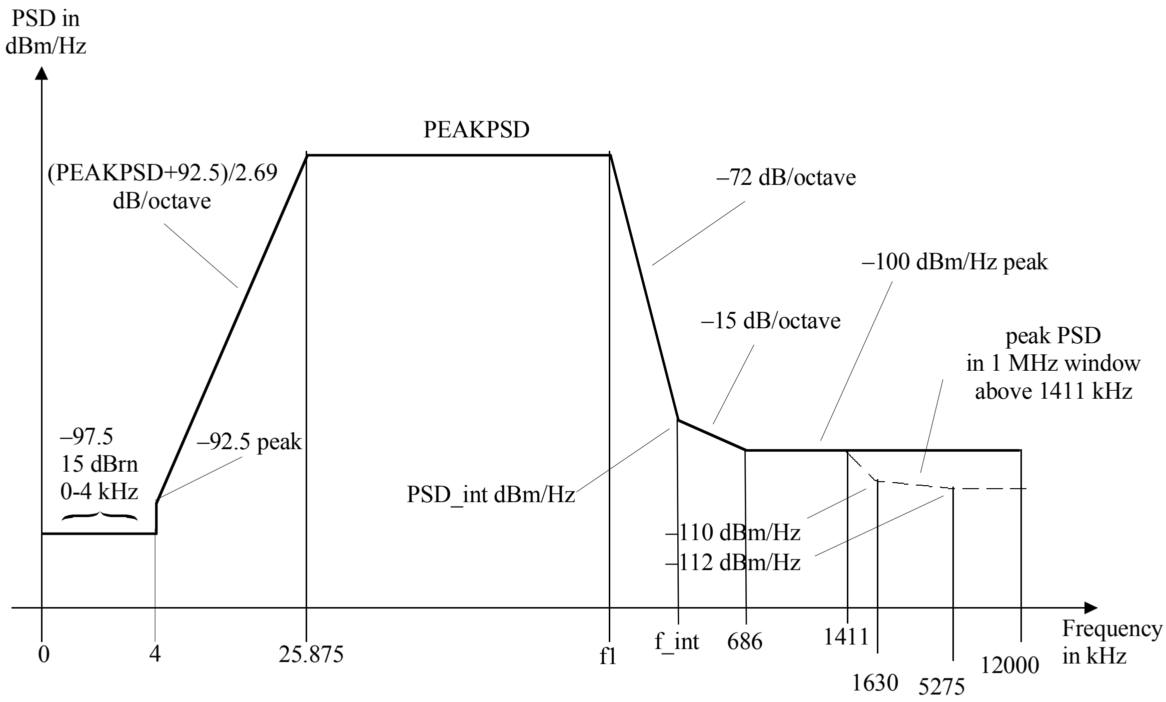
The upstream Nyquist frequency for Annex C-EU shall be at subcarrier NSCus (f = 4.3125*NSCus kHz)..

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):

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 ≤ 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-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, …344
 $S = 256 \times N_{dmt} \bmod 2760$
 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,
 $S = 256 \times N_{dmt} \bmod 2760$
 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
 $S = 272 \times N_{dmt} \bmod 2760$
 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
 $S = 272 \times N_{dmt} \bmod 2760$
 if { (S > a) and (S + 271 < a + b) } then $FEXT_C$ symbols

