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Digital audio – Interface for non-linear PCM encoded audio bitstreams applying IEC 60958 –
Part 15: Non-linear PCM bit streams according to Auro-Cx format

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DIGITAL AUDIO – INTERFACE FOR NON-LINEAR PCM ENCODED AUDIO BITSTREAMS APPLYING IEC 60958 –

Part 15: Non-linear PCM bit streams according to Auro-Cx format

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IEC 61937-15 has been prepared by technical area 20: Analogue and digital audio, of IEC technical committee 100: Audio, video and multimedia systems and equipment. It is an International Standard.

The text of this International Standard is based on the following documents:

Draft	Report on voting
100/3462/CDV	100/3536/RVC

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available

at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts in the IEC 61937 series, published under the general title *Digital audio – Interface for non-linear PCM encoded audio bitstreams applying IEC 60958*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

The Auro-3D®[1] format has brought immersive 3D audio to the digital cinema and consumer electronics markets since 2011, and started a revolution in the audio industry, bringing the next generation audio experience to the user.

To accommodate the shift towards the use of streaming using set-top boxes, smart TVs and other connected devices, a new audio codec was developed: Auro-Cx®[2].

To be able to pass the Auro-Cx bit stream from said connected devices to an AV-receiver for decoding via the IEC 60958 interface, the IEC 61937 series must support the Auro-Cx format.

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1 Auro-3D is a trademark owned by Auro Technologies NV. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

2 Auro-Cx is the trademark of a product supplied by Auro Technologies NV. This information is given for the convenience of users of this document and does not constitute an endorsement by IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

DIGITAL AUDIO – INTERFACE FOR NON-LINEAR PCM ENCODED AUDIO BITSTREAMS APPLYING IEC 60958 –

Part 15: Non-linear PCM bit streams according to Auro-Cx format

1 Scope

This part of IEC 61937 describes the method to convey non-linear PCM bit streams in accordance with the Auro-Cx format.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60958 (all parts), *Digital audio interface*

IEC 61937-1:2021, *Digital audio interface for non-linear PCM encoded audio bitstreams applying IEC 60958 – Part 1: General*

IEC 61937-2:2021, *Digital audio interface for non-linear PCM encoded audio bitstreams applying IEC 60958 – Part 2: Burst Information*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1 Terms and definitions

3.1.1
Auro-Cx block
block containing all Auro-Cx audio data and metadata, formatted in accordance with the Auro-Cx Bit Stream format

3.1.2
block size
number of samples represented by an Auro-Cx block, indicated by the value of the BlockSize Auro-Cx bit stream parameter

3.1.3
latency
delay time introduced by an external Auro-Cx decoder while decoding an Auro-Cx data block, defined as the sum of the receiving delay time and the decoding delay time

3.1.4
sample rate
sampling frequency[3] of the linear PCM samples represented in the Auro-Cx bit stream, as indicated by the value of the acxSampleRateIdx Auro-Cx bit stream parameter

3.1.5
Auro-Cx audio frame rate
number of Auro-Cx blocks per second

3.1.6
fractional frame rate
audio frame rates with non-integer values, which are written in shorthand notation as shown in Table 1

Table 1 – Fractional frame rates

Fractional Auro-Cx frame rate in fps	Shorthand notation
$24 \times {}^{1\,000}/_{1\,001}$	23,976
$30 \times {}^{1\,000}/_{1\,001}$	29,97
$48 \times {}^{1\,000}/_{1\,001}$	47,972
$60 \times {}^{1\,000}/_{1\,001}$	59,94
$120 \times {}^{1\,000}/_{1\,001}$	119,88

3.2 Abbreviated terms

ACX Auro-Cx
fps frames per second
fs sampling frequency
HBR high bit rate
spb samples per block

4 Mapping of the audio bit stream on to IEC 61937-1

4.1 General

The coding of the bit stream and data-burst is in accordance with IEC 61937-1 and IEC 61937-2.

4.2 Auro-Cx burst-info

The 16-bit burst-info contains information about the data that will be found in the data-burst (see Table 2).

[3] Auro-Cx supports sample rates up to 96 kHz.

