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G.992.2

Amendment 1
(03/2003)

SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Digital sections and digital line system – Access networks

Splitterless asymmetric digital subscriber line (ADSL) transceivers

Amendment 1: Revised Annex C

ITU-T Recommendation G.992.2 (1999) – Amendment 1

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ITU-T Recommendation G.992.2

Splitterless asymmetric digital subscriber line (ADSL) transceivers

Amendment 1
Revised Annex C

Summary

This Amendment 1 to ITU-T Rec. G.992.2 revises Annex C for improved robustness and extended reach. It includes the changes introduced by G.992.2 (1999) Corrigendum 1 (07/2002).

Source

Amendment 1 to ITU-T Recommendation G.992.2 (1999) was prepared by ITU-T Study Group 15 (2001-2004) and approved under the WTSA Resolution 1 procedure on 16 March 2003.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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As of the date of approval of this Recommendation, ITU had received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

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ITU-T Recommendation G.992.2

Splitterless asymmetric digital subscriber line (ADSL) transceivers

Amendment 1

Revised Annex C

ADSL above POTS co-existing in the same binder as TCM-ISDN DSL

C.1 Scope

This annex describes those specifications that are unique to an ADSL system co-existing in the same binder as TCM-ISDN as defined in Appendix III/G.961. The subclauses in this annex provide the additions and modifications to the corresponding clauses in the main body. The modifications described in this annex provide a performance improvement over the Splitterless ADSL system specified in main body in an environment co-existing with TCM-ISDN. It is preferred that ADSL system implementing this annex also implements the main body.

This annex 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 C.4 as Profiles 1 to 6) offer improved robustness and extended reach compared to the previously defined operating modes.

NOTE – References to figures or tables of Appendix IV will be defined when Appendix IV is made available.

C.2 Definitions and abbreviations

C.2.1 Definitions

C.2.1.1 Dual Bitmap: The Dual Bitmap method has dual bit rates under the FEXT and NEXT noise from TCM-ISDN.

C.2.1.2 FEXT Bitmap: Similar to the Dual Bitmap method; however, transmission only occurs during FEXT noise from TCM-ISDN.

C.2.1.3 Hyperframe: Five Superframes structure which synchronized TTR.

C.2.1.4 Bitmap-F_R: ATU-C transmitter bitmap under TCM-ISDN FEXT noise generated at ATU-R.

C.2.1.5 Bitmap-N_R: ATU-C transmitter bitmap under TCM-ISDN NEXT noise generated at ATU-R.

C.2.1.6 Bitmap-F_C: ATU-R transmitter bitmap under TCM-ISDN FEXT noise generated at ATU-C.

C.2.1.7 Bitmap-N_C: ATU-R transmitter bitmap under TCM-ISDN NEXT noise generated at ATU-C.

C.2.1.8 $FEXT_R$ duration: TCM-ISDN FEXT duration at ATU-R estimated by the ATU-C.

C.2.1.9 **$NEXT_R$ duration**: TCM-ISDN NEXT duration at ATU-R estimated by the ATU-C.

C.2.1.10 **$FEXT_C$ duration**: TCM-ISDN FEXT duration at ATU-C estimated by the ATU-R.

C.2.1.11 **$NEXT_C$ duration**: TCM-SDN NEXT duration at ATU-C estimated by the ATU-R.

C.2.1.12 **$FEXT_R$ symbol**: DMT symbol transmitted by ATU-C during TCM-ISDN FEXT.

C.2.1.13 **$NEXT_R$ symbol**: DMT symbol transmitted by ATU-C during TCM-ISDN NEXT.

C.2.1.14 **$FEXT_C$ symbol**: DMT symbol transmitted by ATU-R during TCM-ISDN FEXT.

C.2.1.15 **$NEXT_C$ symbol**: DMT symbol transmitted by ATU-R during TCM-ISDN NEXT.

C.2.1.16 **N_{SWF}**: Sliding window frame counter.

C.2.2 Abbreviations

TTR TCM- ISDN Timing Reference

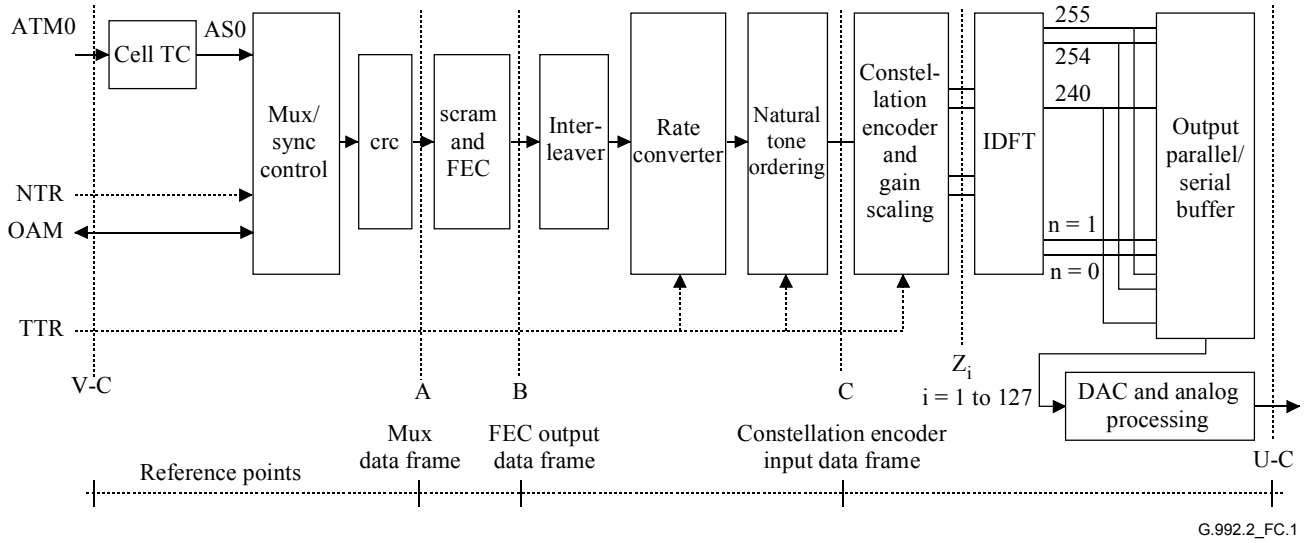
TTR_C Timing Reference used in ATU-C

TTR_R Timing Reference used in ATU-R

UI Unit Interval

C.3 Reference models

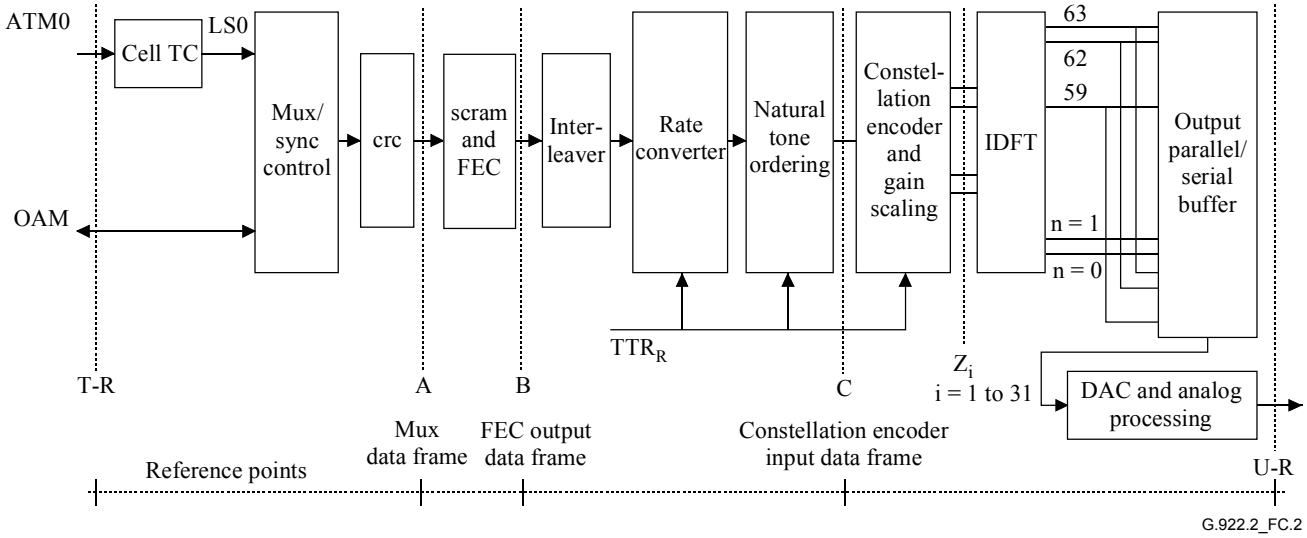
C.3.1 ATU-C transmitter reference model (replaces figure in 4.2)



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

Figure C.1/G.992.2 – ATU-C transmitter reference model for ATM transport

C.3.2 ATU-R transmitter reference model (replaces figure in 4.2)



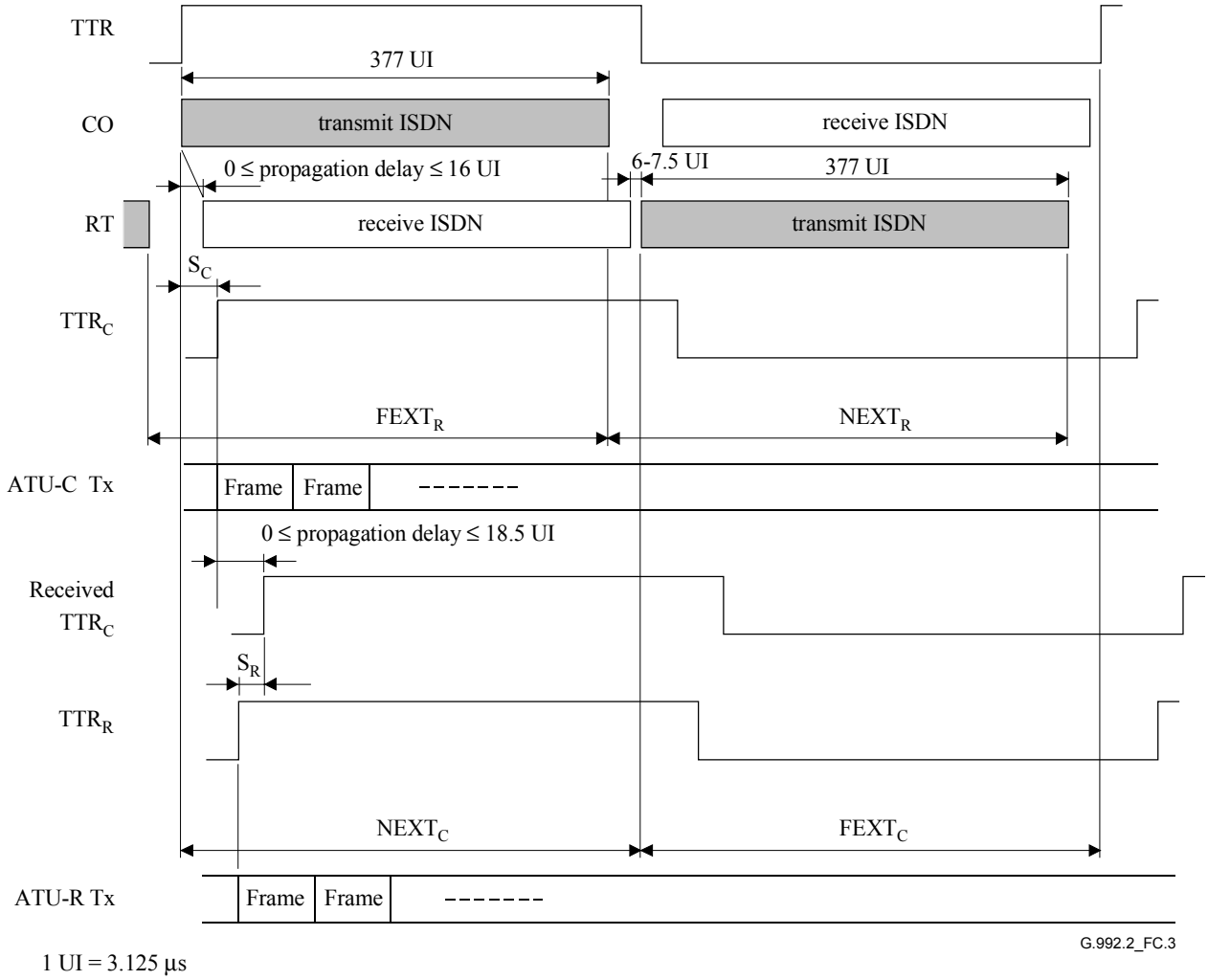
NOTE – The TTR_R shall be generated in the ATU-R from the received TTR_C, and shall be locked to 690 periods of upstream sampling clock (276 kHz).

Figure C.2/G.992.2 – ATU-R transmitter reference model for ATM transport

C.3.3 ATU transmitter timing model (new)

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

Figure C.3 shows the timing chart of the crosstalk from TCM-ISDN.



1 UI = 3.125 µs

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

$FEXT_C$ and $NEXT_C$ are estimated by the 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.3/G.992.2 – Timing chart of the TCM-ISDN cross-talk

The data stream of TCM-ISDN transmitted in a TTR period. The TCM-ISDN CO transmits the symbols in the first half of the TTR period and the TCM-ISDN RT transmits in the second half of the TTR period. The ATU-C receives NEXT noise from ISDN in the first half of the TTR period and FEXT noise from ISDN in the second half of the TTR period. On the other hand, the ATU-R receives FEXT noise from the TCM-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.6.2.2 and in C.9, the ATU-C shall estimate the $FEXT_R$ and $NEXT_R$ duration at ATU-R, and ATU-R shall estimate $FEXT_C$ and $NEXT_C$ duration at ATU-C taking propagation delay on the subscriber line into consideration.

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

C.3.3.2 Sliding Window (new)

Figure C.4 shows the timing chart of the downstream transmission.