else then $NEXT_C$ symbols

where a = 1315, b = 1293

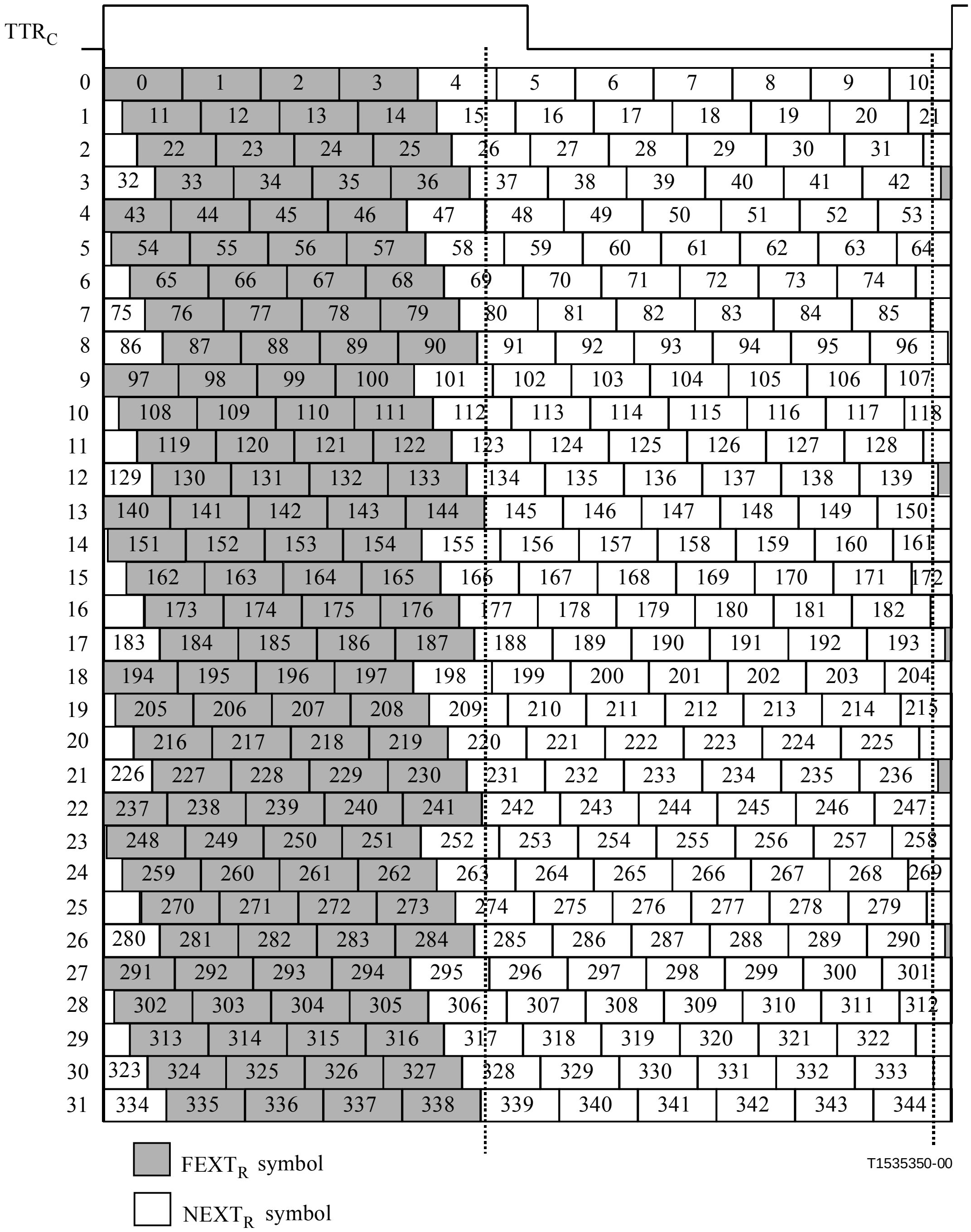


Figure C.15/G.992.1 – Symbol pattern in a hyperframe without cyclic prefix – Downstream

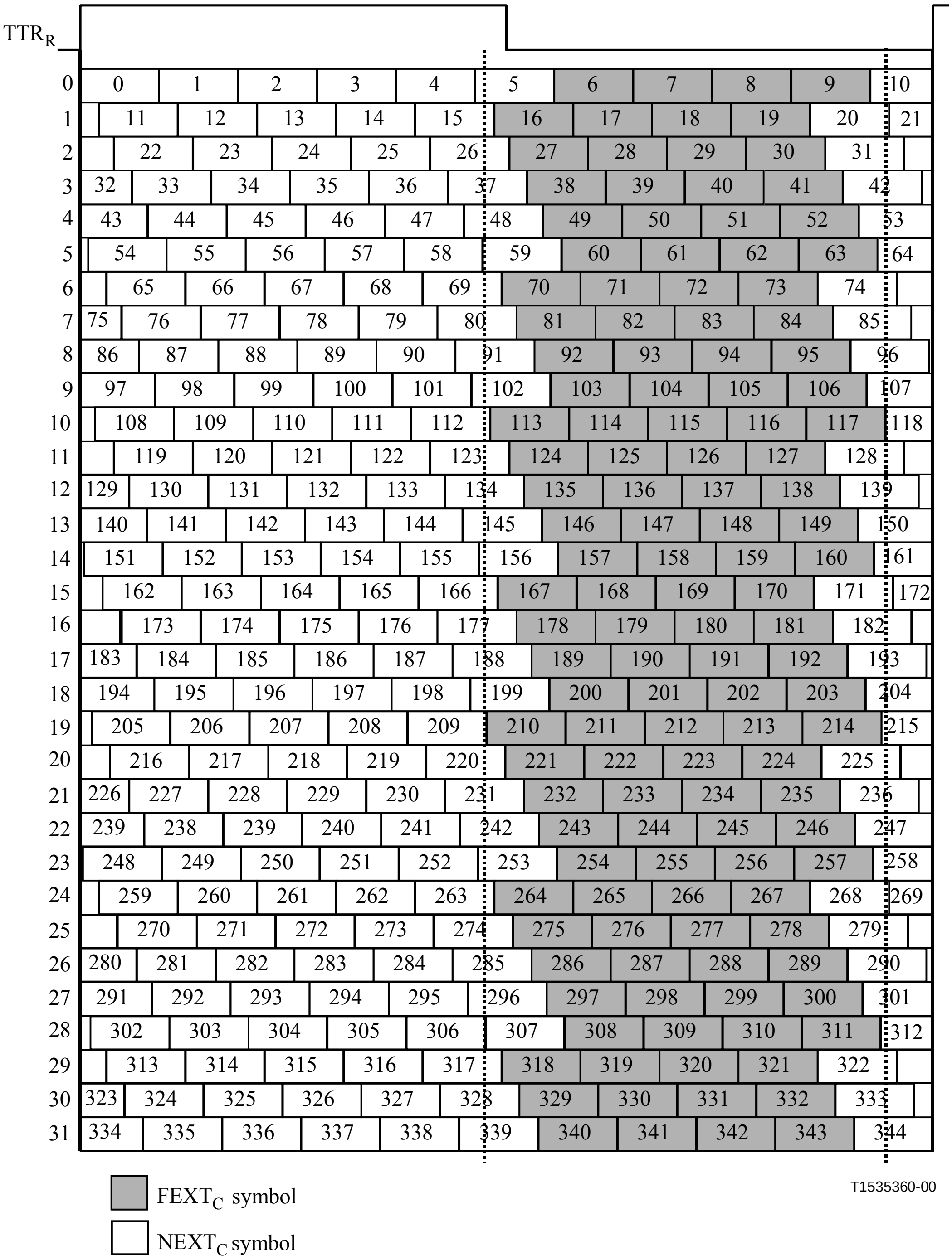


Figure C.16/G.992.1 – Symbol pattern in a hyperframe without cyclic prefix – Upstream

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-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 §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".