Table 2 – Burst-info for Auro-Cx data-type and subdata-types

Bits of Pc	Data type value (bits 0–4)	Subdata-type value (bits 5–6)	Contents	Reference point R	Repetition period of data-burst in IEC 60958 frames
0–6	0–25	According to IEC 61937-2			
	26	0	ACX	bit 0 of Pa	See Table 7
		1	ACX HBR2	bit 0 of Pa	See Table 12
		2	ACX HBR4	bit 0 of Pa	See Table 17
		3	ACX HBR8	bit 0 of Pa	See Table 22
	27–31	According to IEC 61937-2			
7–15	According to IEC 61937-1				

The burst-info (Pc) bits 0-4 signal the data-type used for the transmission. For Auro-Cx, the data-type is set to 26.

Pc bits 5-6 indicate the Auro-Cx bit stream mode. The repetition periods of data-bursts in IEC 60958 frames shall be derived from the data-type-dependent information specified in Table 4, Table 9, Table 14 and Table 19.

5 Format of Auro-Cx data-bursts

5.1 General

This clause specifies the Auro-Cx data-burst. Specific properties such as reference points, repetition period, the method of filling stream gaps and decoding latency are specified.

To establish synchronisation between the picture and decoded audio, the transmitter should use the latency indicated for the data-type to schedule data-bursts as necessary.

5.2 Pause data-burst

The Pause data-burst for Auro-Cx is given in Table 3.

Table 3 – Repetition period of the Pause data-bursts

Data-type of audio data-burst	Repetition period of Pause data-burst	
	Mandatory	Recommended
ACX	-	3
ACX HBR2	-	5
ACX HBR4	-	5
ACX HBR8	-	5

If regular audio data-bursts are not being transmitted because of a pause condition, for example, it is recommended that Pause data-bursts are used to fill the stream gaps in the ACX bit stream, as described in IEC 61937-1. The Pause data-bursts should be transmitted with a repetition rate period in accordance with Table 3, except when other repetition periods are necessary to fill the precise stream gap length, which may not be a multiple of 3 IEC 60958 frames, or to meet the requirement on burst spacing (refer to IEC 61937-1).

When a stream gap in an ACX stream is filled by a sequence of Pause data-bursts, the Pa of the first Pause data-burst shall be located one data-burst repetition period following the Pa of

the previous Auro-Cx block. It is recommended that the sequence(s) of Pause data-bursts, which fill the stream gap, should continue from this point up to (as close as possible considering the total IEC 60958 frame length of the Pause data-burst) the Pa of the first ACX data-burst that follows the stream gap.

The gap length parameter contained in the Pause data-burst is intended to be interpreted by the Auro-Cx decoder as an indication of the number of decoded PCM samples that are missing (due to the resulting audio gap).

5.3 Audio data-bursts

5.3.1 ACX data-burst

An ACX bit stream consists of a sequence of Auro-Cx blocks. The ACX data-burst is headed with a burst-preamble, followed by the burst-payload and stuffing. The structure of the ACX data-burst is shown in Figure 1. The data-type of an ACX data-burst is 26 and the subdata-type is 0. When transmitting Auro-Cx data, the transmitter needs to set both the data-type and subdata-type correctly. The receiving device shall then use both values to make sure that the content of the data-burst is identified as Auro-Cx.

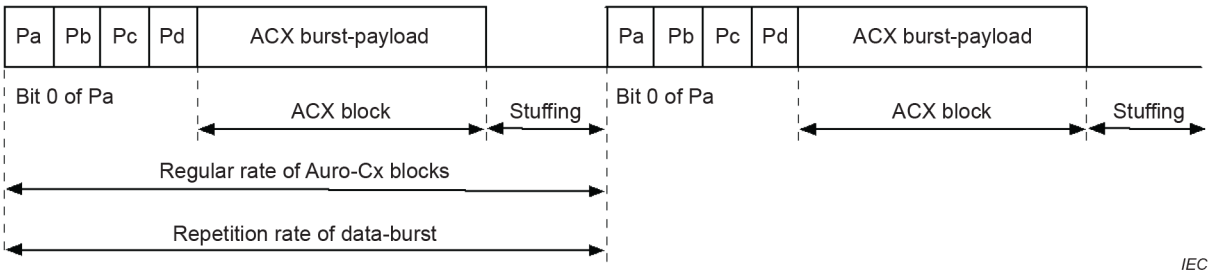


Figure 1 – ACX data-burst

The data-type dependent information for Auro-Cx is specified in Table 4.