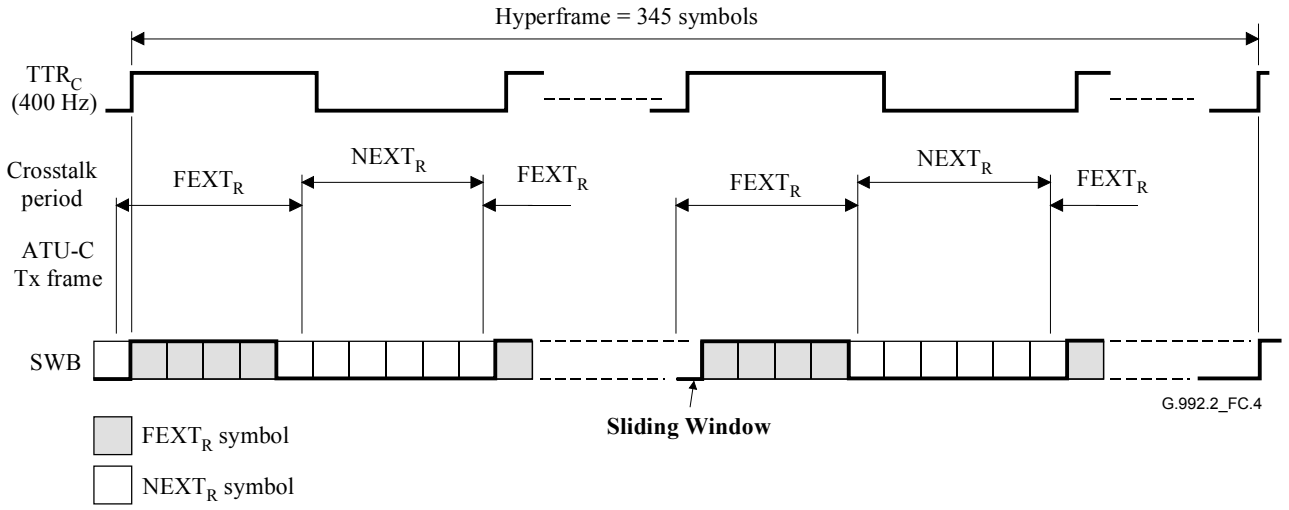


Figure C.4/G.992.2 – Sliding Window

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

The ATU-C decides which transmission symbol is a $FEXT_R$ or $NEXT_R$ symbol according to the Sliding Window and transmits it with the corresponding bit table. Similarly, ATU-R decides which 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 the $TTR_{C/R}$, the pattern is fixed to the 345 frames of the hyperframe (see C.6.2.2).

C.3.3.3 ATU-C symbol synchronization to TTR_C (new)

The time duration of 345 symbols is equal to 34 cycles of TTR_C (or 32 cycles of TTR_C for symbols without a 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~~transmission during $NEXT_{C/R}$~~ (see~~ Table 11-i/G.994.1~~ C.6.7)~~, In this case, the ATU-C shall transmit only the pilot tone as $NEXT_R$ symbol, and ATU-R shall transmit silence as the $NEXT_C$ symbol (see C.5.5 and C.5.7).~~

~~During FEXT Bitmap mode, the ATU-C shall transmit only the pilot tone as $NEXT_R$ symbol~~ 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 reference point U-R shall meet the phase tolerances as shown in Figure C.5.

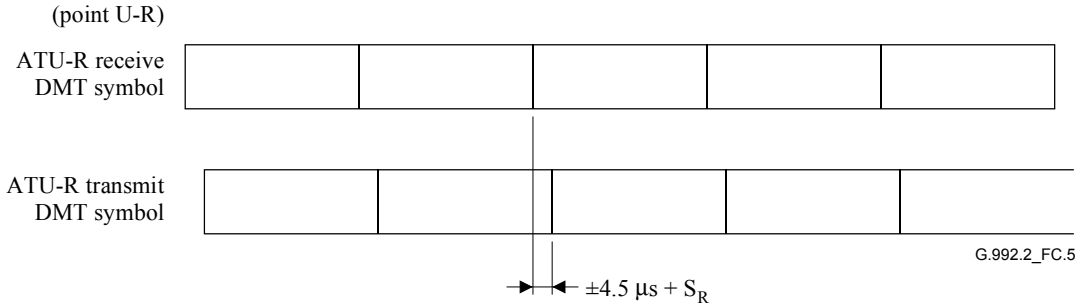


Figure C.5/G.992.2 – Loop timing for ATU-R

C.4~~x~~ 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 IV.3.

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 IV.1 and described in Table IV.1 in Appendix IV. An example of a downstream PSD mask for use with Bitmap-F_R is shown in Figure IV.2 and described in Table IV.2 in Appendix IV.

Profile 6

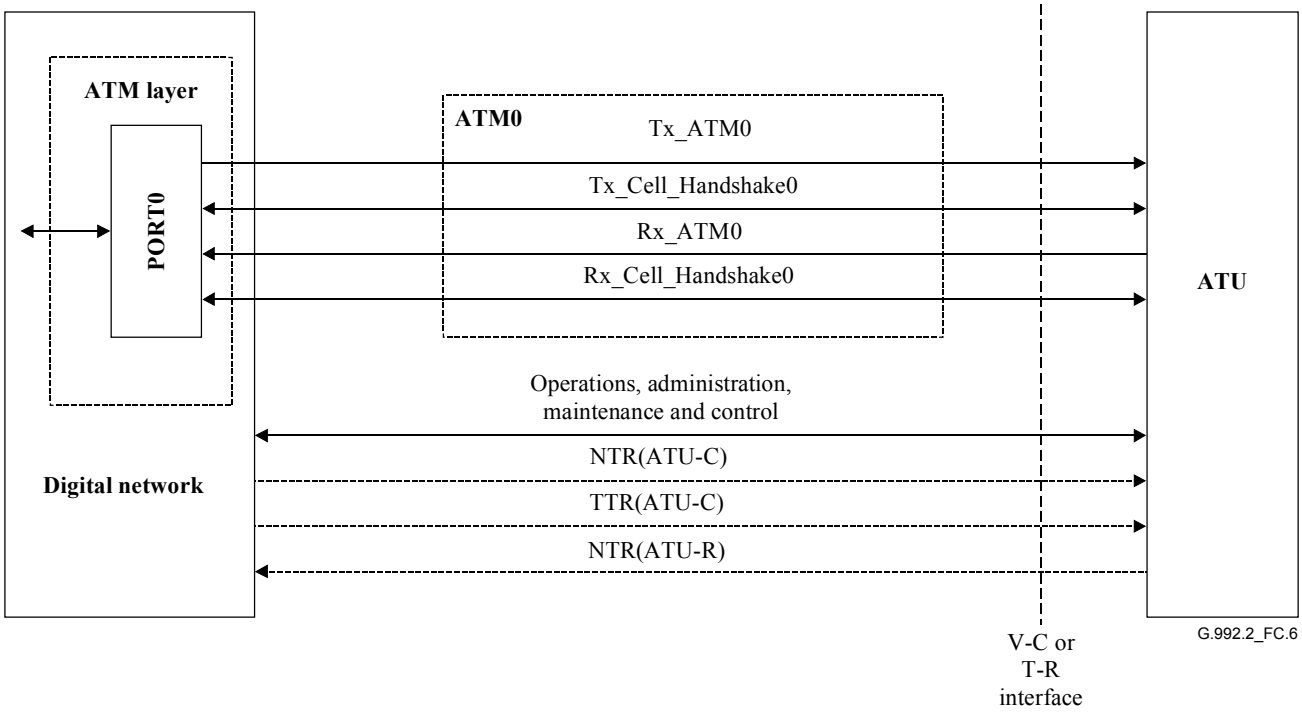
For Profile 6, upstream transmission uses both Bitmap-F_C and Bitmap-N_C, and downstream transmission uses both Bitmap-F_R and Bitmap-N_R. Non-overlapped spectrum is used with Bitmap-N_R, and overlapped spectrum is used with Bitmap-F_R. An example of a downstream PSD mask for use with Bitmap-N_R is shown in Figure IV.1 and described in Table IV.1 in Appendix IV. An example of a downstream PSD mask for use with Bitmap-F_R is shown in Figure IV.2 and described in Table IV.2 in Appendix IV.

Table 11.9.1/G.994.1 contains the code points to support these profiles.

C.45 ATU interfaces

C.54.1 ATM interface for ATM transport (replaces figure in 6.1)

The functional data interface at the ATU for ATM transport are shown in Figure C.6.



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

Figure C.6/G.992.2 – ATU functional interfaces to the ATM layer at the V or T reference point

C.65 ATU functional characteristics (pertains to clause 7)

C.65.1 Payload transfer delay (supplements 7.1.1)

The one-way transfer delay (excluding cell specific functionalities) for payload bits from the V reference point at the central office end (V-C) to the T reference point at remote the end (T-R) shall be as specified in 7.1.1 with an additional 5 ms for transfer delay attributed to the rate converter. The same requirement applies in the opposite direction, from the T-R reference point to the V-C reference point.

The maximum rate converter delay specified in the above text shall not apply to bit rates of 32 kbit/s and 64 kbit/s.

C.65.2 Framing (pertains to 7.3)

C.65.2.1 Superframe structure (supplements 7.3.3.1)

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 7.3.3.1.

C.65.2.2 Hyperframe structure (new)

This annex uses the hyperframe structure shown in Figures C.7 and C.8. Both figures show the phase relationship between the $TTR_{C/R}$ and the hyperframe at the point U-C and U-R. Each hyperframe is composed of five 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 N_{inv}-th superframe, which is generated from a tone-by-tone 180-degree phase reversal of the synchronization symbol (see C.65.3.1) except for the pilot tone. N_{inv}-th is defined as:

$$N_{inv}\text{-th} = \begin{cases} 3\ (\text{SPF\#3}) & \text{for downstream} \\ 0\ (\text{SPF\#0}) & \text{for upstream} \end{cases}$$

The FEC Output Frame from the interleaver is put into the rate-converter. The bit-level data stream from the rate-converter is extracted according to the size of Bitmap-$F_{R/C}$ and Bitmap-$N_{R/C}$ using the Sliding Window (see C.3.3.2 and C.3.3.4).

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.65.6). The hyperframe is composed of 345 DMT symbols, numbered from 0 to 344. Each symbol is assigned as a $FEXT_{R/C}$ or $NEXT_{R/C}$ symbol in a $FEXT_{R/C}$ or $NEXT_{R/C}$ duration (see C.3.3.1). The following numerical formula gives the information which duration N_{dmt}-th DMT symbol belongs to at ATU transmitter.

Downstream data (see Figure C.9):

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

Upstream data (see Figure C.10):

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

Thus, 128 DMT symbols are allocated in the $FEXT_{R/C}$ duration ($FEXT_{C/R}$ symbols), and 217 DMT symbols are allocated in the $NEXT_{R/C}$ duration ($NEXT_{C/R}$ symbols). The symbols are composed of:

$FEXT_{C/R}$ symbol:

– Number of symbols using Bitmap-$F_{R/C}$ = 126
– Number of synch symbols = 1
– Number of inverse synch symbols = 1

$NEXT_{C/R}$ symbol:

– Number of symbols using Bitmap-$N_{R/C}$ = 214

– Number of synch symbols = 3

For modems not using any of the profiles defined in C.4, and modems using Profile 1, during~~During~~ FEXT Bitmap mode, 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 remaining Profiles, i.e. Profiles 2, 4, 5, and 6 use the dual bit map technique.

During FEXT Bitmapping mode, ~~and~~ the ATU-R shall not transmit any signal as $NEXT_C$ symbol.

