TS 101 388 V1.1.1 (1998-11)

Technical Specification

Transmission and Multiplexing (TM); Access transmission systems on metallic access cables; Asymmetric Digital Subscriber Line (ADSL) - Coexistence of ADSL and ISDN-BA on the same pair

[ANSI T1.413 - 1998, modified]

Reference

DTS/TM-06006 (cuo00icr.PDF)

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Transmission and Multiplexing (TM).

It is necessary to read the present document in conjunction with ANSI T1.413 (1998) which is considered to be endorsed and modified by the requirements contained herein.

1 Scope

The present document specifies methods for the coexistence of ADSL and ISDN-BA on the same subscriber line. The scope is to establish viable ways enabling the simultaneous deployment of asymmetric services and 160 kbit/s (2B+D) Basic Rate Access with the constraint to use existing transmission technologies as those specified in [1].

The definition of new line codes and/or transmission systems is outside the scope of the present document.

The present document endorses ANSI T1.413 (1998), the contents of which apply with the modifications being covered herein which are related to the following aspects:

1) Methods to allow the simultaneous delivery of ADSL and ISDN-BA services on a single pair. For example the techniques and redefinition of the ADSL signals/parameters as defined in [2] to allows ISDN-BA baseband signals to occupy frequencies below ADSL (from here onwards referred as outband transport).

2) Impacts of the above methods on the ADSL line system performances.

3) Impacts of the above methods on the ISDN-BA transmission systems performances.

4) ADSL backward compatibility.

5) TS 102 080 backward compatibility.

6) Power feeding for the transported ISDN-BA.

7) Latency.

8) ISDN-BA splitter characteristics (cut-off frequencies, order, ...).

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

[1] TS 102 080 (V1.3.1): "Transmission and Multiplexing (TM); Integrated Services Digital Network (ISDN) basic rate access; Digital transmission on metallic local lines".

[2] ANSI T1.413 (1998): "Network and Customer Installation Interfaces - Asymmetric Digital Subscriber Line (ADSL)".

[3] ETR 328 (1996): "Transmission and Multiplexing (TM); Asymmetric Digital Subscriber Line (ADSL); Requirements and performance".

3 Definitions and abbreviations

3.1 Definitions

For the purposes of the present document, the following definitions apply:

downstream: high speed digital data channel(s) in the direction of ALT towards ANT (network to customer premises).

upstream: high speed digital data channel(s) in the direction of ANT towards ALT (customer premises to network).

3.2 Abbreviations

For the purposes of the present document, the following abbreviations apply:

2B1Q	2 Binary 1 Quatrenary (Baseband linecode for ISDN-BA (4-PAM))
4B3T	4 Binary 3 Ternary (Alternative ISDN-BA baseband linecode with higher frequency spectrum than 2B1Q)
ADSL	Asymmetric Digital Subscriber Line
ALT	ADSL Line Termination
ANT	ADSL Network Termination
ATM	Asynchronous Transfer Mode
ATU-C	ADSL Terminal Unit-Central office
ATU-R	ADSL Terminal Unit-Remote
ISDN-BA	ISDN Basic rate Access
FDM	Frequency Division Multiplexing
IDFT	Inverse Discrete Fourier Transform
ISDN	Integrated Services Digital Network
PSD	Power Spectral Density
PRU	Pseudo-Random Upstream
STM	Synchronous Transfer Mode

4 Methods for allocating ADSL above ISDN

The ADSL signals described in the present document shall be allocated above the operating band of ISDN-BA signals based on 2B1Q/4B3T line signals as those defined in [1]. In order to allow sufficient upstream bandwidth capacity the ATU-R shall have a transmission bandwidth making use of tones 33 to 63. The use of an extended range making use of tones between 1 and 63 is optional.

The IDFT implementation at the ATU-R side shall be implemented as follows. Tones 33 to 63 will contain complex values generated by the encoder and scaler.

The values in tones 1 to 31 shall be:

a) mirrored complex-conjugate of tones 33 to 63 if the transmitter uses only 32 tones (tone #32 = 0);

b) zero if the transmitter uses 64 tones and the receiver uses 32 tones (tone #32 = 0);

c) complex data generated by the encoder and scaler if both the transmitter and receiver use 64 tones (tone 32 also equals value generated by encoder and scaler).