Table C.a – Non-standard information field – NPar(1) coding

Bits 8	7	6	5	4	3	2	1	**NPar(1)s**
x	x	x	x	x	x	x	1	Reserved for future use
x	x	x	x	x	x	1	x	Reserved for future use
x	x	x	x	x	1	x	x	Reserved for future use
x	x	x	x	1	x	x	x	Reserved for future use
x	x	x	1	x	x	x	x	Reserved for future use
x	x	1	x	x	x	x	x	Reserved for future use
x	1	x	x	x	x	x	x	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

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

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**
x	x	x	x	x	x	x	1	$n_{\text{C-PILOT1}} = 64$
x	x	x	x	x	x	1	x	$n_{\text{C-PILOT1}} = 128$
x	x	x	x	x	1	x	x	Reserved for future use
x	x	x	x	1	x	x	x	Reserved for future use
x	x	x	1	x	x	x	x	Reserved for future use
x	x	1	x	x	x	x	x	$n_{\text{C-PILOT1}} = 96$
x	x	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**
x	x	x	x	x	x	x	1	R-ACK1
x	x	x	x	x	x	1	x	R-ACK2
x	x	x	x	x	1	x	x	DBM
x	x	x	x	1	x	x	x	$n_{\text{C-PILOT1}} = 48$
x	x	x	1	x	x	x	x	$n_{\text{C-PILOT1}} = 32$
x	x	1	x	x	x	x	x	G.997.1 – Clear EOC OAM
x	x	0	0	0	0	0	0	No parameters in this octet
Since Annex C-EU only supports ATM transport, STM and ATM parameters are not specified.								

Table C.b.5.2 – Non-standard information field – G.992.1 Annex C-EU NPar(2) coding – Octet 3

Bits 8	7	6	5	4	3	2	1	G.992.1 Annex C-EU NPar(2)s – Octet 3
x	x	x	x	x	x	x	1	$n_{C\text{-}PILOT1} = 16$
x	x	x	x	x	x	1	x	A_{48} / B_{48}
x	x	x	x	x	1	x	x	C-REVERB33-63
x	x	x	x	1	x	x	x	A_{24} / B_{24}
x	x	x	1	x	x	x	x	C-REVERB6-31
x	x	1	x	x	x	x	x	Reserved for future use
x	x	0	0	0	0	0	0	No parameters in this octet

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
x	x	x	x	x	x	x	1	Profile 1
x	x	x	x	x	x	1	x	Profile 2
x	x	x	x	x	1	x	x	Profile 3
x	x	x	x	1	x	x	x	Profile 4
x	x	x	1	x	x	x	x	Profile 5
x	x	1	x	x	x	x	x	Profile 6
x	x	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

Bits 8	7	6	5	4	3	2	1	G.992.1 Annex C-EU SPar(2)s
x	x	x	x	x	x	x	1	Reserved for future use
x	x	x	x	x	x	1	x	Extended upstream
x	x	x	x	x	1	x	x	Profile 3 downstream PSD
x	x	x	x	1	x	x	x	Reserved for future use
x	x	x	1	x	x	x	x	Reserved for future use
x	x	1	x	x	x	x	x	Reserved for future use
x	x	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

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

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	X	x	x	x	x	x	1	EU-40
x	X	x	x	x	x	1	x	EU-44
x	X	x	x	x	1	x	x	EU-48
x	X	x	x	1	x	x	x	EU-52
x	x	x	1	x	x	x	x	EU-56
x	x	1	x	x	x	x	x	EU-60
x	x	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	x	x	x	x	x	x	1	LD-TIF1
x	x	x	x	x	x	1	x	LD-TIF2
x	x	x	x	x	1	x	x	FBMsOL
x	x	x	x	1	x	x	x	Reserved for future use
x	x	x	1	x	x	x	x	Reserved for future use
x	x	1	x	x	x	x	x	Reserved for future use
x	x	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)

Table C.3/G.992.1 – ATU-C CL message bit definitions for Annex C-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 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.
$n_{C\text{-}PILOT1}$=128	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 128.
$n_{C\text{-}PILOT1}$=96	This Npar(2) bit shall be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 96.
$n_{C\text{-}PILOT1}$=64	This NPar(2) bit shall also be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 64.
$n_{C\text{-}PILOT1}$=48	This NPar(2) bit shall also be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 48.
$n_{C\text{-}PILOT1}$=32	This NPar(2) bit shall also be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 32.
$n_{C\text{-}PILOT1}$=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).

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.
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 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 ignored by the ATU-R. Note 2: Only one of LD-TIF1, LD-TIF2 and FBMsOL bits can be set to 1.	

C.7.3.1.2 MS messages (supplements 10.2.2)

Table C.4/G.992.1 – ATU-C MS message bit definitions for Annex C-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 (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.
$n_{C\text{-}PILOT1}=128$	If set to ONE, this NPar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 128 (Note 2).
$n_{C\text{-}PILOT1}=96$	If set to ONE, this bit NPar(2) shall indicate that the ATU-C is selecting the pilot tone on subcarrier 96 (Note 2).
$n_{C\text{-}PILOT1}=64$	If set to ONE, this NPar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 64 (Note 2).
$n_{C\text{-}PILOT1}=48$	If set to ONE, this NPar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 48 (Note 2).
$n_{C\text{-}PILOT1}=32$	If set to ONE, this NPar(2) bit shall indicate that the ATU-C is selecting the pilot tone on subcarrier 32 (Note 2).
$n_{C\text{-}PILOT1}=16$	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)

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)

Table C.5/G.992.1 – ATU-R CLR message bit definitions for Annex C-EU

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-EU	If set to ONE, this Spar(1) bit indicates that the ATU-R is configured to support G.992.1 Annex C-EU.
$n_{C\text{-}PILOT1}=128$	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 128.
$n_{C\text{-}PILOT1}=96$	This Npar(2) bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 96.
$n_{C\text{-}PILOT1}=64$	This bit shall be set to ONE, indicating that the ATU-R supports reception of pilot tone on subcarrier 64.
$n_{C\text{-}PILOT1}=48$	If set to ONE, this bit shall indicate that the ATU-R supports reception of pilot tone on subcarrier 48.
$n_{C\text{-}PILOT1}=32$	If set to ONE, this bit shall indicate that the ATU-R supports reception of pilot tone on subcarrier 32.
$n_{C\text{-}PILOT1}=16$	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 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.
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.