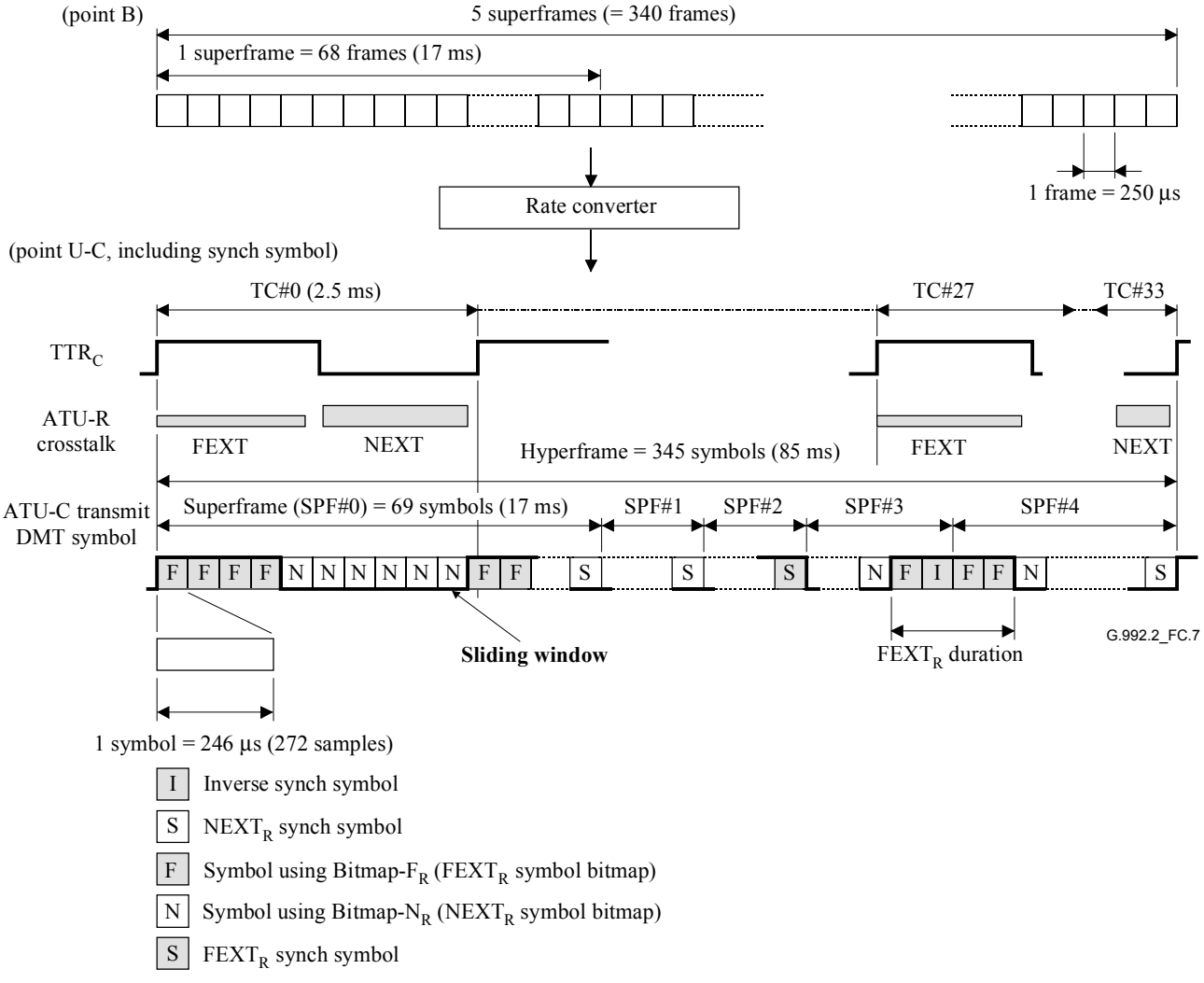


Figure C.7/G.992.2 – Hyperframe structure for downstream

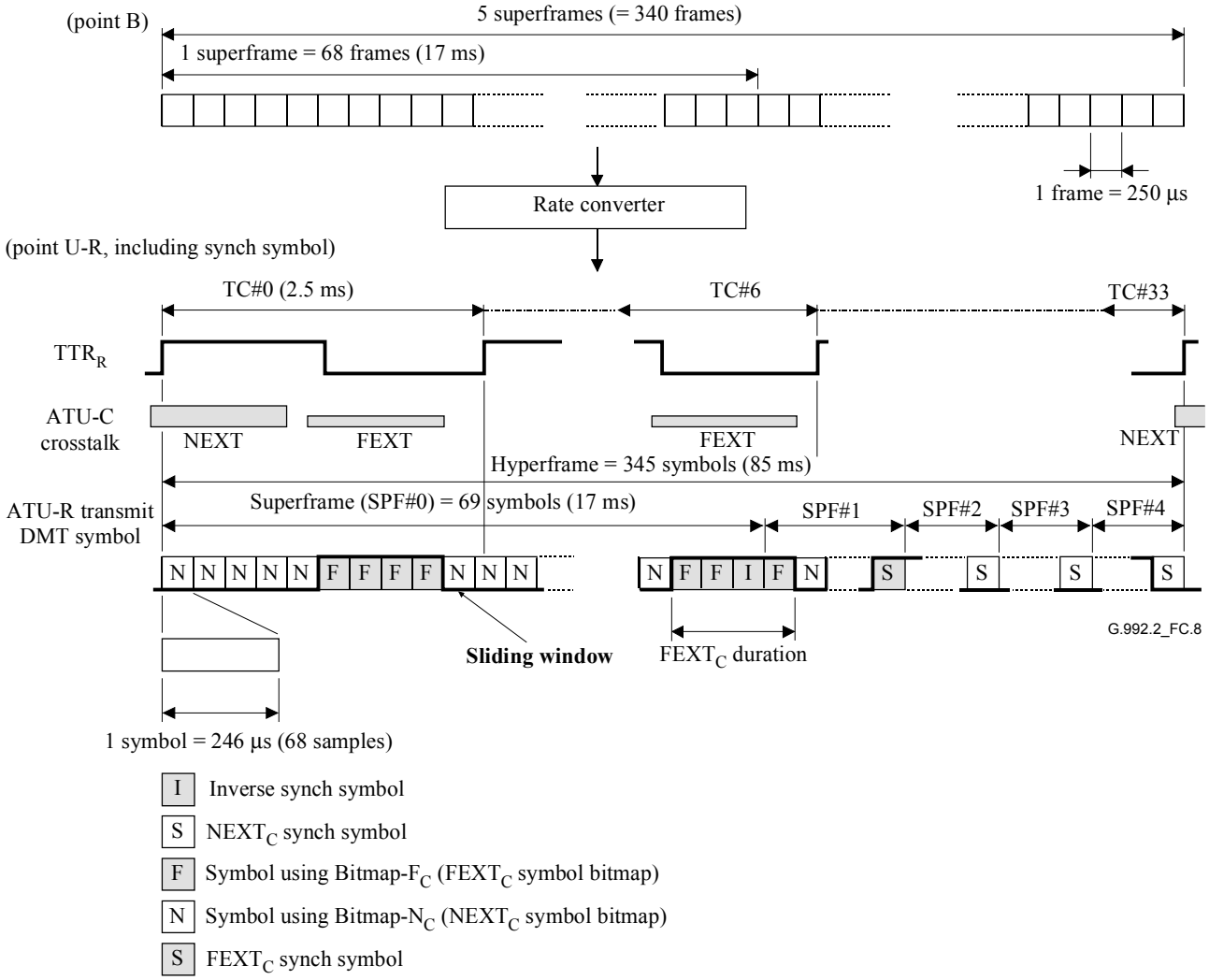


Figure C.8/G.992.2 – Hyperframe structure for upstream

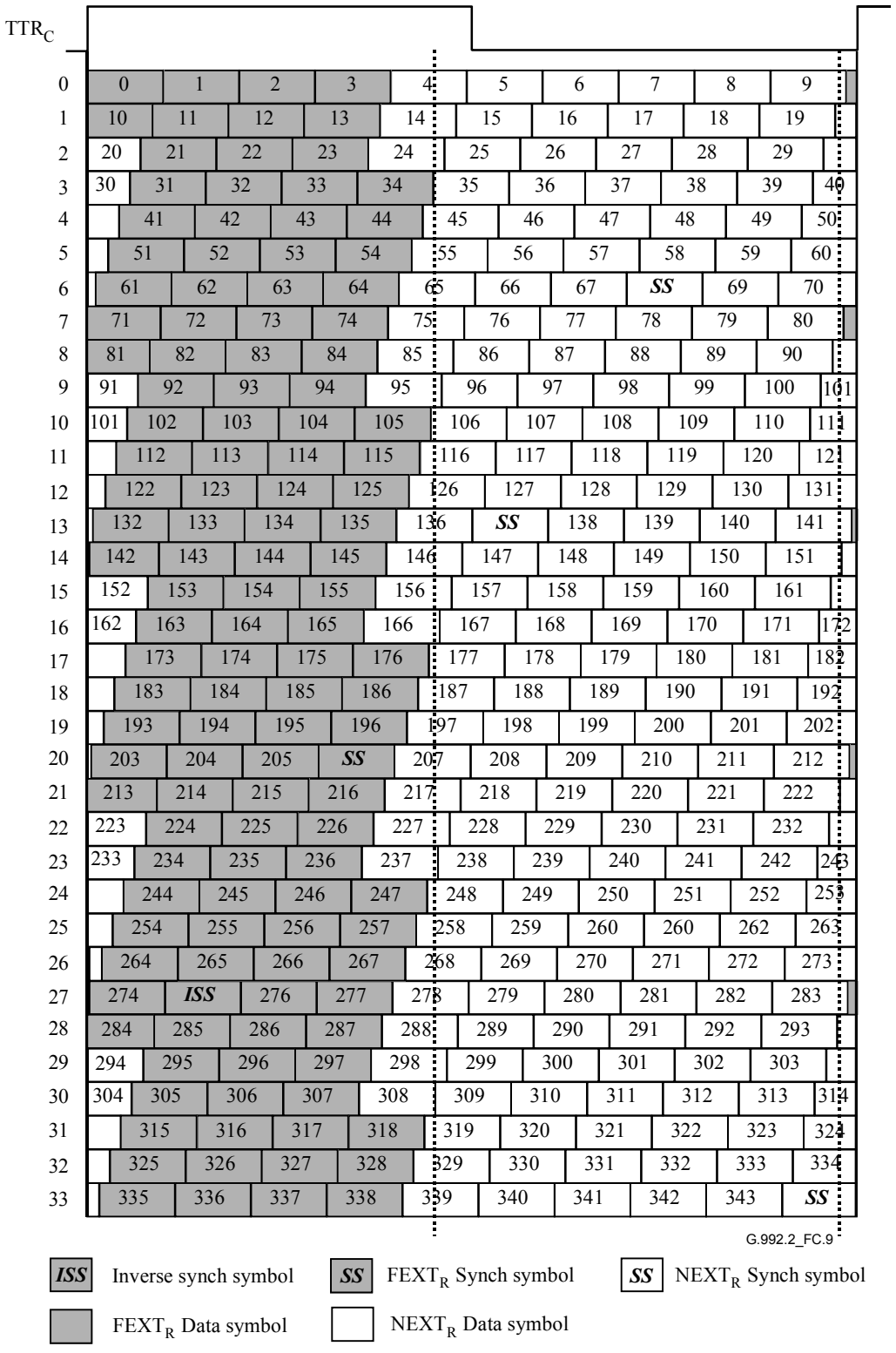


Figure C.9/G.992.2 – Symbol pattern in a hyperframe with cyclic prefix – Downstream

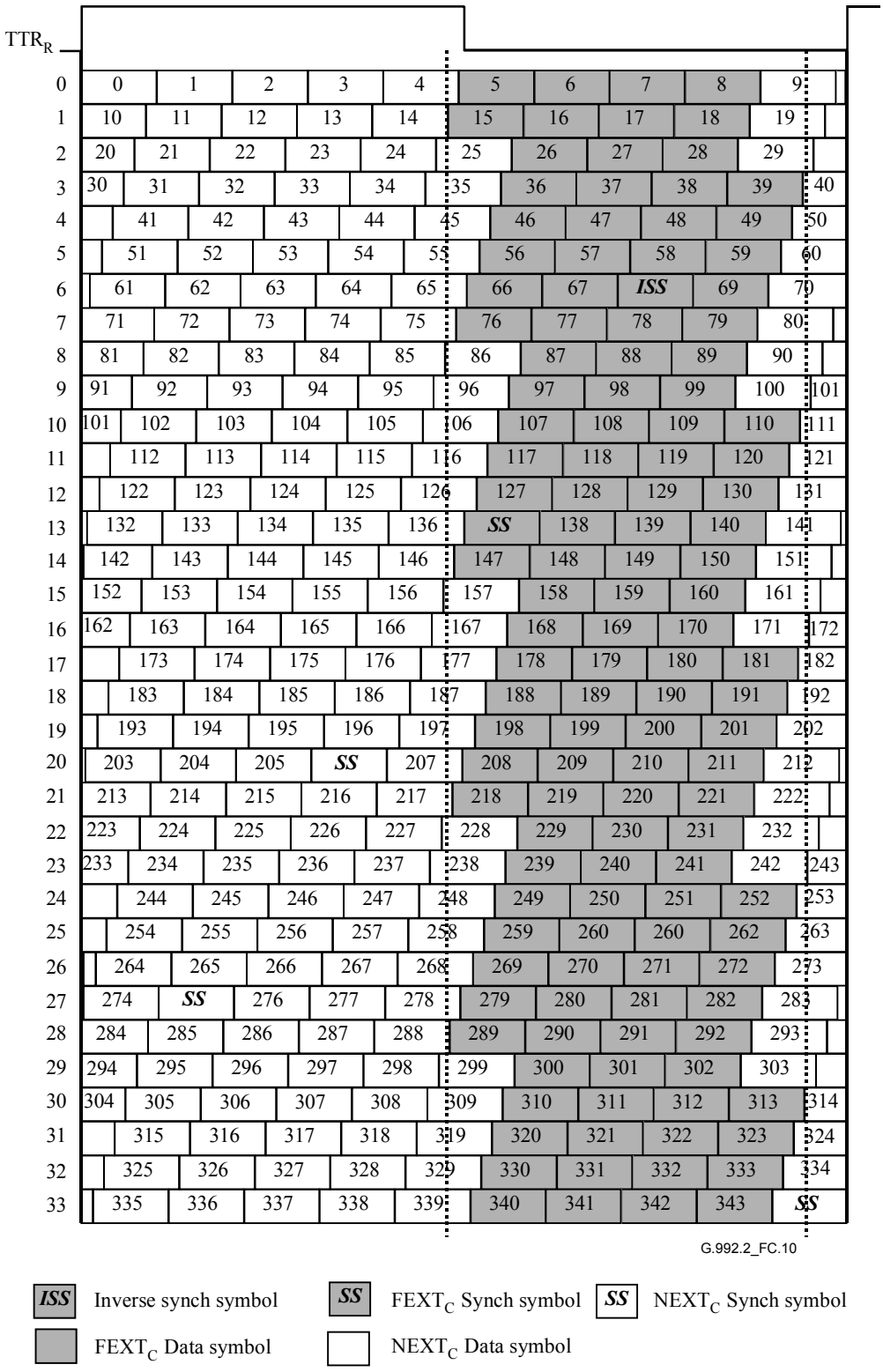


Figure C.10/G.992.2 – Symbol pattern in a hyperframe with cyclic prefix – Upstream

C.6~~5~~.3 Modulation (pertains to 7.10)

C.6~~5~~.3.1 Inverse Synchronization Symbol (new)

Except for the pilot tone, the 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.65.3.2 Gain scaling of synchronization symbol

At Initialization, the sync symbol reference transmit PSD level shall be set at the reference 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.65.3.3 Downstream Pilot subcarrier (supplements 7.10.1.2)

In the downstream direction, subcarrier $n_{C\text{-}PILOT1}$ ($f = n_{C\text{-}PILOT1} \times \Delta f$ kHz) shall be reserved for a pilot; that is $b(n_{C\text{-}PILOT1}) = 0$ and $g(n_{C\text{-}PILOT1}) = g_{sync}$.

C.65.3.4 Downstream data pattern (supplements 7.10.5)

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.

C.65.4 Transmitter spectral mask (replaces 7.12.3)

The spectral mask(s) of this annex shall fall within the~~use the same~~ masks ~~as~~ defined in Annex A or Annex B. For modems not using any of the profiles defined in C.4, when~~When~~ C-MSG1 bit 16 is 0_b, the PSD mask specified in Annex A shall be used. When C-MSG1 bit 16 is 1, the PSD mask specified in Annex B shall be used.

For modems complying with Profiles 1 and 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 or Annex B. Example PSD masks can be found in Appendix IV.

C.65.5 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, $\{b_i, g_i\}$. The dual bitmaps are switched synchronized with the sliding window pattern of NEXT/FEXT symbols.