The information whether the upstream transmitter and/or receiver uses 32 or 64 tones is communicated via activation and acknowledgement tones constituting a handshake procedure.

5 ATU-C

5.1 Used frequency band

The ATU-C shall use tones between #33 (f = 142,3125 kHz) and #255 (f = 1 099,6875 kHz). The use of tones below #33 is optional.

5.2 Nominal aggregate power level

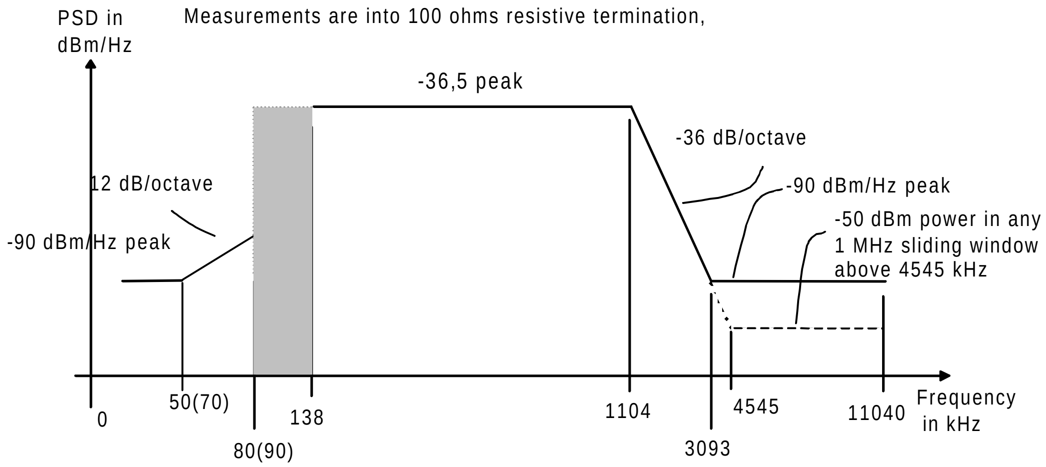
The nominal aggregate power level shall be 19,83 dBm.

5.3 Pilot frequency

Tone #96 (f = 414 kHz) shall be reserved for a pilot (see [2], subclause 6.11.1.2); that is $b_{96} = 0$ and $g_{96} = 1$.

5.4 Transmit spectral mask

The ATU-C transmitter spectral response shall be as defined in figure 1 and in table 1.



NOTE 1: 50 kHz and 80 kHz are frequency limits referring to ADSL over ISDN lines operating with 2B1Q code. 70 kHz and 90 kHz are frequency limits referring to ADSL over ISDN lines operating with 4B3T code.

NOTE 2: There is a discrepancy between the out-of-band power spectral density limits given in the present document and those given in TS 102 080 [1].
The out-of-band limits on ISDN-BA are more stringent than the ADSL system described in the present document. It is acknowledged that there is a need to make the documents consistent. This is an area of further study and will be addressed by ETSI TM6.

Figure 1: ATU-C transmitted PSD mask

Table 1: Line equations for the ATU-C Transmitted PSD mask

Frequency Band (kHz)	Equation for line (dBm/Hz)
0 - 50 (70)	-90
> f_1 = 50 (70) to 80 (90)	$-90 + 12 \times \log_2 (f/f_1)$
80 (90) to 138	see note
138 to 1 104	-36,5
1 104 to 3 093	$-36,5 - 36 \times \log_2 (f/1\,104)$
3 093 to 4 545	-90 peak, with maximum power in the [f, f + 1 MHz] window of $(-36,5 - 36 \times \log_2 (f/1\,104) + 60)$ dBm
4 545 to 11 040	-90 peak, with maximum power in the [f, f + 1 MHz] window of -50 dBm

NOTE: The value of PSD in this region depends on the low pass and high pass filter designs. The filters affect the ISDN-BA performance when combined with ADSL in two ways:

1) the residual ADSL power, filtered by the high pass and received by the ISDN-BA receiver as noise;
2) the amplitude and phase distortion introduced by low pass filters.