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)

Table C.6/G.992.1 – ATU-R MS message NPar(2) bit definitions for Annex C-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 (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	
$n_{C\text{-}PILOT1}$=128	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is selecting the pilot tone on subcarrier 128 (Note 2).
$n_{C\text{-}PILOT1}$=96	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is selecting the pilot tone on subcarrier 96 (Note 2).
$n_{C\text{-}PILOT1}$=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).
$n_{C\text{-}PILOT1}$=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).
$n_{C\text{-}PILOT1}$=32	If set to ONE, this NPar(2) bit shall indicate that the ATU-R is selecting the pilot tone on subcarrier 32 (Note 2).
$n_{C\text{-}PILOT1}$=16	If set to ONE, this NPar(2) bit shall indicate that the ATU-R 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-R is selecting the 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-R is selecting the 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-R is selecting the TTR 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 PSD	If set to ONE, this Spar(2) bit indicates that the ATU-R is selecting profile 3.
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-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 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.
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)

Table C.6a/G.992.1 – ATU-R MP message bit definitions for Annex C-EU

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
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.
$n_{C\text{-}PILOT1}=128$	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the pilot tone on subcarrier 128 (Note 2).
$n_{C\text{-}PILOT1}=96$	If set to ONE, this Npar(2) bit shall indicate that the ATU-C is proposing the pilot tone on subcarrier 96 (Note 2).
$n_{C\text{-}PILOT1}=64$	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the use of pilot tone on subcarrier 64 (Note 2).
$n_{C\text{-}PILOT1}=48$	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the use of pilot tone on subcarrier 48 (Note 2).
$n_{C\text{-}PILOT1}=32$	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the use of pilot tone on subcarrier 32 (Note 2).
$n_{C\text{-}PILOT1}=16$	If set to ONE, this Npar(2) bit shall indicate that the ATU-R is proposing the use of pilot 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 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 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 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 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 operation.
Profile 3 downstream PSD	If set to ONE, this Spar(2) bit indicates that the ATU-R is proposing profile 3.
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 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 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.

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-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 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 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 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. $f_{C\text{-PILOT1}}$ = 276 kHz ($n_{C\text{-PILOT1}}$ = 64);
2. $f_{C\text{-PILOT1}}$ = 207 kHz ($n_{C\text{-PILOT1}}$ = 48).

For Profiles 3 to 6, the frequency of the pilot tone shall be selected from one of the following choices:

1. $f_{C\text{-PILOT1}}$ = 276 kHz ($n_{C\text{-PILOT1}}$ = 64);
2. $f_{C\text{-PILOT1}}$ = 207 kHz ($n_{C\text{-PILOT1}}$ = 48);
3. $f_{C\text{-PILOT1}}$ = 138 kHz ($n_{C\text{-PILOT1}}$ = 32);
4. $f_{C\text{-PILOT1}}$ = 69 kHz ($n_{C\text{-PILOT1}}$ = 16).

For modems not using any of the profiles defined in §C.3.4, the frequency of the pilot tone shall be:

$f_{C\text{-PILOT1}}$ = 276 kHz ($n_{C\text{-PILOT1}}$ = 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 $n_{C\text{-PILOT1}}$ = 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.

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:

1. B_{48} signal –the constellation encoding of the 48th 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.

2. B_{24} 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.

3. 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. 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.

2. A_{24} 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.

3. 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:

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.

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 A_{48}. 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.

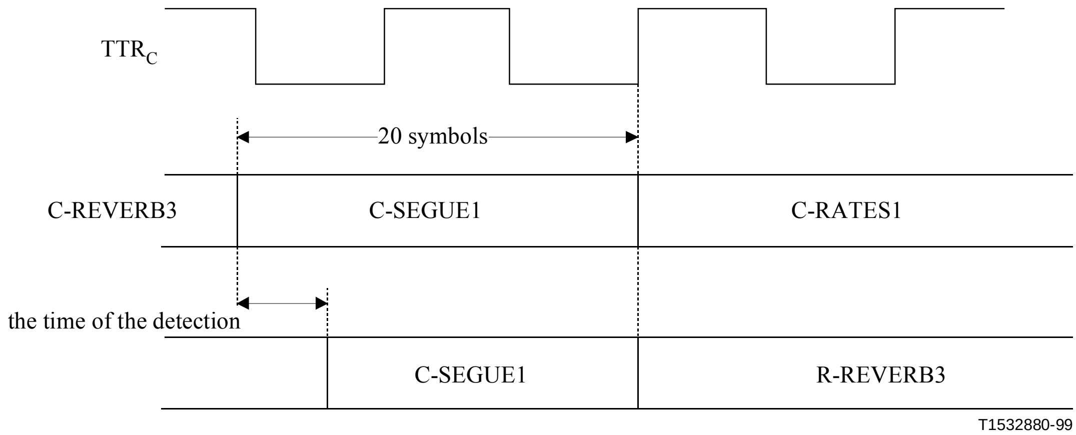


Figure C.17/G.992.1 – Timing diagram from C-SEGUE1 to C-RATES1

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:

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

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:

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

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 2^{14}-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:

For N_{dmt} = 0, 1, …, 344

S = 272 x 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), 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.