C.65.6 Rate Converter (new)

The output of the interleaver is input to the rate converter. The rate converter buffering changes the data frame boundaries between the reference points B and C according to Bitmap-$F_{R/C}$, Bitmap-$N_{R/C}$ and the Sliding Window. However for the difference of the data rates between the reference points B and C, and to make the bit rate to be a multiple of 32 kbit/s, the dummy bits are inserted at the end of the hyperframe. The number of the dummy bits shall be:

$$\#\,dummy_R = (f_R \times 126 + n_R \times 214) - (t_R \times 340) \qquad \text{for downstream data}$$

$$\#dummy_C = (f_C \times 126 + n_C \times 214) - (t_C \times 340) \qquad \text{for upstream data}$$

where t_R is the number of allocated bits in one frame at the reference point B in ATU-C transmitter, f_R and n_R are the numbers of bits in Bitmap-F_R and Bitmap-N_R, respectively. Similarly, where t_C is the number of allocated bits in one frame at the reference point B in ATU-R transmitter, f_C and n_C are the numbers of bits in Bitmap-F_C and Bitmap-N_C, respectively. During FEXT Bitmap mode, n_R and n_C are zero.

At the receiver, the inserted dummy bits shall be removed.

The receiver shall determine Bitmap-$F_{R/C}$ and Bitmap-$N_{R/C}$ so that the number of dummy bits is less than 126 in initialization sequence.

C.65.7 FEXT Bitmap (new)

The FEXT Bitmap mode uses the Dual Bitmap technique (see C.65.5) 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 Bitmap mode upstream and downstream independently.

For modems not using any of the profiles defined in C.4 and modems using Profile 1,~~When Bitmap-N_R and Bitmap-N_C are disabled (see Table 11-i/G.994.1),~~ 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.

~~and t~~The ATU-R disables Bitmap-N_C and shall not transmit any signal as $NEXT_C$ symbol (see Figures C.7 and C.8).

For modems not using any of the profiles defined in C.4, the~~The~~ Dual versus FEXT bit mapping mode is selected during G.994.1 using bit "DBM" (see 11.2 and 11.3). For modems using any of the profiles defined in C.4, the bitmap mode is selected during G.994.1.

C.76 aoc on-line adaptation and reconfiguration (pertains to clause 9)

C.76.1 Bit swap request message encoding (replaces 9.2.4)

This message tells the transmitter which subcarriers are to be modified. The format of the request is shown in Table C.1.

Table C.1/G.992.2 – Format of the bit swap request message

Message header	Message field 1-4		
{11111111_b} (8 bits)	Bitmap index (1 bit)	Command (7 bits)	Subcarrier index (8 bits)

The request shall comprise nine bytes as follows:

- An aoc message header consisting of eight binary ones.
- Message fields 1-4, each of which each consists of a one-bit bitmap index, a seven-bit command followed by a related eight-bit subcarrier index. One-bit bitmap index and valid seven-bit commands for the bit swap message shall be as shown in Table C.2. In Table C.2, the MSB for the bit swap request command represents the bitmap index. In the Bitmap index, 0 indicates Bitmap F_R, and 1_b indicates N_R for downstream data. Similarly, 0 indicates Bitmap F_C and 1_b indicates N_C for upstream data. The eight-bit subcarrier 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.2/G.992.2 – Bit swap request command

Value (8 bit)	Interpretation
y0000000_b	Do nothing
y0000001_b	Increase the number of allocated bits by one
y0000010_b	Decrease the number of allocated bits by one
y0000011_b	Increase the transmitted power by 1 dB
y0000100_b	Increase the transmitted power by 2 dB
y0000101_b	Increase the transmitted power by 3 dB
y0000110_b	Reduce the transmitted power by 1 dB

$y0000111_b$	Reduce the transmitted power by 2 dB
$y0001xxx_b$	Reserved for vendor discretionary commands
NOTE – y is "0_b" for $FEXT_{C/R}$ symbols, and "1_b" for $NEXT_{C/R}$ symbols of the Sliding Window.	

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:

$$g_i' = (1/512) \times \text{round}(512 \times g_i \times 10 \exp(\Delta/20))$$

C.76.2 Extended bit swap request message encoding (supplements 9.2.5)

The format of the extended bit swap request is shown in Table C.3.

Table C.3/G.992.2 – Format of the bit swap request message

Message header	Message field 1-6		
$\{11111100_b\}$ (8 bits)	Bitmap index (1 bit)	Command (7 bits)	Subcarrier 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 a one-bit bitmap index, a seven-bit command followed by a related eight-bit subcarrier index.

C.76.3 Bit swap acknowledge message encoding (supplements 9.2.6)

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.

C.87 In-service performance monitoring and surveillance (pertains to clause 10)

C.87.1 ADSL line related primitives (pertains to 10.1)

C.87.1.1 ADSL line related near-end defects (supplements 10.1.3)

Two near-end defects are defined:

- *Loss of signal (LOS)*: 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. A 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.87.1.2 ADSL line related far-end defects (supplements 10.1.4)

- *Far-end 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.87.2 Test parameters (supplements 10.4)

C.87.2.1 Near-end test parameters (supplements 10.4.1)

The following near-end test parameters are 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 the 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.87.2.2 Far-end test parameters (supplements 10.4.2)

The following far-end test parameters are 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 the 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.98 Initialization

C.98.1 Initialization with Hyperframe (new)

The exchange of messages between ATU-C and ATU-R are performed using $FEXT_C$ and $FEXT_R$ symbols. The initialization sequence has two symbol rates. One is 4.3125 kbaud for the symbol without a cyclic prefix, and the other is $4 \times 69/68$ kbaud for the symbol with a cyclic prefix. 32 TTR cycles have the same period as 345 times 4.3125 kHz DMT symbols, and 34 TTR cycles have the same period as 345 times $4 \times 69/68$ kHz DMT symbols.

During FEXT Bitmap mode, the ATU-R shall not transmit any signal as the $NEXT_C$ symbols. For modems not using any of the profiles defined in C.4 and modems using Profile 1, ~~and~~ the ATU-C shall only transmit the pilot tone as the $NEXT_R$ symbols except:

- C-PILOT1 (C-PILOT1A): accompanied by a signal to allow the ATU-C to indicate the phase of TTR_C to the ATU-R ~~A_{48} signal~~ (see C.98.3.1);
- C-QUIETn: not transmit any signal.

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 shall enter C-PILOT1 at the beginning of the hyperframe. The ATU-C transmits information regarding the phase of the TTR_C to ATU-R during C-PILOT1. The ATU-R shall enter R-REVERB1 at the beginning of the hyperframe without cyclic prefix.

From C-PILOT1 to C-SEGUE1, the following numerical formula gives the information which duration N_{dmt}-th DMT symbol belongs to (see Figure C.11):

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

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

if { (S + 255 < a) or (S > a + b) } then $FEXT_R$ symbol
else then $NEXT_R$ symbol

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 DMT symbol belongs to (see Figure C.12):

For $S = 256 \times N_{dmt} \bmod 2760$ ($N_{dmt} = 0, 1, ..., 344$)

if { (S > a) and (S + 255 < a + b) }	then $FEXT_C$ symbol
else	then $NEXT_C$ symbol

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.9).

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

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.10).

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

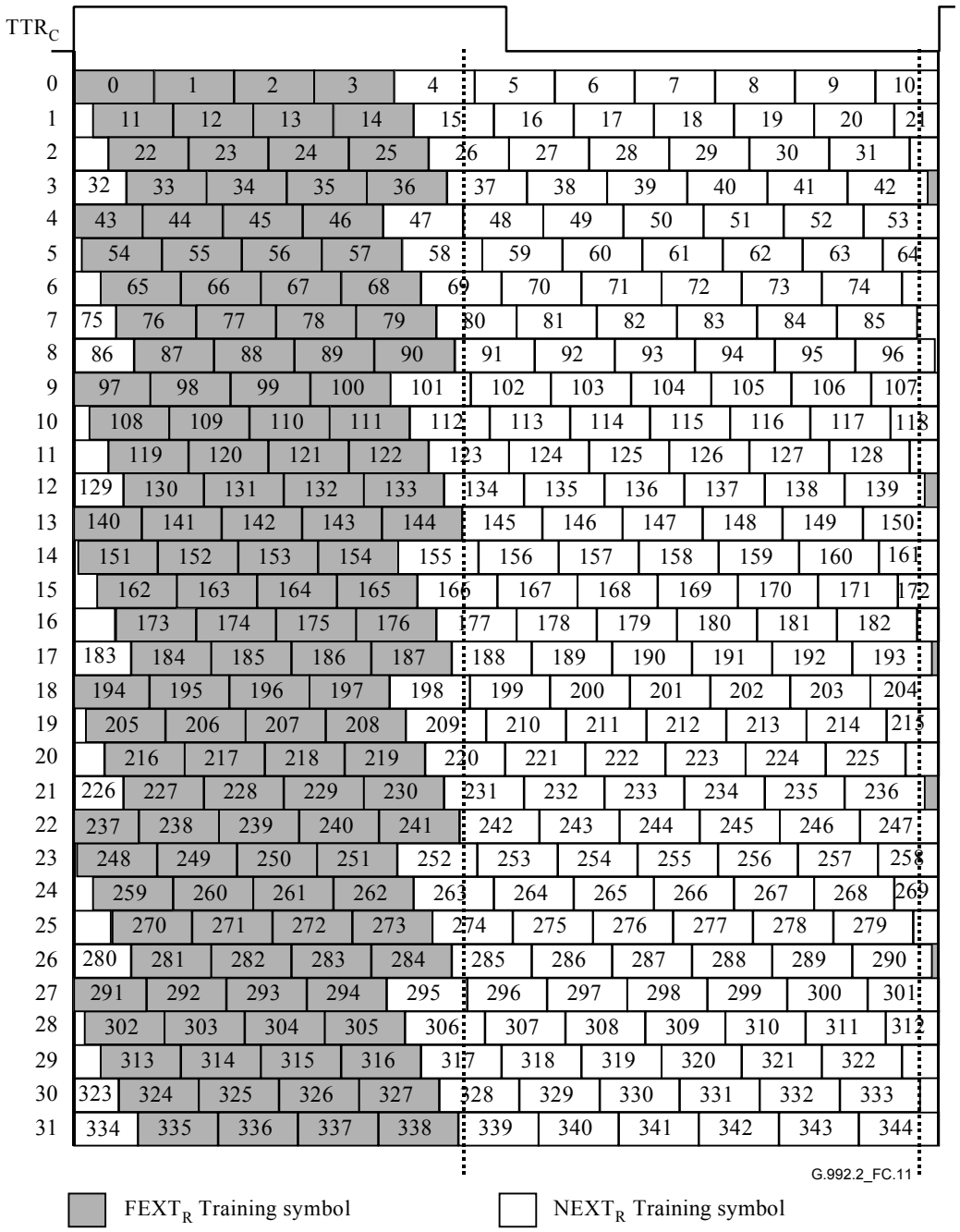


Figure C.11/G.992.2 – Symbol pattern in a hyperframe without cyclic prefix – Downstream

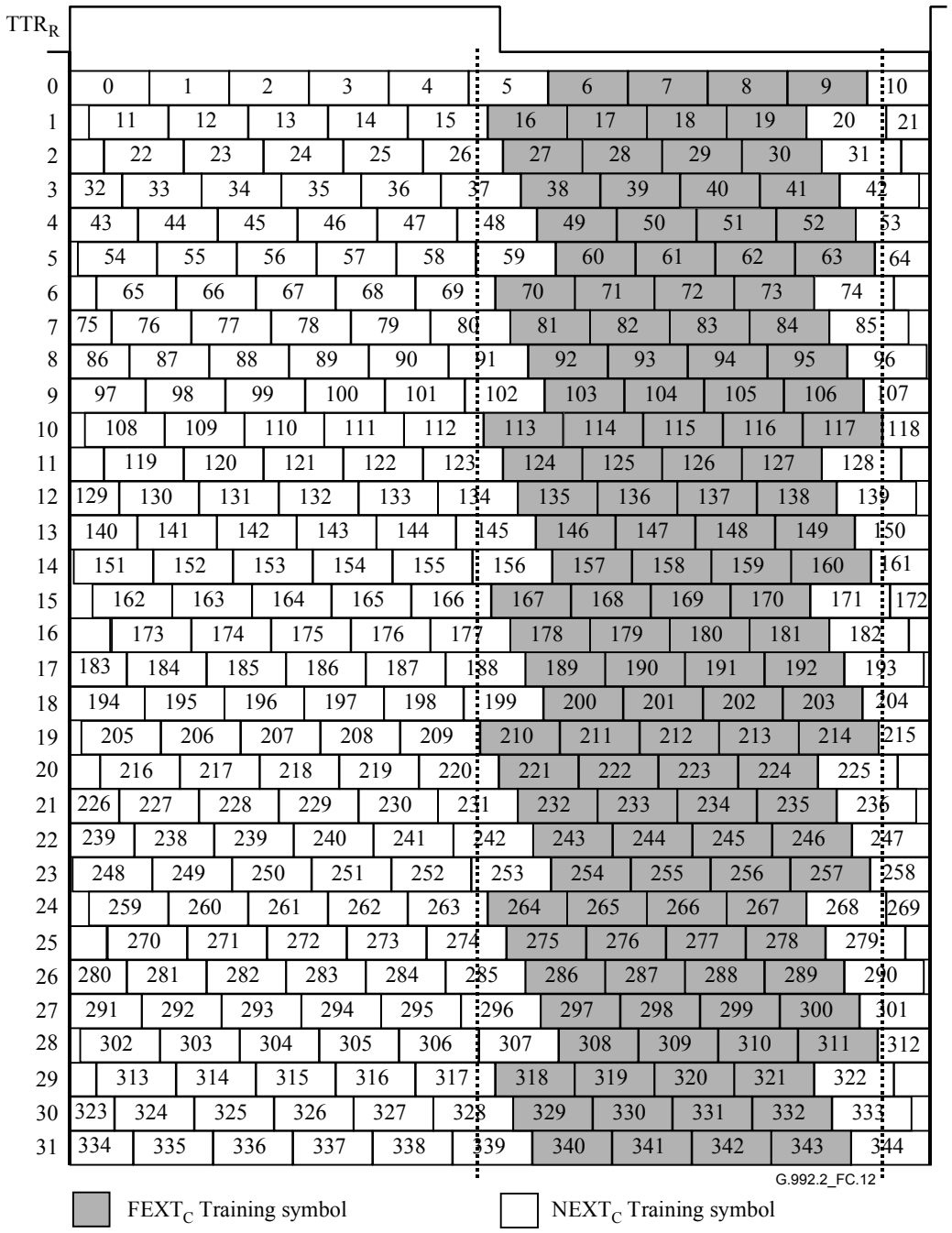


Figure C.12/G.992.2 – Symbol pattern in a hyperframe without cyclic prefix – Upstream

C.9.28.~~x~~ Handshake – ATU-C (supplements 11.2)

From C-SILENT1, the ATU-C may transition to either C-TONES or C-SYNC under instruction of the network operator.