It is expected that the degradation impact on the ISDN-BA line system performance be not more than 4,5 dB and 4 dB, for 2B1Q and 4B3T line codes respectively, at the insertion loss reference frequency.

The maximum level of the PSD of the ADSL signal measured at the ISDN port of the splitter shall not exceed the limits defined in the first two rows of table 1.

All PSD measurements made at the Line port of the ISDN splitter shall use a 100 Ω resistive reference impedance.

All PSD measurements made at the ISDN port of the ISDN splitter shall use the design impedance of ISDN-BA for 2B1Q and 4B3T respectively as defined in [1].

6 ATU-R

6.1 ATU-R transmitter reference models

The ATU-R reference model for STM transport is given in figure 2.

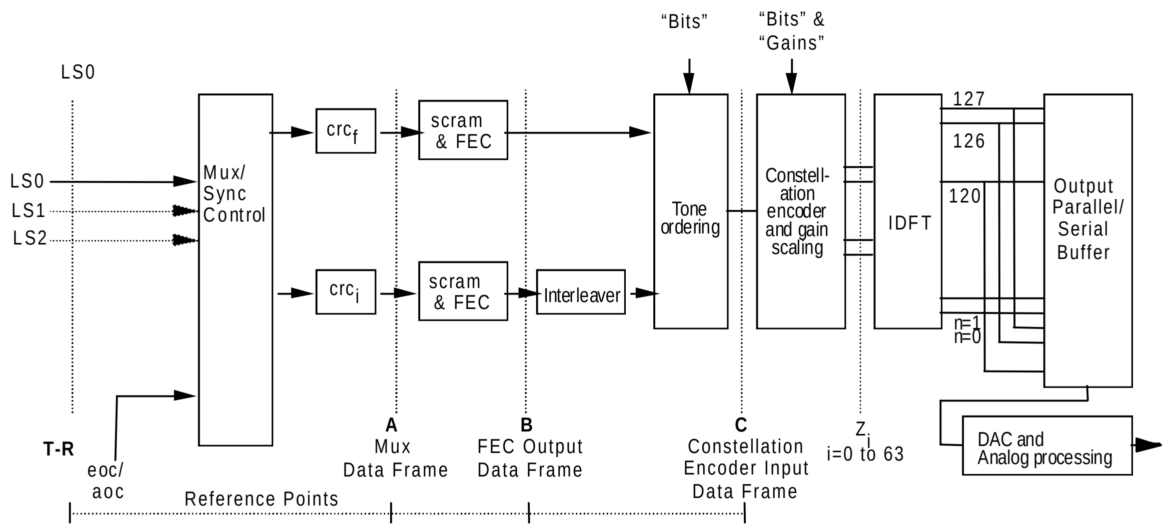


Figure 2: ATU-R transmitter reference model for STM transport

The ATU-R reference model for ATM transport is given in figure 3.