Table 4 – Data-type-dependent information for ACX

Bits of Pc LSB..MSB	Value	Meaning
8–12	See Table 5.	Repetition period of the data-burst in IEC 60958 frames

The ACX burst-payload always contains a single Auro-Cx block. The transmitter shall therefore make sure that the ACX burst-payload is constructed from a single Auro-Cx block only. It is not allowed to transmit a single Auro-Cx block using multiple data-bursts. The length of the Auro-Cx data-burst will depend on the encoded block size.

The reference point R of an Auro-Cx data-burst is bit 0 of Pa. The block size of the Auro-Cx bit stream defines the repetition period of the Auro-Cx data-burst. The IEC 60958 frame rate shall be equal to the sample rate of the ACX bit stream. Because Auro-Cx supports multiple block sizes that match commonly used video frame rates, the transmitter shall ensure that the selected ACX data-burst repetition rate is equal to the block size, as specified in Table 5.

Table 5 – ACX data-burst: meaning of Pc bits 8 – 12

Value	Audio sample rate in kHz	IEC 60958 frame rate in kHz	Auro-Cx block size	Repetition period of Auro-Cx data-burst in IEC 60958 frames	Auro-Cx audio frame rate in fps
0	48	48	256	256	187,5
1			400	400	120
2			400 / 402 (see Table 7)	400 / 402 (see Table 7)	119,88
3			480	480	100
4			500	500	96
5			512	512	93,75
6			768	768	62,5
7			800	800	60
8			800 / 802 (see Table 7)	800 / 802 (see Table 7)	59,94
9			960	960	50
10			1 000	1 000	48
11			1 001	1 001	47,952
12			1 024	1 024	46,875
13			1 536	1 536	31,25
14			1 600	1 600	30
15			1 600 / 1 602 (see Table 7)	1 600 / 1 602 (see Table 7)	29,97
16			1 920	1 920	25
17			2 000	2 000	24
18			2 002	2 002	23,976
19			2 048	2 048	23,438
20			3 072	3 072	15,625
21			3 840	3 840	12,5
22			4 096	4 096	11,72
23–31			Reserved	Reserved	-
0	44,1	44,1	256	256	172,27
1–4			Reserved	Reserved	-
5			512	512	86,13
6			768	768	57,42
7–11			Reserved	Reserved	-
12			1 024	1 024	43,066
13			1 536	1 536	28,71
14–15			Reserved	Reserved	-
16			1 920	1 920	22,97
17–18			Reserved	Reserved	-
19			2 048	2 048	21,53
20			3 072	3 072	14,36
21			3 840	3 840	11,48
22			4 096	4 096	10,76
23–31			Reserved	Reserved	-

For higher audio sample rates (88,2 and 96kHz), the IEC 60958 frame rate and Auro-Cx audio frame rate are multiplied by 2, as shown in Table 6.

Table 6 – ACX IEC 60958 frame rate for high sample rates

Audio sample rate in kHz	IEC 60958 frame rate in kHz
88,2	88,2
96	96

The various Auro-Cx audio frame rates are defined to provide full synchronization with many possible video frame rates. For most video frame rates higher than 30 fps, a one-to-one match exists between the video frames and Auro-Cx blocks. However, for frame rates up to 30 fps, two Auro-Cx blocks are transmitted for each video frame. Note that several block sizes (256 spb, 512 spb, 768 spb, 1 024 spb, 1 536 spb, 2 048 spb, 3 072 spb, 3 840 spb and 4 096 spb) are typically used in audio-only applications.

For Auro-Cx audio frame rates of 29,97 fps, 59,94 fps and 119,88 fps, the duration of an Auro-Cx block does not correspond to an integer number of IEC 60958 frames. To ensure that precise time alignment is maintained between the Auro-Cx data-burst and the Auro-Cx audio frames at these frame rates, the repetition period of data-bursts varies so that over a sequence of 5 data bursts, the Auro-Cx data-bursts are time-aligned with the corresponding 5 audio frames, as specified in Table 7.

Table 7 – ACX repetition periods for fractional frame rates 29,97 fps, 59,94 fps and 119,88 fps

Auro-Cx audio frame rate in fps	Repetition period of ACX data-burst sequence in IEC 60958 frames				
	Data-burst 0	Data-burst 1	Data-burst 2	Data-burst 3	Data-burst 4
29,97	1 602	1 602	1 600	1 602	1 602
59,94	800	802	800	802	800
119,88	400	400	402	400	400

The burst-length (Pd) shall be expressed in bytes with a maximum value determined from 2 × 16 bits × $R_P - (P_{ABCD} + B_S)$, where

R_P repetition period of data-bursts in IEC 60958 frames

P_{ABCD} = 4 × 16 bits size of preamble words Pa-Pd

B_S = 4 × 16 bits burst spacing

The maximum size of an Auro-Cx burst-payload is dependent on the repetition rate of the data-burst and is specified in Table 8. The values shown assume a provision for two IEC 60958 frames for padding between bursts.