C.9.28.x.1CL messages (supplements 11.2)

Table C.4/G.992.1 – ATU-C CL message bit definitions for Annex C

NPar(2) bit	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.992.2 Annex C) (Note).
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.
SPar(2) bit	**Definition**
C-PILOT	If set to ONE, this bit shall indicate that the ATU-C supports negotiation of the optional pilot tones and TTR indication signals. This bit shall be set to ONE to indicate support for any of the profiles defined in C.4.
NPar(3) bit	**Definition**
$n_{C\text{-}PILOT1}$=64	If the C-PILOT bit is set to ONE, this 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	If the C-PILOT bit is set to ONE, this 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	If the C-PILOT bit is set to ONE, this 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	If the C-PILOT bit is set to ONE, this bit shall also be set to ONE, indicating that the ATU-C supports transmission of pilot tone on subcarrier 16.
A_{48} / B_{48}	If the C-PILOT bit is set to ONE, this 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}	If the C-PILOT bit is set to ONE, this 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	If the C-PILOT bit is set to ONE, this bit shall also be set to ONE, indicating that the ATU-C supports transmission of TTR indication signal C-REVERB33-63.
C-REVERB6-31	If the C-PILOT bit is set to ONE, this bit shall also be set to ONE, indicating that the ATU-C supports transmission of TTR indication signal C-REVERB6-31.
NOTE – The DBM bit is only used to maintain backward compatibility with G.992.2 Annex C 1999. If any of the profile bits (Table 11.9.1/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.	

C.9.2~~8.x~~.2 MS messages (supplements 11.2)

Table C.5/G.992.1 – ATU-C MS message bit definitions for Annex C

NPar(2) bit	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.992.2 Annex C) (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.
SPar(2) bit	**Definition**
C-PILOT	If set to ONE, this bit shall indicate that the ATU-C wishes to select a pilot tone and TTR indication signal. This bit shall be set to ONE to select one of the profiles defined in C.4
NPar(3) bit	**Definition**
$n_{C\text{-}PILOT1}$=64	If set to ONE, this 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 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 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 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 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 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 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 bit shall indicate that the ATU-C is selecting TTR indication signal C-REVERB6-31 (Note 2).
NOTE 1 – The DBM bit is only used to maintain backward compatibility with G.992.2 Annex C 1999. 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.9.3~~8.y~~ Handshake – ATU-R (supplements 11.3)

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-SYNC state.

C.9.38.y.1 CLR messages (supplements 11.3)

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

NPar(2) bit	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.
SPar(2) bit	**Definition**
C-PILOT	If set to ONE, this bit shall indicate that the ATU-R supports negotiation of the optional pilot tones and TTR indication signals. This bit shall be set to ONE to indicate support for any of the profiles defined in C.4.
NPar(3) bit	**Definition**
$n_{C\text{-}PILOT1}$=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).
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).
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.
NOTE – A_{48} and A_{24} shall not be used for Profile 3.	

C.9.38.y.2 MS messages (supplements 11.3)

Table C.7/G.992.1 – ATU-R MS message NPar(2) bit definitions for Annex C

NPar(2) bit	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.992.2 Annex C) (Note).
NOTE – The DBM bit is only used to maintain backward compatibility with G.992.2 Annex C 1999.	

C.9.38.y.3 MP messages (new)

Table C.8/G.992.1 – ATU-R MP message bit definitions for Annex C

NPar(2) bit	Definition
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.
SPar(2) bit	**Definition**
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.4.
NPar(3) bit	**Definition**
$n_{C\text{-}PILOT1}$=64	If set to ONE, this 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 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 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 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 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 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 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 bit shall indicate that the ATU-R is proposing the use of TTR indication signal C-REVERB6-31 (Note 2).
NOTE 1 – The DBM bit is only used to maintain backward compatibility with G.992.2 Annex C 1999. 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.9.48.2 Escape from Handshake to Fast Retrain (replaces 11.5)

See Figure C.13.

C.9.48.2.1 C-QUIET-EF1 (replaces 11.5.1)

C-QUIET-EF1 begins at the termination of G.994.1. The minimum duration of C-QUIET-EF1 is 128 symbols. The maximum duration of C-QUIET-EF1 is 2048 symbols. The ATU-C terminates C-QUIET-EF1 and enters C-RECOV at the beginning of the hyperframe.

C.9.48.2.2 R-QUIET-EF1 (replaces 11.5.2)

R-QUIET-EF1 begins at the termination of G.994.1. The minimum duration of R-QUIET-EF1 is 128 DMT symbols after the detection of C-RECOV. The ATU-R shall progress to R-RECOV only after it has detected any part of the C-RECOV signal that is needed for reliable detection. The ATU-R enters R-RECOV2 synchronized with the hyperframe after the synchronization of ADC clock with the received C-RECOV signal.

Time-outs C-TO2, R-TO1, R-TO3 are vendor discretionary. It is advisable to make these duration as short as possible.

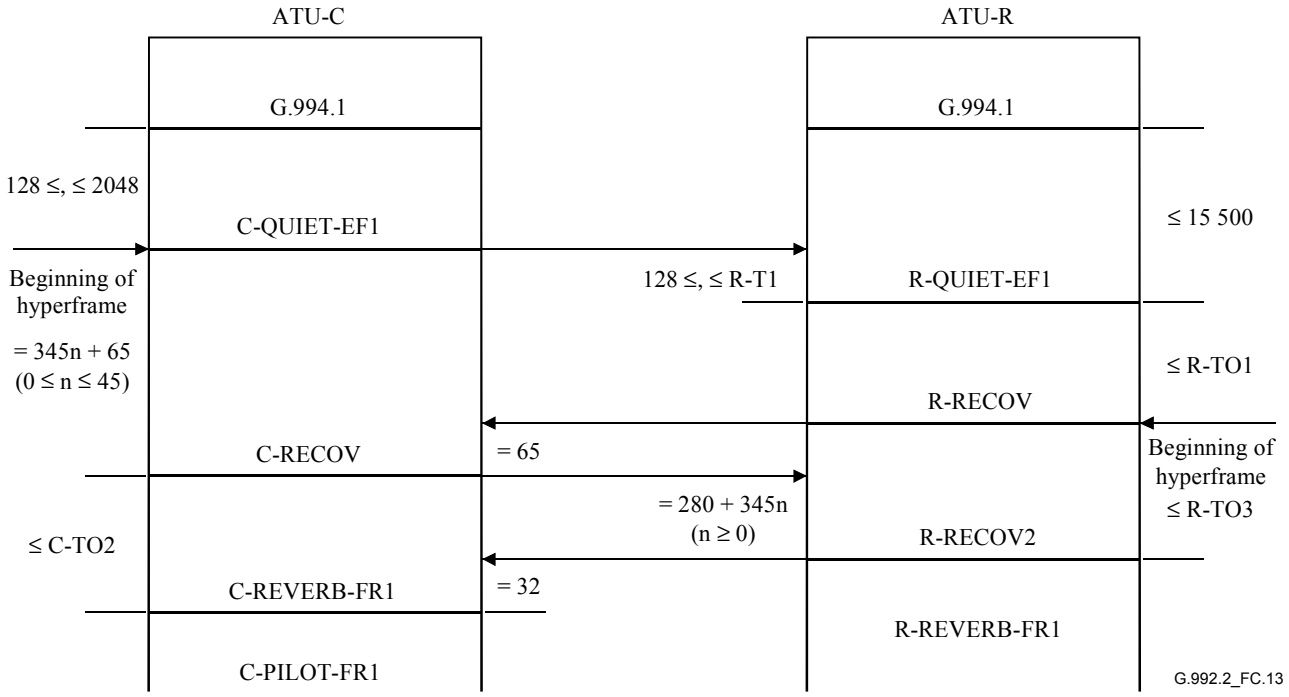


Figure C.13/G.992.2 – Timing diagram of Escape to Fast Retrain

C.9.58.3 Transceiver training – ATU-C (supplements 11.7)

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~~. For modems not using any of the profiles defined in C.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.18.

C.9.58.3.1 C-PILOT1 (supplements 11.7.2)

The ATU-C shall start its N_{SWF} counter immediately after entering C-PILOT1, and then increment the N_{SWF} counter with modulo 345 from 0 when it transmits 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 (see Figures C.11 and C.9).

C-PILOT1 has two ~~subcarriers~~signals.

~~One~~ The first signal is the pilot tone as a single frequency sinusoid ~~at 276 kHz (see 11.7.2)~~.

For Profiles 1 and 2, the frequency of the pilot tone shall be selected from one of the following choices:

1) $f_{\text{C-PILOT1}}$ = 276 kHz ($n_{\text{C-PILOT1}}$ = 64);

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

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

1) $f_{\text{C-PILOT1}}$ = 276 kHz ($n_{\text{C-PILOT1}}$ = 64);

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

3) $f_{\text{C-PILOT1}}$ = 138 kHz ($n_{\text{C-PILOT1}}$ = 32);

4) $f_{\text{C-PILOT1}}$ = 69 kHz ($n_{\text{C-PILOT1}}$ = 16).

For modems not using any of the profiles defined in C.4, the frequency of the pilot tone shall be:

$f_{\text{C-PILOT1}}$ = 276 kHz ($n_{\text{C-PILOT1}}$ = 64)

Transmitters that use any of the profiles defined in C.4 shall support all of these pilot tones. For backwards compatibility, receivers shall support $n_{\text{C-PILOT1}}$ = 64. Support of the other pilot tones by a receiver is optional. The pilot tone shall be selected during G.994.1.

~~A second carrier (A_{48}: 48-th carrier)~~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 ~~the A_{48}~~this signal.

For Profiles 1 and 2, the TTR indication signal shall be selected from one of the following choices:

1) A_{48} signal – ~~The~~ the constellation encoding of the 48-th carrier with 2-bit constellation ~~shall be~~ as the follows:

   (+ , +)~~;~~ to indicate~~s~~ a FEXT_R symbol;

   (+ , –)~~;~~ to indicate~~s~~ 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.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.

Transmitters that use any of the profiles defined in C.4 shall support all of these TTR indication signals. 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.9.5~~8.3~~.2 C-PILOT1A (supplements 11.7.3)

C-PILOT1A has two ~~subcarriers~~ signals and it is the same transmitted signal as C-PILOT1 (see C.9~~8~~.3.1).

C.9.5~~8.3~~.3 C-REVERB3 (supplements 11.7.11)

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 ATU-R, the first symbol of C-SEGUE1 shall be transmitted inside of the $FEXT_R$ duration. Therefore, the duration of C-REVERB3 is 3628 DMT symbols (see Figure C.14).

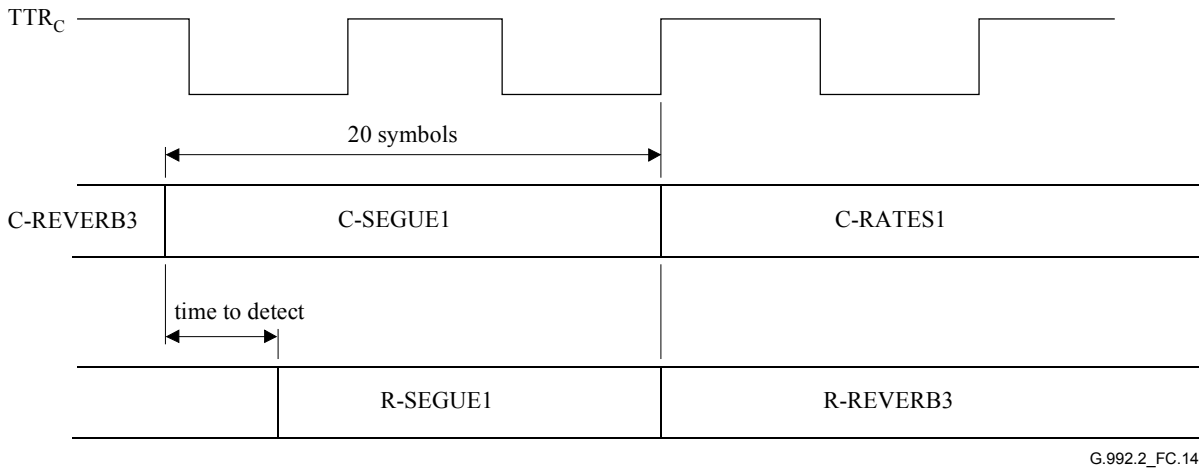


Figure C.14/G.992.2 – Timing diagram of C-SEGUE1 to C-RATES1

C.9.5~~8.3~~.4 C-REVERB1 (supplements 11.7.5)

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.

C.9.6~~8.4~~ Transceiver training – ATU-R (supplements 11.8)

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 in Figure C.18.

C.9.6~~8.4~~.1 R-QUIET2 (supplements 11.8.1)

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

C.9.6~~8.4~~.2 R-REVERB1 (supplements 11.8.2)

The ATU-R shall start its N_{SWF} counter immediately after entering R-REVERB1, and then increment the N_{SWF} counter 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.9.6~~8.4~~.3 R-QUIET3 (replaces 11.8.3)

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.9.6~~8.4~~.4 R-REVERB2 (supplements 11.8.5)

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

C.9.7~~8.5~~ Channel analysis (ATU-C) (supplements 11.9)

The ATU-C shall transmit the $FEXT_R$ symbols~~, and shall not transmit the $NEXT_R$ symbols except the pilot tone from C-RATES1 to C-CRC2.~~ For modems not using any of the profiles defined in C.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. In C-MEDLEY, 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.4 and modems using Profile 1, the ATU-C shall not transmit $NEXT_R$ 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.18.

C.9.7~~8.5~~.1C-SEGUE1 (supplements 11.9.1)

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 (see Figure C.14).