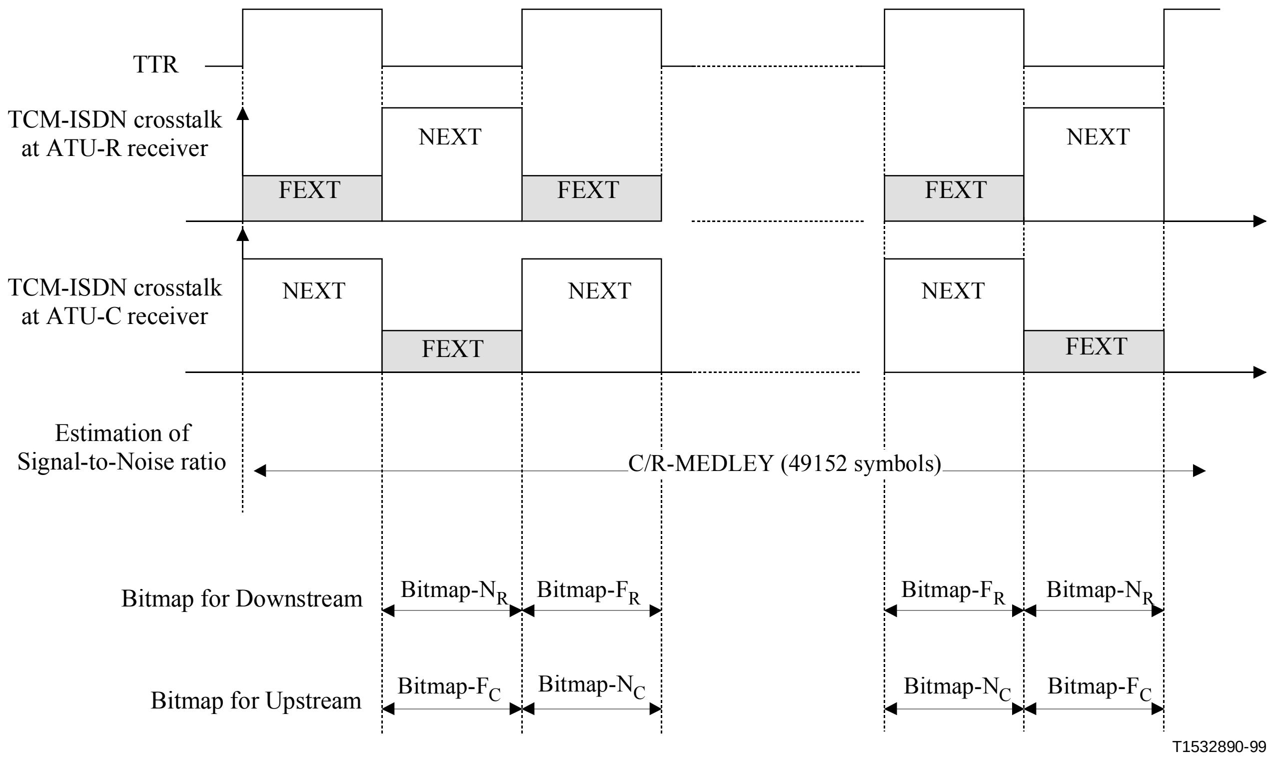


Figure C.18/G.992.1 – Estimation of periodic Signal-to-Noise Ratio

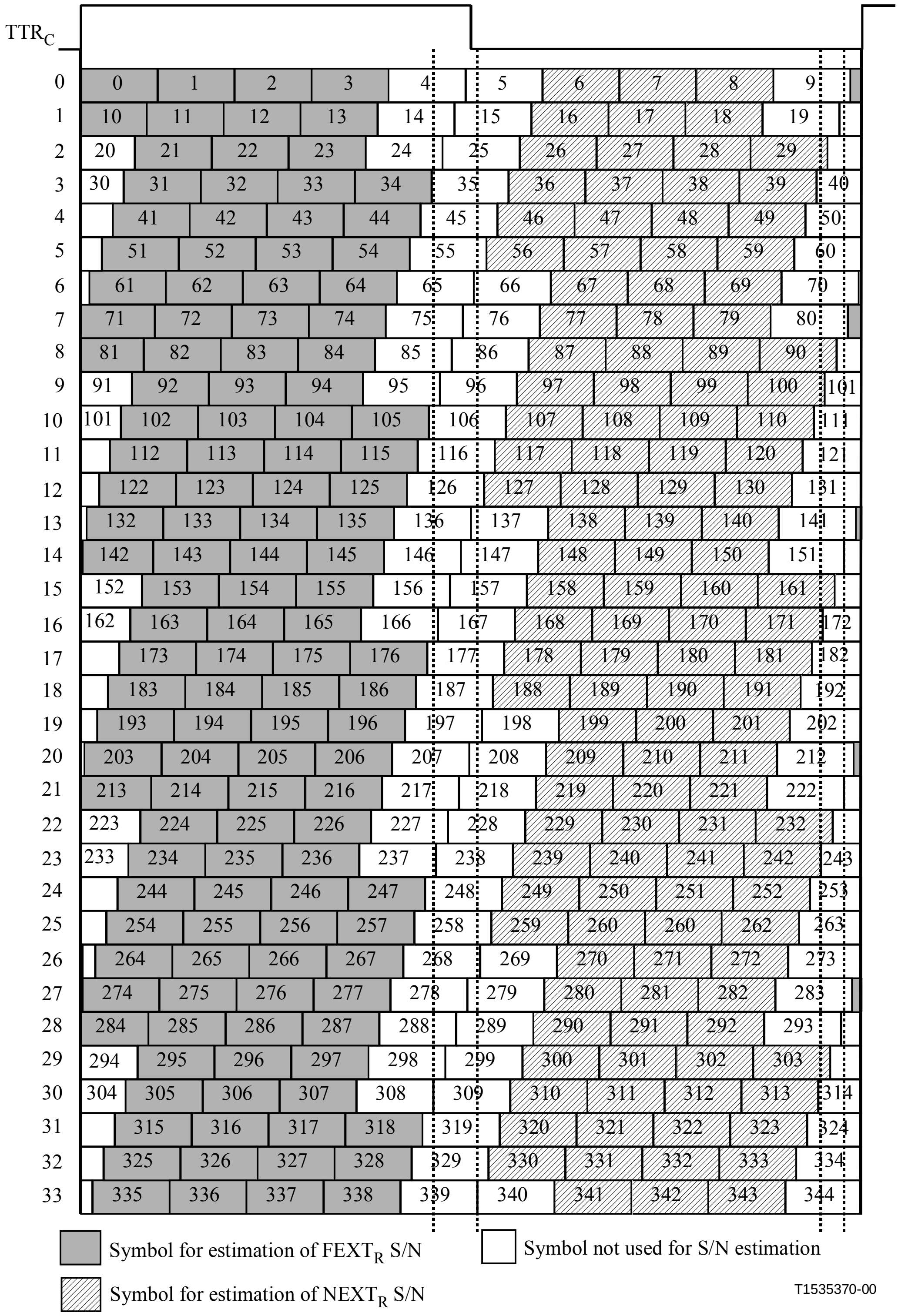


Figure C.19/G.992.1 – Symbol pattern in a hyperframe for S/N estimation – Downstream

I.7.6.3 C-MSG1 (supplements 10.6.4)

Table C.bb/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; binary coded 0-15 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 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:

$$d_n = 1 \text{ for } n = 1 \text{ to } 23 \text{ and } d_n = d_{n-18} \oplus d_{n-23} \text{ for } n > 23.$$

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

$S = 272 \times N_{dmt} \bmod 2760$

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.

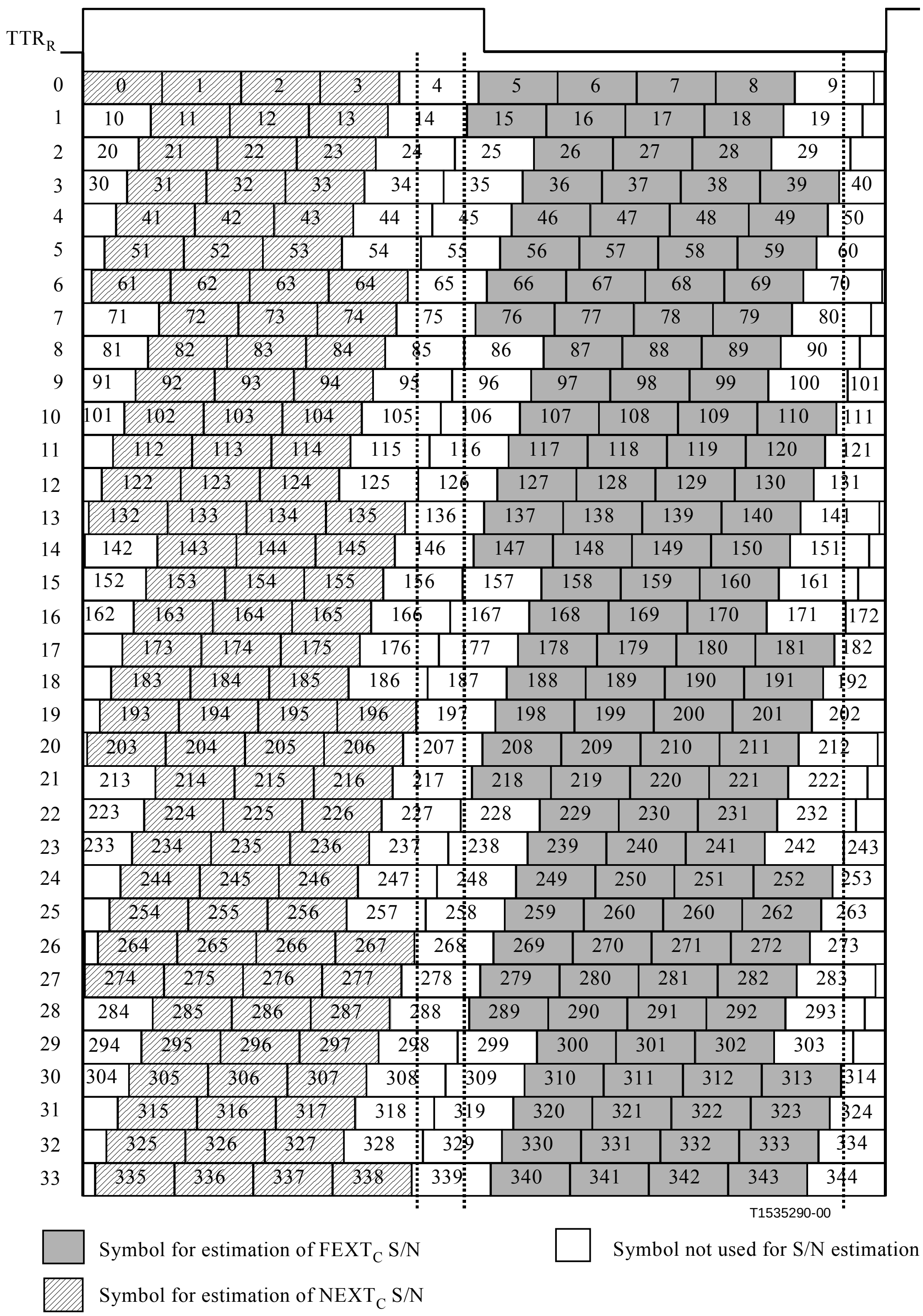


Figure C.20/G.992.1 – Symbol pattern in a hyperframe for S/N estimation – Upstream

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 binary ONE.	