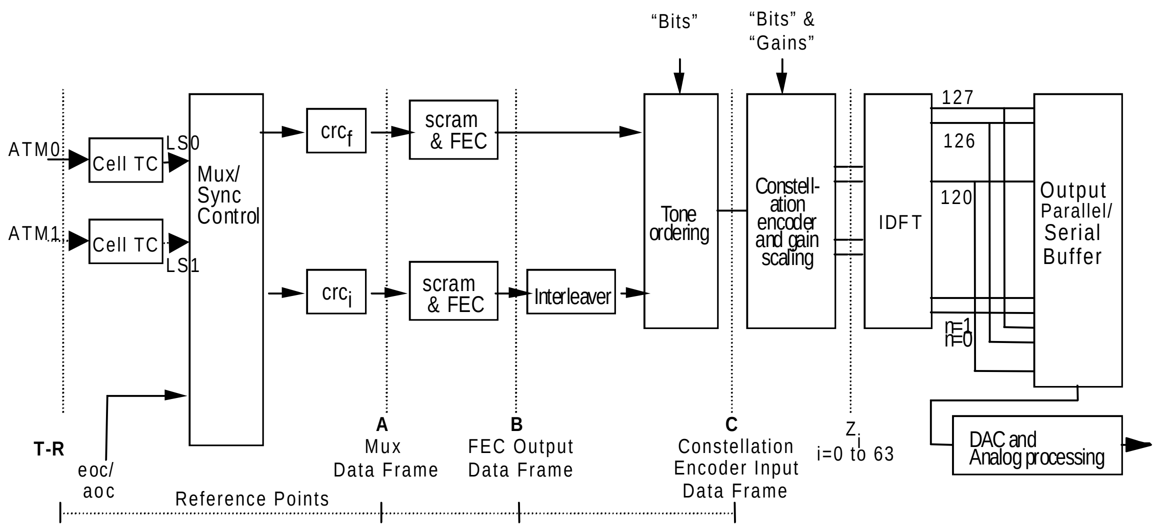


Figure 3: ATU-R transmitter reference model for ATM transport

6.2 Used frequency band

The ATU-R shall use tones between #33 and #63. The use of tones below #33 is optional.

6.3 Nominal aggregate power level

The nominal aggregate power level shall be 13,26 dBm.

6.4 Maximum number of data sub-carriers

The maximum number of data sub-carriers shall be 63, however the use of carriers between #1 and #32 is optional. The lower frequency limit of the used sub-carriers is partly determined by the ISDN splitting filters. If FDM is used to separate the upstream and downstream ADSL signals, the upper limit is set by down-up splitting filters. The cut-off frequencies of these filters are completely at the discretion of the manufacturer. The range of usable bandwidth is determined during the channel estimation.

6.5 Pilot frequency

There is no upstream pilot, the ATU-R shall perform slave loop timing based on the downstream pilot.

6.6 Nyquist frequency

The upstream Nyquist frequency shall be at sub-carrier #64 (f = 276 kHz).

6.7 Modulation by the Inverse Discrete Fourier Transform (IDFT)

The modulating transform defines the relationship between the 128 real values x_k and the $Z_i^{'}$:

$$x_k = \sum_{i=0}^{127} \exp\left(\frac{j\pi ki}{64}\right) Z_i^{'} \qquad \text{for } k = 0 \text{ to } 127$$

The encoder and scaler generate complex values of $Z_i^{'}$ corresponding to tones 1 to 63 (plus zero at dc and one real value if the Nyquist frequency is used). In order to generate real values of x_k these values shall be augmented so that the vector $Z_i^{'}$ has Hermitian symmetry. That is,

$$Z_i^{'} = \mathrm{conj}[Z_{128-i}^{'}] \qquad \text{for } i = 65 \text{ to } 128$$

If the transceiver receives C-ACT1 during transceiver training then,

$$Z_i^{'} = 0 \qquad \text{for } i = 1 \text{ to } 32$$

NOTE: For the mirrored complex conjugate transmitter,

$$Z_i^{'} = \mathrm{conj}[Z_{64-i}^{'}] \qquad \text{for } i = 1 \text{ to } 31$$

$$Z_{32}^{'} = 0$$

6.8 Synchronization symbol

The data pattern used in the synchronization symbol shall be the pseudo-random sequence PRU (d_n, for n = 1 to 128), defined by:

$$d_n = 1 \qquad \text{for } n = 1 \text{ to } 6$$

$$d_n = d_{n-5} \oplus d_{n-6} \qquad \text{for } n = 7 \text{ to } 128$$

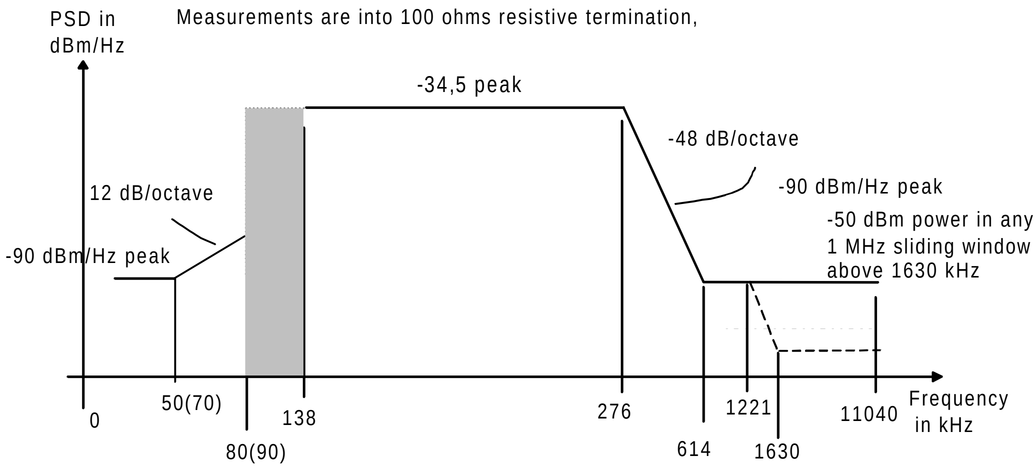
The bits are used as follows: the first pair of bits (d_1 and d_2) is used for the dc and Nyquist sub-carriers (the power assigned to them is, of course, zero, so the bits are effectively ignored); then the first and second bits of subsequent pairs shall be used to define the X_i and Y_i for i = 1 to 63 in accordance to table 16 of [2].

6.9 Cyclic prefix

The last 8 samples of the output of the IDFT (x_k for k = 120 to 127) shall be prepended to the block of 64 samples and read out to the DAC in sequence. That is, the subscript, k, of the DAC samples in sequence are 120...127, 0…127.

6.10 Transmit spectral mask

The ATU-R transmitter spectral response shall be as defined in figure 4 and in table 2.



NOTE 1: 50 kHz and 80 kHz are frequency limits to ADSL over ISDN lines operating with 2B1Q code.
70 kHz and 90 kHz are frequency limits referring to ADSL over ISDN lines operating with 4B3T code.

NOTE 2: There is a discrepancy between the out-of-band power spectral density limits given in the present document and those given in TS 102 080 [1].
The out-of-band limits on ISDN-BA are more stringent than the ADSL system described in the present document. It is acknowledged that there is a need to make the documents consistent. This is an area of further study and will be addressed by ETSI TM6.

Figure 4: Transmitted PSD mask

Table 2: ATU-R Transmitted PSD mask

Frequency band (kHz)	Equation for line (dBm/Hz)
0 - 50 (70)	-90
> f_1 = 50 (70) to 80 (90)	-90 + 12 x $\log_2 (f/f_1)$
80 (90) to 138	see note
138 to 276	-34,5
276 to 614	-34,5 - 48 x $\log_2$ (f/276)
614 to 1 221	-90
1 221 to 1 630	-90 peak, with maximum power in the [f, f + 1 MHz] window of (-90 - 48 x $\log_2$ (f/1 221) + 60) dBm
1 630 to 11 040	-90 peak, with maximum power in the [f, f + 1 MHz] window of -50 dBm
NOTE: The value of PSD in this region depends on the low pass and high pass filter designs. The filters affect the ISDN-BA performance when combined with ADSL in two ways: 1) the residual ADSL power, filtered by the high pass and received by the ISDN-BA receiver as noise; 2) the amplitude and phase distortion introduced by low pass filters. It is expected that the degradation impact on the ISDN-BA line system performance be not more than 4,5 dB and 4 dB, for 2B1Q and 4B3T line codes respectively, at the insertion loss reference frequency.	

The maximum level of the PSD of the ADSL signal measured at the ISDN port of the splitter shall not exceed the limits defined in the first two rows of table 2.

All PSD measurements made at the Line port of the ISDN splitter shall use a 100 Ω resistive reference impedance.

All PSD measurements made at the ISDN port of the ISDN splitter shall use the design impedance of ISDN-BA for 2B1Q and 4B3T respectively as defined in [1].

7 Initialization

7.1 C-Activate

C-ACT2m or C-ACT2e shall be sent to initiate a communication link to the ATU-R.

As shown in table 3, the ATU-C shall transmit C-ACT2m or C-ACT2e to indicate its ability to receive 32 or 64 upstream tones.

Table 3

	ATU-C Receiver
C-ACT2m	Tones above 32 only
C-ACT2e	Tones below 33 allowed

7.2 C-ACT2m

ATU-C shall transmit C-ACT2m to indicate that it is able to receive tones above 32 only.