C.9.7~~8.5~~.2C-MEDLEY (supplements 11.9.6)

The definition of C-MEDLEY is the same as in 11.9.6, except for the duration of the SNR estimation at ATU-R for the downstream. With the periodical noise of TCM- ISDN, the SNR also changes in the same cycle, as shown in Figure C.15. When Bitmap-N_R is enabled, ATU-C transmits the signal in both of $FEXT_R$ and $NEXT_R$ symbols and ATU-R estimates two SNRs from the received $NEXT_R$ and $FEXT_R$ symbols, respectively, as defined in Figure C.16.

The following numerical formula gives the information that received N_{dmt}-th DMT symbol at ATU-R 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), 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.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 $FEXT_R$.

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.

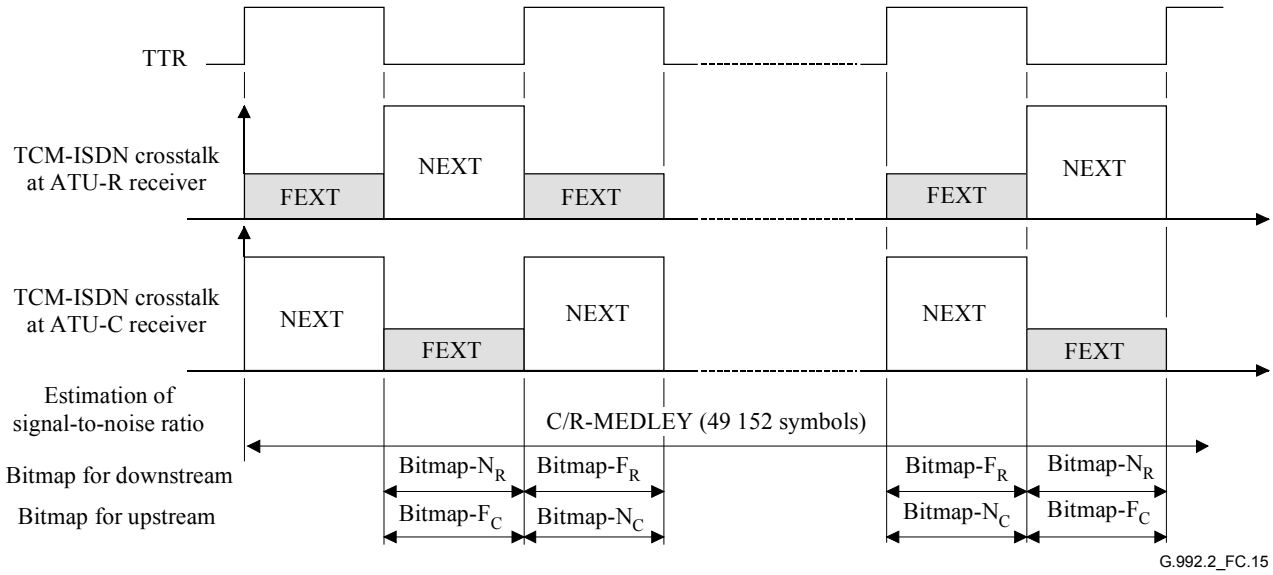


Figure C.15/G.992.2 – Estimation of periodic Signal-to-Noise Ratio

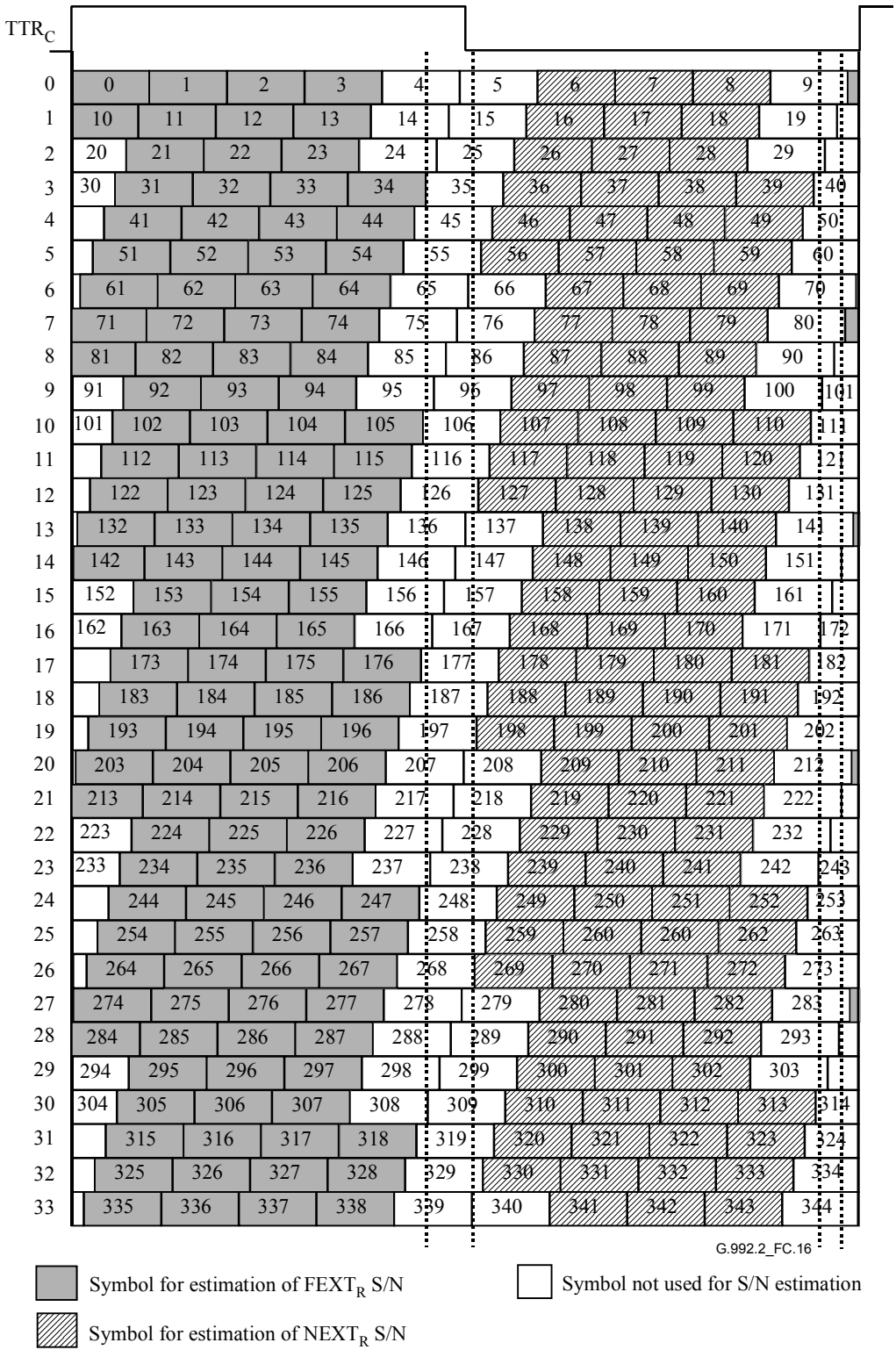


Figure C.16/G.992.2 – Symbol pattern in a hyperframe for S/N estimation – Downstream

C.9.~~88.6~~ Channel analysis (ATU-R) (supplements 11.10)

From R-RATES1 to R-CRC2, the ATU-R shall transmit 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.18.

C.9.88.6.1 R-SEGUE1 (supplements 11.10.1)

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

C.9.88.6.2 R-REVERB3 (supplements 11.10.2)

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

C.9.88.6.3 R-SEGUE2 (supplements 11.10.3)

The duration of R-SEGUE2 is 13 symbols.

C.9.88.6.4 R-MEDLEY (supplements 11.10.8)

The definition of R-MEDLEY is the same as in 11.10.8, except for the duration of the SNR estimation at the ATU-C for the upstream channel. With the periodic noise of TCM- ISDN, the SNR also changes in the same cycle, as shown in Figure C.15. When Bitmap-N_C is enabled, the ~~The~~ ATU-R shall transmit the signal in both of $FEXT_C$ and $NEXT_C$ symbols, and ATU-C shall estimate two SNRs from the received $NEXT_C$ and $FEXT_C$ symbols, respectively, as defined in Figure C.17.

The following numerical formula gives the information that received N_{dmt}-th DMT symbol at ATU-C 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 only transmits the signal in $FEXT_C$ symbols, and the ATU-C estimates the SNR from the received $FEXT_C$ symbols. ~~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.

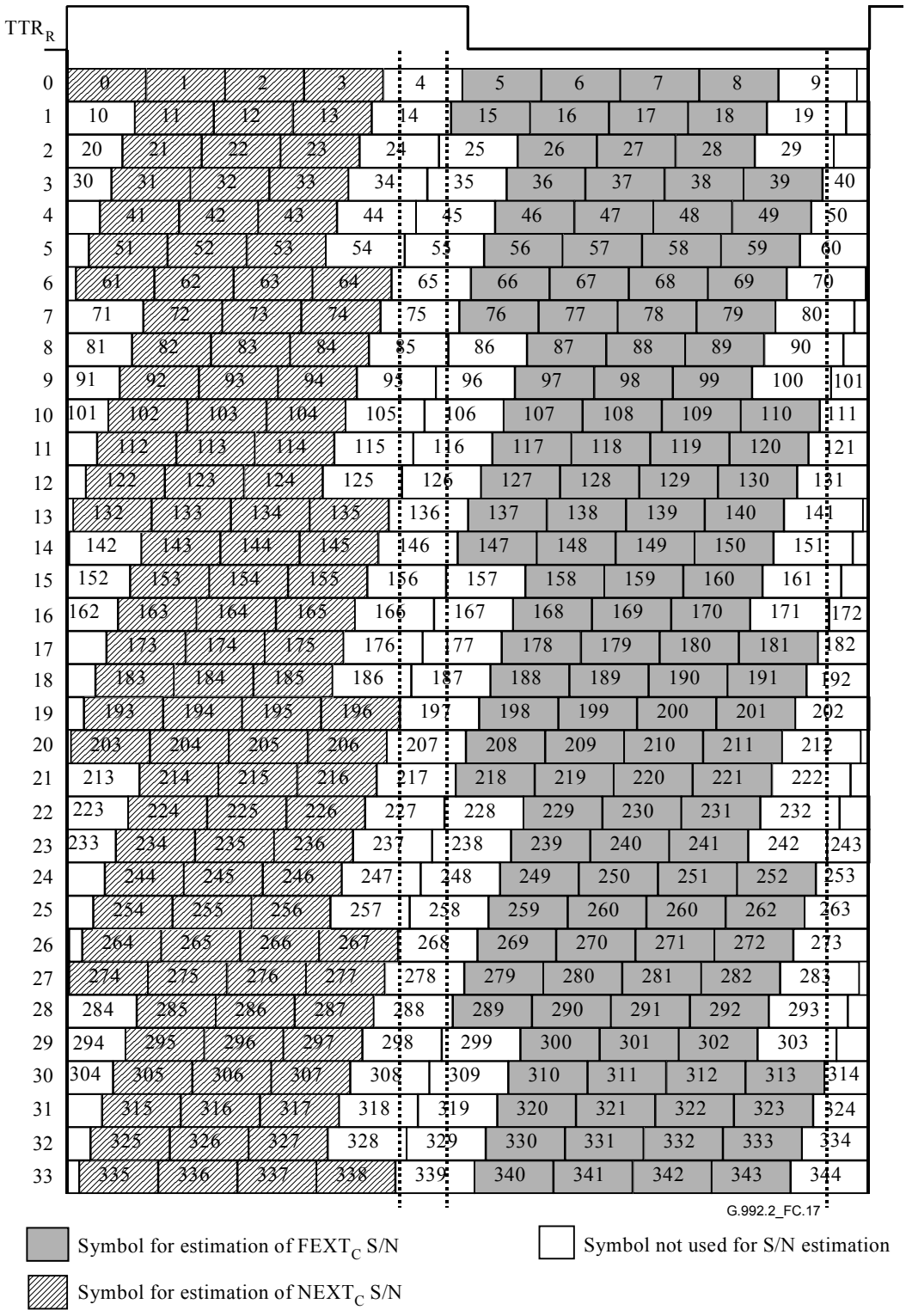


Figure C.17/G.992.2 – Symbol pattern in a hyperframe for S/N estimation – Upstream

C.9.~~98.7~~ Exchange – ATU-C (supplements 11.11)

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.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.19.