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.

Table C.dd/G.992.1 – Assignment of 32 bits of C-MSG2

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".	

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:

$n_{1\text{C-MSG2}} = 43$

$n_{2\text{C-MSG2}} = 91$

Otherwise,

$n_{1C\text{-}MSG2} = 91$
$n_{2C\text{-}MSG2} = 139$

For Profile 3:
$n_{1C\text{-}MSG2} = 13$
$n_{2C\text{-}MSG2} = 25$

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 x 126 + 88 x 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), $\{m_{10}, ..., m_0\} = 00001111111_2$].

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-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_is 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 (00000_2 and $00000000\ 000_2$, 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 (000.00110000_2 to 001.01010101_2).

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:

$m = \{m_{32*(NSCu-1)-1}, m_{32*(NSCu-1)-2}, \ldots, m_1, m_0\} = \{ g_{2*NSCu-1}, b_{2*NSCu-1}, \ldots, g_{NSCu+1}, b_{NSCu+1}, g_{NSCu-1}, b_{NSCu-1}, \ldots, g_1, b_1\},$ (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.

Table C.7/G.992.1 – Assignment of 80 bits of R-MSG-RA (Annex C-EU)

Suffix(ces) of m_i (Note)	Parameter All reserved bits shall be set to 0
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 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)

$B_{fast\text{-}max}$ 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 $B_{fast\text{-}max}$ is t_f.

C.7.10.2 R-MSG2 (supplements 10.9.8)

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

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, g_{96} and g_{352} shall be set to g_{sync}. For Profile 3, g_{96} 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, g_{64} 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, g_{32} and g_{288} 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:

$$m = \{m_{8159}, m_{8158}, \ldots, m_1, m_0\} = \{ g_{511}, b_{511}, \ldots, g_{257}, b_{257}, g_{255}, b_{255}, \ldots, g_1, b_1\}, \qquad \text{(C.10-3)}$$

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.