C-ACT2m is a single frequency sinusoid at $f_{C\text{-}ACT2m}$ = 319,125 kHz defined as in [2], subclause 9.2.1.3, but with k = 74.

The level and duration of C-ACT2m shall be the same as those of C-ACT1 (see [2], subclause 9.2.2.1).

C-QUIET2 immediately follows C-ACT2m.

7.3 C-ACT2e

ATU-C shall transmit C-ACT2e to indicate that it is able to receive tones below 33.

C-ACT2e is a single frequency sinusoid at $f_{C\text{-}ACT2e}$ = 327,75 kHz defined as in [2], subclause 9.2.1.3, but with k = 76.

The level and duration of C-ACT2e shall be the same as those of C-ACT1 (see [2], subclause 9.2.2.1).

C-QUIET2 immediately follows C-ACT2e.

NOTE: The sets of downstream tones defined in the present document do not include the C-TONE (defined in [2]). In the future C-TONE might disappear completely. However, for a purely tone based activation of ADSL over ISDN ETSI TM6 decided that it should be defined. The use of tone 82 is for further study.

7.4 R-Acknowledgment

As shown in table 4, the ATU-R shall transmit R-ACK1m/e or R-ACK2m/e as acknowledgment to C-ACT2e/m to indicate whether it use 32 or 64 tones for upstream transmission.

Table 4

	R-ACK1m	**R-ACK1e**	**R-ACK2m**	**R-ACK2e**
C-QUIET3	PILOT QUIET		PILOT	
C-QUIET4	PILOT		PILOT	
C-QUIET5	QUIET		PILOT	
ATU-R Tx Carriers	33 to 63 only	33 to 63 mandatory 1 to 32 optional	33 to 63 only	33 to 63 mandatory 1 to 32 optional

7.5 R-ACT-REQ

R-ACT-REQ is a single frequency sinusoid at $f_{R\text{-}ACT\text{-}REQ}$ = 181,125 kHz defined as in [2], subclause 9.2.1.3, but with k = 42.

7.6 R-ACK1m

R-ACK1m is a single frequency sinusoid at $f_{R\text{-}ACK1m}$ = 189,75 kHz defined as in [2], subclause 9.2.1.3, but with k = 44.

7.7 R-ACK1e

R-ACK1e is a single frequency sinusoid at $f_{R\text{-}ACK1e}$ = 198,375 kHz defined as in [2], subclause 9.2.1.3, but with k = 46.

7.8 R-ACK2m

R-ACK2m is a single frequency sinusoid at $f_{R\text{-}ACK2m}$ = 207 kHz defined as in [2], subclause 9.2.1.3, but with k = 48.

7.9 R-ACK2e

R-ACK2e is a single frequency sinusoid at $f_{R\text{-}ACK2e}$ = 215,625 kHz defined as in [2], subclause 9.2.1.3, but with k = 50.

7.10 C-REVEILLE

C-REVEILLE is a single frequency sinusoid at $f_{C\text{-}REVEILLE}$ = 336,375 kHz defined as in [2], subclause 9.2.1.3, but with k = 78.

7.11 C-PILOT1

C-PILOT1 is a single frequency sinusoid at $f_{C\text{-}PILOT1}$ = 414 kHz defined as in [2], subclause 9.2.1.3, but with k = 96.

7.12 R-REVERB1

The data pattern used in R-REVERB1 shall be the pseudo-random sequence PRU (d_n, for n = 1 to 128), defined by

$$d_n = 1 \qquad \text{for } n = 1 \text{ to } 6$$

$$d_n = d_{n-5} \oplus d_{n-6} \qquad \text{for } n = 7 \text{ to } 128$$

The bits are used as follows: the first pair of bits (d_1 and d_2) is used for the dc and Nyquist sub-carriers (the power assigned to them is, of course, zero, so the bits are effectively ignored); then the first and second bits of subsequent pairs shall be used to define the X_i and Y_i for i = 1 to 63 as defined for C-REVERB1 in table 16 of [2].

NOTE: The d_1 to d_6 are re-initialized for each symbol, so each symbol of R-REVERB1 uses the same data.