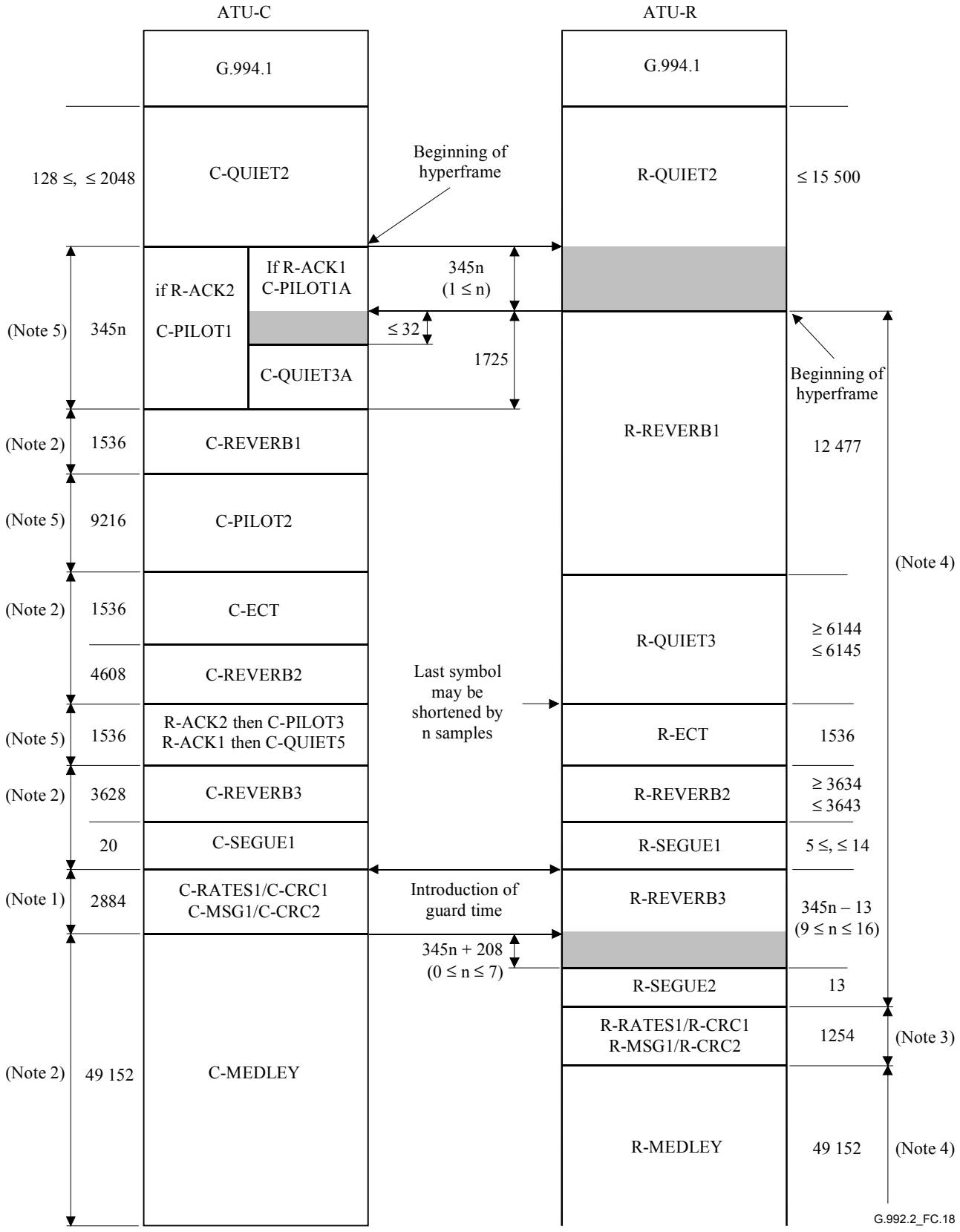


Figure C.18/G.992.2 – Timing diagram of the initialization sequence *(part 1)*

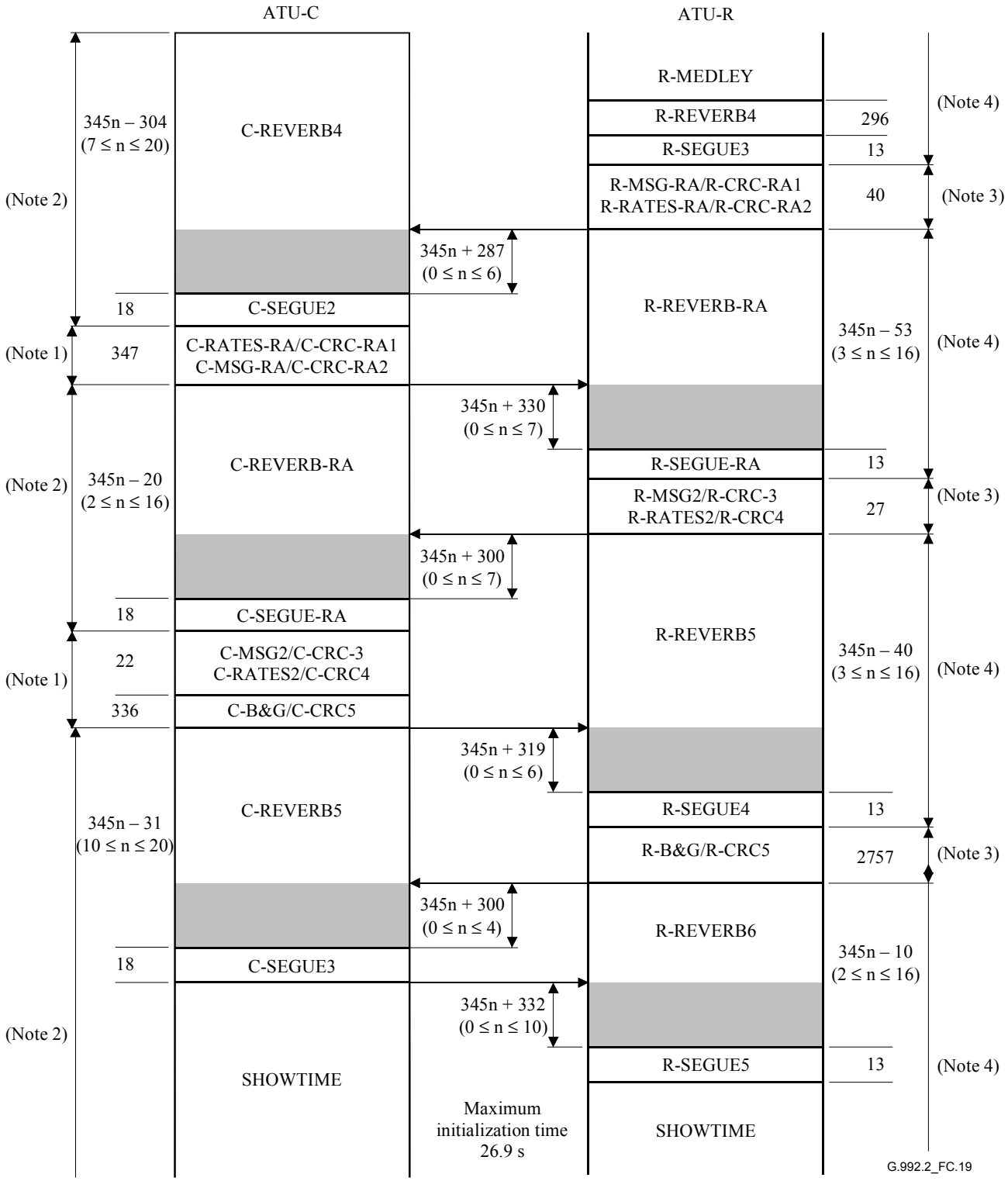


Figure C.19/G.992.2 – Timing diagram of the initialization sequence *(part 2)*

Notes to Figures C.18 and C.19

NOTE 1 – The ATU-C shall transmit the $FEXT_R$ symbols~~, and shall not transmit the $NEXT_R$ symbols except pilot tone~~ For modems not using any of the profiles defined in C.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.

NOTE 2 – 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.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.

NOTE 3 – ATU-R shall transmit the $FEXT_C$ symbols, and shall not transmit the $NEXT_C$ symbols.

NOTE 4 – ATU-R shall transmit both $FEXT_C$ and $NEXT_C$ symbols, when Bitmap-N_C is enabled (Dual Bitmap mode). ATU-R shall not transmit $NEXT_C$ symbols, when Bitmap-N_C is disabled (FEXT Bitmap mode).

NOTE 5 – Except for Profile 3, for which the ATU-C shall only transmit $FEXT_R$ symbols, the ATU-C shall transmit both $FEXT_R$ and $NEXT_R$ symbols.

C.9.98.7.1 C-MSG2 (supplements to 11.11.9)

Two bits are encoded onto each of the subcarriers numbered $n_{1C\text{-}MSG2}$ through ($n_{1C\text{-}MSG2}$ + 3) using the 4-QAM constellation labelling given in 7.10.3 (for the synchronization symbol) and 11.7.5 (for C-REVERB1). The same two bits are also encoded in the same way onto a set of backup carriers, namely, subcarriers $n_{2C\text{-}MSG2}$ through ($n_{2C\text{-}MSG2}$ + 3). The least significant byte of the message is transmitted in the first symbol of C-MSG2, with the two least significant bits of each byte encoded onto carriers $n_{1C\text{-}MSG2}$ and $n_{2C\text{-}MSG2}$. In addition, the pilot, subcarrier $n_{C\text{-}PILOT1}$, shall be modulated with (+,+). Following C-MSG2, the ATU-C shall enter signalling state C-CRC3.

For modems not using any of the profiles defined in C.4 and modems using Profiles 1, 2, 4, 5 or 6 :

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

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

For Profile 3:

$n_{1C\text{-}MSG2} = 13$

$n_{2C\text{-}MSG2} = 25$

C.9.98.7.1.1 Total number of bits per symbol supported (supplements 11.11.9.4)

The maximum number of bits per symbol is defined at the reference point B, that is calculated from the $FEXT_C$ and $NEXT_C$ upstream 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 × 126 + 88 × 214)/340 = 96).

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

C.9.98.7.2 C-B&G (replaces 11.11.13)

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.

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

$$m = \{m_{991}, m_{990}, \ldots, m_1, m_0\} = \{g_{63}, b_{63}, \ldots g_{33}, b_{33}, g_{31}, b_{31}, \ldots g_1, b_1\},$$

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 11.11.9.

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

C.9.9~~8.7~~.3 C-SEGUE3 (supplements 11.11.16)

The duration of C-SEGUE3 is 18 symbols. Following C-SEGUE-3, 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.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.9.10~~8.8~~ Exchange – ATU-R (supplements 11.12)

The 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.19.

C.9.10~~8.8~~.1 R-MSG-RA (related to 11.12.2)

C.9.10~~8.8~~.1.1 Total number of bits supported (B_{max}) (replaces 11.12.2.7)

This parameter shall be defined as in R-MSG2; see C.9.10.2.

C.9.10~~8.8~~.2 R-MSG2 (supplements 11.12.8)

C.9.10~~8.8~~.2.1 Total number of bits per symbol supported (supplements 11.12.8.4)

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.

C.9.10~~8.8~~.3 R-B&G (replaces 11.12.14)

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. ~~Because~~ When subcarrier 64 is reserved as the pilot tone, b_{64} and b_{320}, shall be set to 0_b, and, for modems not using any of the profiles defined in C.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.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.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.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:

$$m = \{m_{8159}, m_{8158}, \ldots, m_1, m_0\} = \{g_{511}, b_{511}, \ldots g_{257}, b_{257}, g_{255}, b_{255}, \ldots g_1, b_1\},$$

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 11.12.8.

Values of b_i and g_i shall be set to 0 for values of $127 < I < 256$, and $383 < i < 512$.

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

C.9.10~~8.8~~.4 R-SEGUE5 (replaces 11.12.17)

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.

C.10~~9~~ Fast retraining (supplements clause 12)

The definition of Fast Retrain procedure is the same as main body except for the definition of C-RECOV, the introduction of R-RECOV2, and duration of symbols which includes the Sliding Window operation. The definition of C-RECOV and R-RECOV2 are defined in C.10~~9~~.2. The duration of each state is defined in Figure C.22.

C.10~~9~~.1 Fast Retrain overview (pertains to 12.1)

For modems using any of the profiles defined in C.4, the fast retrain procedure shall not be used. The use of fast retrain for these profiles is for further study.

C.10~~9~~.1.1 Profile requirement (supplements 12.1.1)

B&G tables of profile contain both Bitmap-F_R and Bitmap-N_R in the ATU-C, and both Bitmap-F_C and Bitmap-N_C in the ATU-R.

C.10~~9~~.2 Definition of Fast Retrain signals (supplements 12.2)

C-RECOV signal is changed and the signal R-RECOV2 is added.

- C-RECOV consists of a single tone signal corresponding to subcarrier 68 without cyclic prefix accompanied by the C-PILOT1 signal which contains subcarrier 64 and 48 (see C.9.5.1). ATU-C shall transmit ~~the~~ this signal which includes 64, 68 and 48th subcarrier as $FEXT_R$ symbol, and shall transmit the signal which includes 64 and 48th subcarrier as $NEXT_R$ symbol. This signal allows the ATU-R to perform or maintain timing recovery and hyperframe synchronization.
- R-RECOV2 is single tone signal corresponding to subcarrier 22 without cyclic prefix. The PSD level to be used for R-RECOV2 shall be the same as R-RECOV. ATU-R transmits R-RECOV2 both ~~$FEXT_R$~~ $FEXT_C$ and ~~$NEXT_R$~~ $NEXT_C$ symbols.

C.10~~9~~.3 Fast Retrain procedure (supplements 12.3)

C.10~~9~~.3.1 ATU-C initiated from SHOWTIME (supplements 12.3.1)

Figures C.20 and C.21 show the timing diagrams for the Fast Retrain with the ATU-C initiating the procedure.

Time-outs C-TO2, C-TO3, R-TO1, R-TO3 are vendor discretionary. It is advisable to make these durations as short as possible.

The following issues are different from main body and transition state timing is similar to initialization (see C.9).

- The ATU-C shall enter C-RECOV at the beginning of the hyperframe without cyclic prefix.
- The ATU-C shall transmit the pilot tone as the $NEXT_R$ symbols in C-MSG-n and C-CRC-n.
- When Bitmap-N_R is disabled (FEXT Bitmap mode) in preceding SHOWTIME, the ATU-C shall transmit the pilot tone as $NEXT_R$ symbols, except C-RECOV and C-QUIET-FR.
- The ATU-C enters C-MEDLEY-FR at the beginning of the hyperframe with cyclic prefix.
- The ATU-R shall enter R-RECOV2 at the beginning of the hyperframe without cyclic prefix after the synchronization of ADC clock with the received C-RECOV signal. Last symbol of R-RECOV may be shortened.
- The ATU-R shall not transmit any signal as the $NEXT_C$ symbols in R-MSG-n and R-CRC-n.
- When Bitmap-N_C is disabled (FEXT Bitmap mode) in preceding SHOWTIME, the ATU-R shall not transmit the $NEXT_C$ symbols, except R-RECOV and R-RECOV2.
- The ATU-R enters R-MEDLEY-FR at the beginning of the hyperframe with cyclic prefix.

C.109.3.2 ATU-R initiated from SHOWTIME (supplements 12.3.2)

Figure C.22 shows the timing diagram for the Fast Retrain with the ATU-R initiating the procedure.

Time-outs C-TO2, R-TO2, R-TO3 are vendor discretionary. It is advisable to make these durations as short as possible.