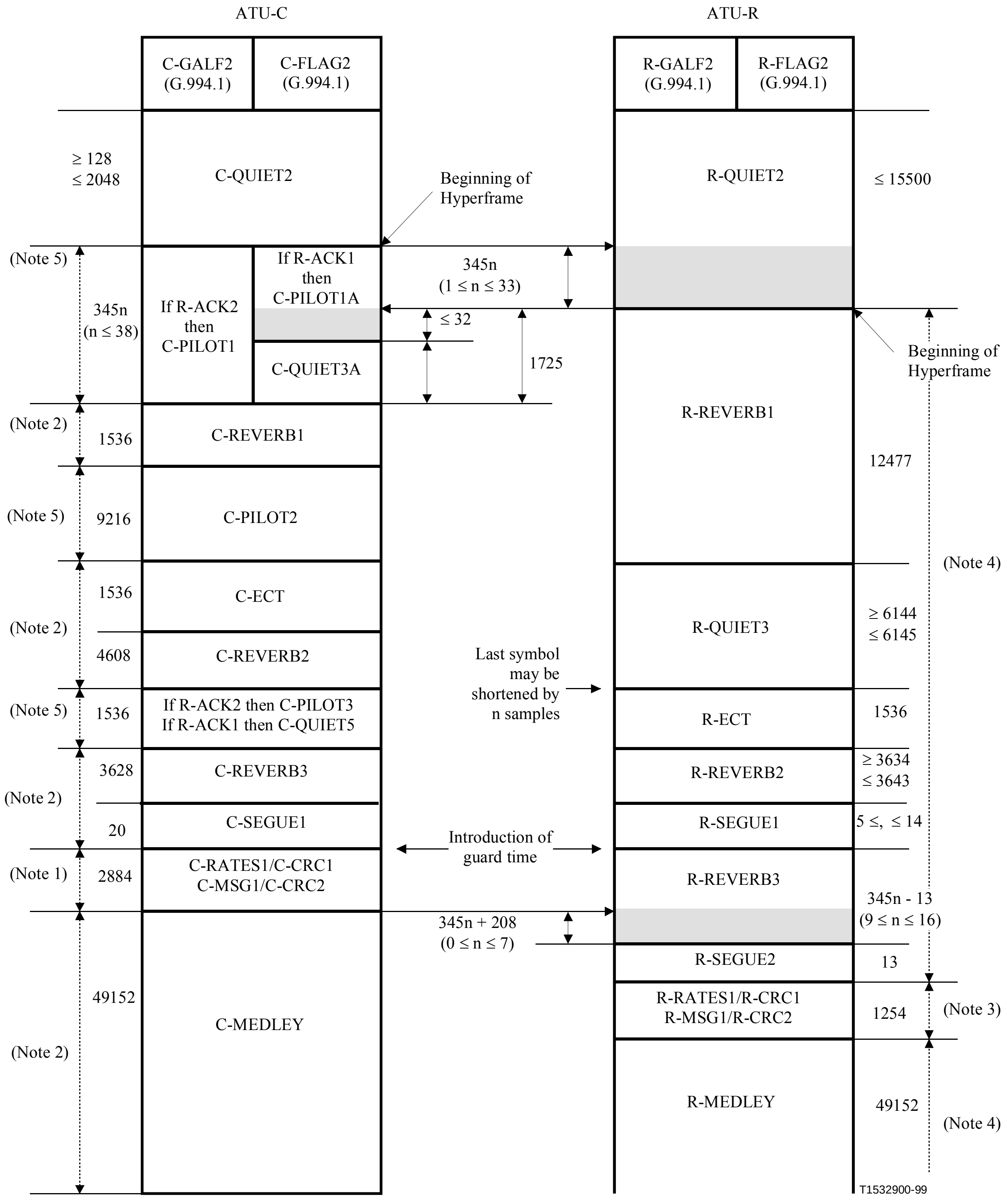
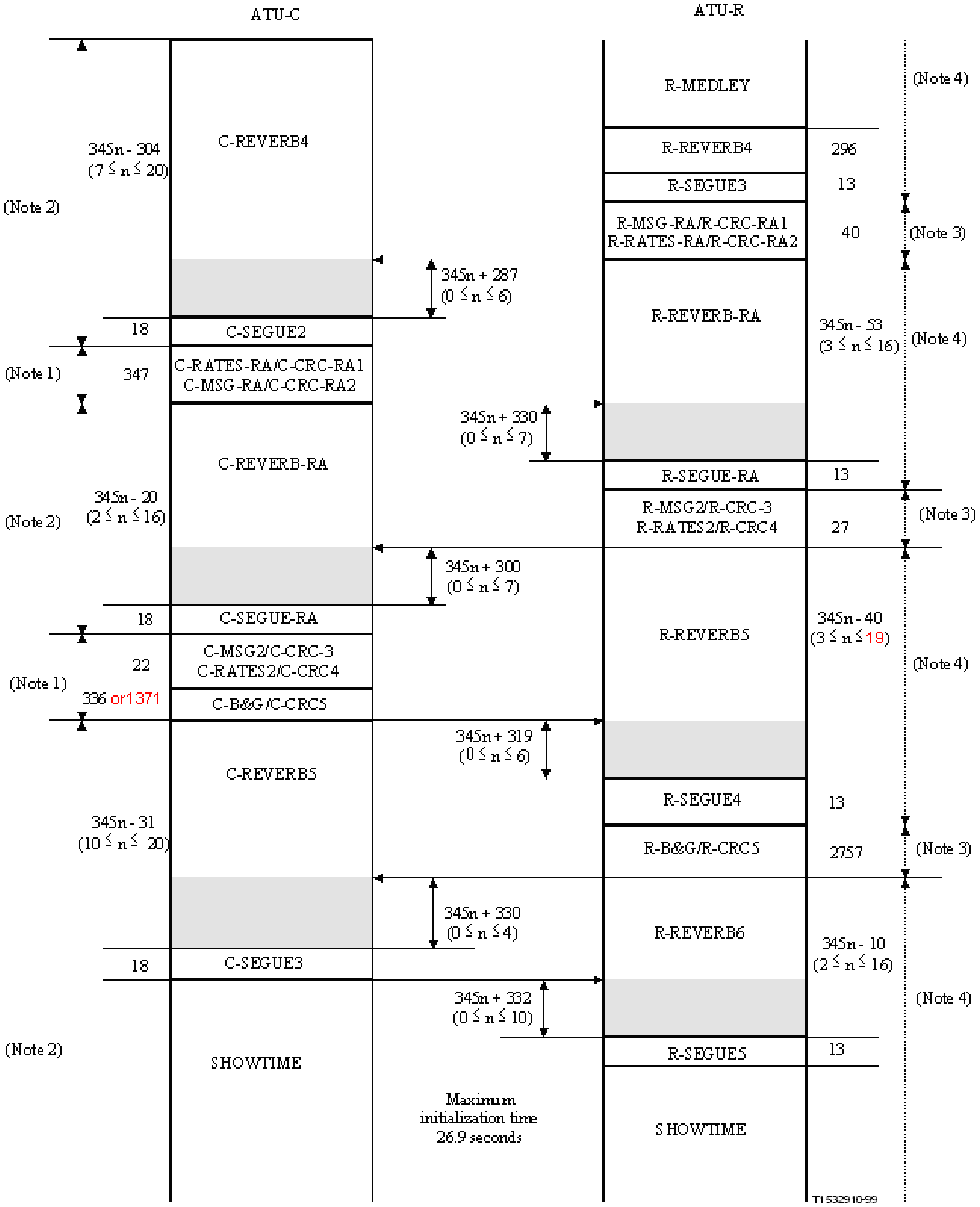


Figure C.21/G.992.1 – Timing diagram of the initialization sequence – Part 1



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.

Table C.8/G.992.1 – Format of the bit swap request message

Message header	Message field 1-4		
$\{11111111_2\}$ (8 bits)	Bitmap index (1 bit)	Command (7 bits)	Subchannel index (8 bits)

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.

Table C.9/G.992.1 – Bit swap request command

Value (8 bit)	Interpretation
$y0000000_2$	Do nothing
$y0000001_2$	Increase the number of allocated bits by one
$y0000010_2$	Decrease the number of allocated bits by one
$y0000011_2$	Increase the transmitted power by 1 dB
$y0000100_2$	Increase the transmitted power by 2 dB
$y0000101_2$	Increase the transmitted power by 3 dB
$y0000110_2$	Reduce the transmitted power by 1 dB
$y0000111_2$	Reduce the transmitted power by 2 dB
$y0001xxx_2$	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.	

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:

$$g_i' = (1/512) \times round(512 \times g_i \times 10 \exp(\Delta/20)) \qquad \text{(C.11-1)}$$

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.

Table C.10/G.992.1 – Format of the bit swap request message

Message header	Message field 1-6		
$\{11111100_2\}$ (8 bits)	Bitmap index (1 bit)	Command (7 bits)	Subchannel index (8 bits)

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.