7.13 R-MEDLEY

R-MEDLEY is a wide band 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 defined for R-REVERB1 in subclause 7.12. In contrast to R-REVERB1, however, the cyclic prefix is used and the data sequence continue from one symbol to the next. Because the sequence is of length 63, and 128 bits are used for each symbol, the sub-carrier vector for R-MEDLEY changes from one symbol to the next. R-MEDLEY is transmitted for 16 384 symbol periods. Following R-MEDLEY the ATU-R enters signalling state R-REVERB4.

7.14 C-MSGS2

Two bits are encoded onto each of the sub-carriers numbered 75 through 78 using 4QAM constellation labelling given in subclause 6.11.3 and table 16 of [2]. The same bits are also encoded in the same way onto a set of backup carriers, namely, sub-carriers 91 through 94. The least significant byte of the message is transmitted in the first symbol of C-MSGS2, with the two least significant bits of each byte encoded onto carriers 75 and 91. In addition, the pilot subcarrier 96 shall be modulated with the (+,+) constellation point.

7.15 R-MSGS2

Two bits are encoded onto each of the sub-carriers numbered 44 through 47 using 4QAM constellation labelling given in subclause 6.11.3 and table 16 of [2]. The same bits are also encoded in the same way onto a set of backup carriers, namely, sub-carriers 49 through 52. The least significant byte of the message is transmitted in the first symbol of C-MSGS2, with the two least significant bits of each byte encoded onto carriers 44 and 49.

7.16 C-ECT and R-ECT

Because C-ECT and R-ECT are vendor defined signals (see [2], subclauses 9.4.9 and 9.5.5) the PSD specification shall be interpreted only as a maximum. This maximum level is -39 - 2n dBm/Hz (for C-ECT) and -37 dBm/Hz (for R-ECT) (with n indicating the power cut back, n = 0 to 6) for the band from 138 kHz to 1 104 kHz (for C-ECT) and to 276 (for R-ECT). Subcarriers 1 to 31 may be used, but the power in the ISDN band shall conform to the specification given in subclauses 5.4 and 6.10 of the present document.

7.17 Power Cut-back

If the total upstream power measured on sub-carriers 40 to 51 during R_REVERB1 is greater than 3 dBm, then the PSD for C-REVERB1 and all subsequent downstream signals shall be as shown in table 5.

Table 5: Power cut-back: downstream PSD as a function of upstream received power

Upstream received power (dBm) <	0	1,5	3	4,5	6	7,5	9
Max downstream PSD (dBm/Hz)	-40	-42	-44	-46	-48	-50	-52

This chosen level shall become the reference level for all subsequent gain calculations.

7.18 C-B&G

C-B&G shall be used to transmit to the ATU-R the bits and gains information, {i.e. $b_1, g_1, b_2, g_2, \ldots\ldots b_{63}, g_{63}$}, that are to be used on the upstream carriers. b_i indicates the number of bits to be coded by the ATU-R transmitter onto the i^{th} upstream carrier; g_i 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. Because no bits or energy shall be transmitted at dc or one-half the sampling rate, b_0, g_0, b_{64}, and g_{64} shall all be presumed to be zero and shall not be transmitted.

Each b_i shall be represented as an unsigned 4-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 sub-carrier, which is communicated in R-MSGS1.

Each g_i shall be represented as an unsigned 12-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) 001.010000000 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 sub-carriers on which no data are to be transmitted, and the receiver will never allocate bits (e.g., out-of-band sub-carriers) both b_i and g_i shall be set to zero (0000 and 00000000 0000, respectively). For sub-carriers 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 1 a value in the 0,75 to 1,33 range (000.1100000 00 to 001.010101011).

A total of 126 bits and gains information is to be transmitted during C B&G, and a total of 126 symbol period is required, using the method described in [2], subclause 9.8.9. Following C-B&G the ATU-C shall enter state C-CRC5.

The C-B&G information shall be mapped in a 1 008-bit message *m* defined by:

$$m = \{m_{1007}, m_{1006}, \ldots, m_1, m_0\} = \{g_{63}, b_{63}, \ldots g_1, b_1\},$$

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 126 symbols, using the transmission method as described in [2], subclause 9.8.9.