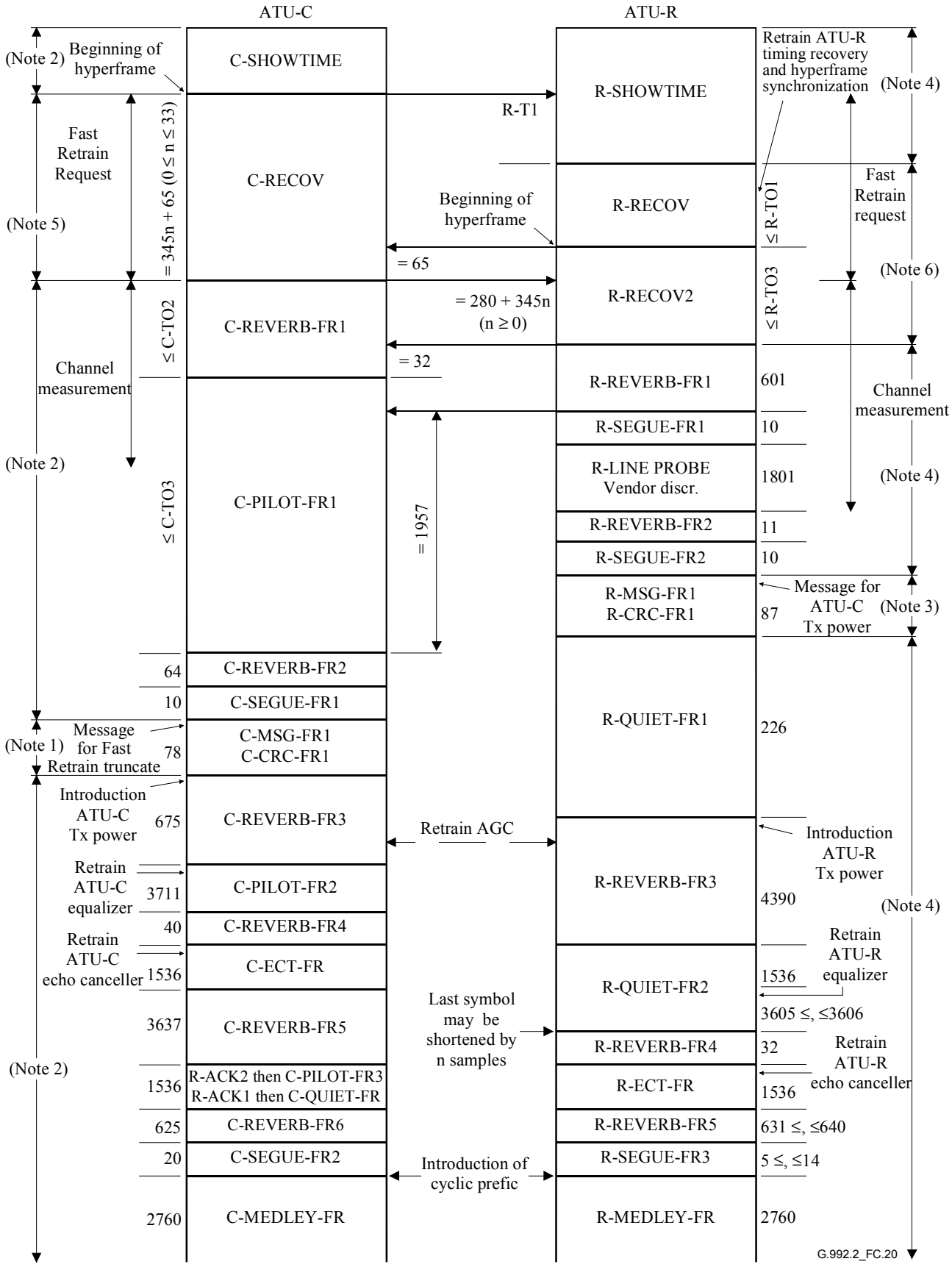


Figure C.20/G.992.2 – Timing diagram of the Fast Retrain procedure, ATU-C initiated from SHOWTIME *(part 1)*

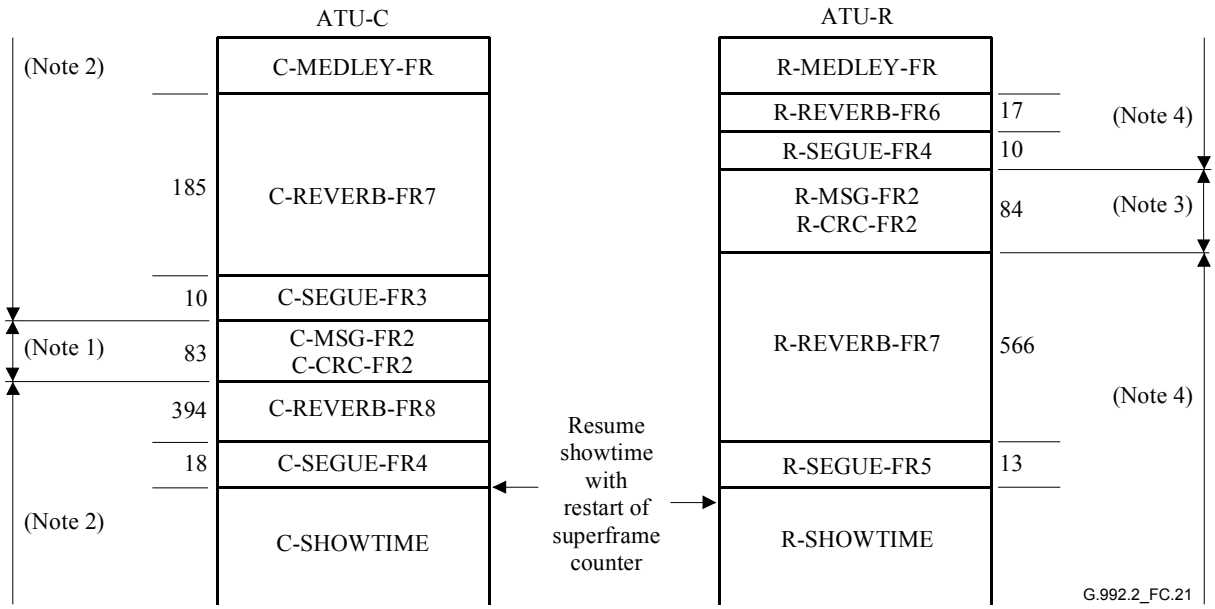


Figure C.21/G.992.2 – Timing diagram of the Fast Retrain procedure, ATU-C initiated from SHOWTIME *(part 2)*

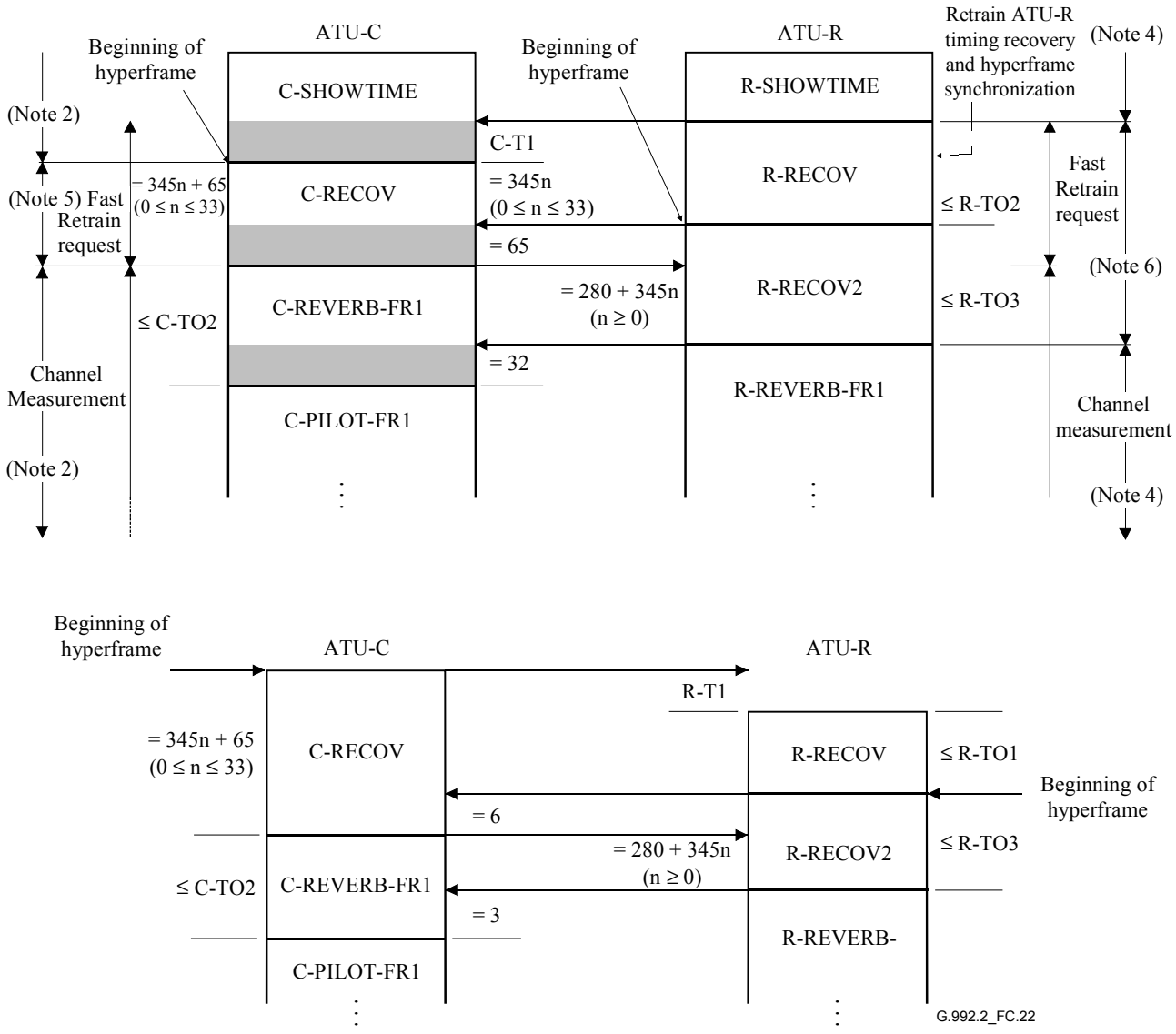


Figure C.22/G.992.2 – Timing diagram of the Fast Retraining procedure, ATU-R initiated from SHOWTIME

Notes to Figures C.21 and C.22

NOTE 1 – ATU-C shall transmit the $FEXT_R$ symbols, and shall not transmit the $NEXT_R$ symbols except pilot tone.

NOTE 2 – The ATU-C shall transmit both $FEXT_R$ and $NEXT_R$ symbols, when Bitmap-N_R is enabled (Dual Bitmap mode). ATU-C shall not transmit the $NEXT_R$ symbols except pilot tone, when Bitmap-N_R is disabled (FEXT Bitmap mode).

NOTE 3 – ATU-R shall transmit the $FEXT_C$ symbols, and shall not transmit the $NEXT_C$ symbols.

NOTE 4 – ATU-R shall transmit both $FEXT_C$ and $NEXT_C$ symbols, when Bitmap-N_C is enabled (Dual bitmap mode). ATU-R shall not transmit $NEXT_C$ symbols, when Bitmap-N_C is disabled (FEXT Bitmap mode).

NOTE 5 – ATU-C shall transmit both $FEXT_R$ and $NEXT_R$ symbols. However, the transmission signal is different between $FEXT_R$ and $NEXT_R$ symbol (see C.10.2).

NOTE 6 – ATU-R shall transmit both $FEXT_C$ and $NEXT_C$ symbols.

C.10~~9~~.4 Initiated from L3 or ITU-T Rec. G.994.1 (replaces 12.5)

A Fast Retrain Procedure initiated from an idle link state or via an Escape from Handshake shall be according to C.10~~9~~.3.1 or C.10~~9~~.3.2 except for a longer time duration for R-TO1 or R-TO2 of the R-RECOV signal. This will allow for re-acquisition of loop timing and hyperframe synchronization with the received C-RECOV signal at the ATU-R.

C.11~~0~~ Power management (pertains to clause 13)

C.11~~0~~.1 Transition from L0 to L1 (T0d) (pertains to 13.4.2)

C.11~~0~~.1.1 Exchange entry procedure (replaces 13.4.2.1)

This clause defines the Exchange entry procedure. This procedure reuses states, signals, and rules for determining the next state contained within C.9~~8~~.6 as defined in the following steps.

1) After successful termination of the eoc handshake procedure, the ATU-R shall start R-QUIET-PM at the Hyperframe boundary. R-QUIET-PM is defined as no transmitted signal onto the U-R interface. The ATU-R shall maintain loop timing and Hyperframe synchronization during the R-QUIET-PM signal.

2) After the detection of R-QUIET-PM, the ATU-C shall start C-REVERB4 at next 287th symbol (frame 286) of the hyperframe. In this procedure, the duration of C-REVERB4 is $345n - 304$ ($3 \leq n \leq 9$).

3) After the detection of C-REVERB4, the ATU-R responds by sending R-REVERB4 at next 37th symbol (frame 36) of the hyperframe. The exchange portion of the initialization procedure defined in C.9.6 shall continue from this point (i.e. the ATU-R shall send R-SEGUE after 296 symbols of R-REVERB4). During R-MSG-RA, the ATU-R shall use the "no options selected" message. The ATU-C implementation shall include a means that blocks the loss of signal defect during exchange entry procedure.

Appendix IV

Example Overlapped PSD Masks for use in a TCM-ISDN crosstalk environment

(For further study. See Note in C.1, Scope.)

SERIES OF ITU-T RECOMMENDATIONS

Series A	Organization of the work of ITU-T
Series B	Means of expression: definitions, symbols, classification
Series C	General telecommunication statistics
Series D	General tariff principles
Series E	Overall network operation, telephone service, service operation and human factors
Series F	Non-telephone telecommunication services
Series G	**Transmission systems and media, digital systems and networks**
Series H	Audiovisual and multimedia systems
Series I	Integrated services digital network
Series J	Cable networks and transmission of television, sound programme and other multimedia signals
Series K	Protection against interference
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Series M	TMN and network maintenance: international transmission systems, telephone circuits, telegraphy, facsimile and leased circuits
Series N	Maintenance: international sound programme and television transmission circuits
Series O	Specifications of measuring equipment
Series P	Telephone transmission quality, telephone installations, local line networks
Series Q	Switching and signalling
Series R	Telegraph transmission
Series S	Telegraph services terminal equipment
Series T	Terminals for telematic services
Series U	Telegraph switching
Series V	Data communication over the telephone network
Series X	Data networks and open system communications
Series Y	Global information infrastructure and Internet protocol aspects
Series Z	Languages and general software aspects for telecommunication systems

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