Following C-B&G, the ATU-C shall enter the state C-CRC5. The modified timing diagram of the initialization sequence (part2) is shown in figure 5.

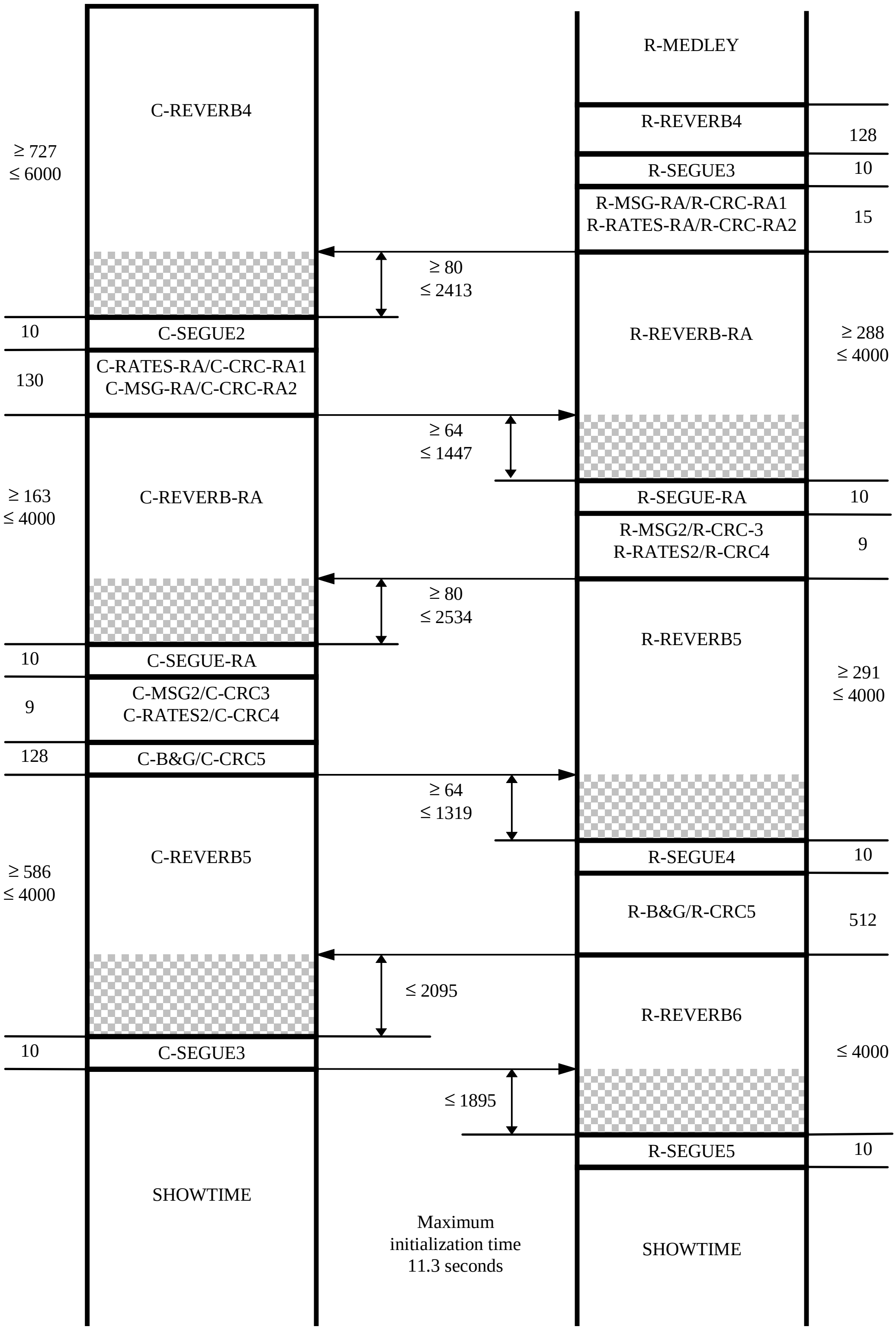


Figure 5: Timing diagram of the initialization sequence (part 2)

8 Performance objectives

This subject is for further study.

9 ADSL/ISDN splitter

This subject is for further study.

History

Document history		
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