Table 8 – Maximum burst-length values per ACX data-burst repetition period

Auro-Cx block size	Repetition period of the Auro-Cx data-burst in IEC 60958 frames	Maximum burst-length of the Auro-Cx data-burst in bytes	Maximum bit-rate in Mbps (fs = 48 kHz)
256	256	1 008	1,512
400	400	1 584	1,521
400 / 402	400 / 402	1 584 / 1 592	1,521
480	480	1 904	1,523
500	500	1 984	1,524
512	512	2 032	1,524
768	768	3 056	1,528
800	800	3 184	1,528
800 / 802	800 / 802	3 184 / 3 192	1,528
960	960	3 824	1,530
1 000	1 000	3 984	1,530
1 001	1 001	3 988	1,530
1 024	1 024	4 080	1,530
1 536	1 536	6 128	1,532
1 600	1 600	6 384	1,532
1 600 / 1 602	1 600 / 1 602	6 384 / 6 392	1,532
1 920	1 920	7 664	1,533
2 000	2 000	7 984	1,533
2 002	2 002	7 992	1,533
2 048	2 048	8 176	1,533
3 072	3 072	12 272	1,534
3 840	3 840	15 344	1,534
4 096	4 096	16 368	1,535

5.3.2 Latency of the Auro-Cx Decoder

The latency of the Auro-Cx decoder is defined as the sum of the receiving delay time and decoding delay time, as shown in Figure 2.

The receiving delay time is the time required to receive the complete Auro-Cx burst-payload and is dependent on the encoded bitrate and audio frame rate of the Auro-Cx bit stream. To maintain synchronisation between audio and video, a constant value of receiving delay time is recommended for each block size and corresponding repetition period. The value is calculated using the size of an Auro-Cx burst-payload and is equal to the time occupied by the duration of the Auro-Cx data-burst in IEC 60958 frames at the IEC 60958 frame rate.

The decoding delay time is equal to the time occupied by the number of PCM samples represented by an Auro-Cx block at the Auro-Cx sample rate, as defined by the Auro-Cx block size, increased with the time occupied by 256 PCM samples at the Auro-Cx sample rate, represented by 256 IEC 60958 frames at the IEC 60958 frame rate.

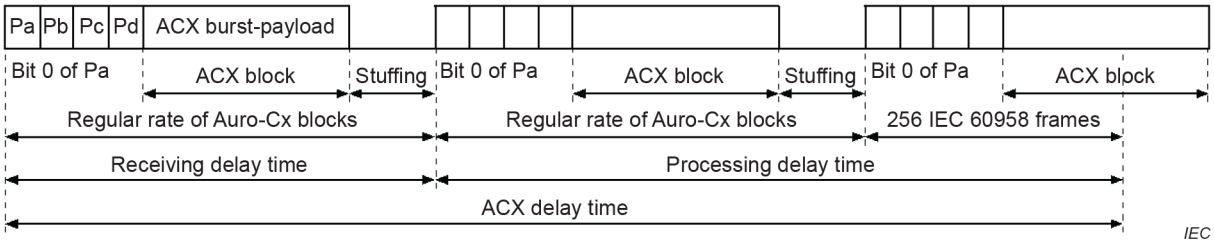


Figure 2 – ACX Delay Time

5.3.3 ACX HBR2 data-burst

If the required bit rate for Auro-Cx data exceeds the maximum data rate supported by the ACX data-burst, the ACX HBR2 data type is used instead. An ACX HBR2 bit stream consists of a sequence of Auro-Cx blocks. The ACX HBR2 data-burst is headed with a burst-preamble, followed by the burst-payload and stuffing. The structure of the ACX HBR2 data-burst is shown in Figure 3. The data-type of an ACX HBR2 data-burst is 26 and the subdata-type is 1. When transmitting ACX HBR2 data, the transmitter needs to set both the data-type and subdata-type correctly. The receiving device shall then use both values to make sure that the content of the data-burst is identified as ACX HBR2.

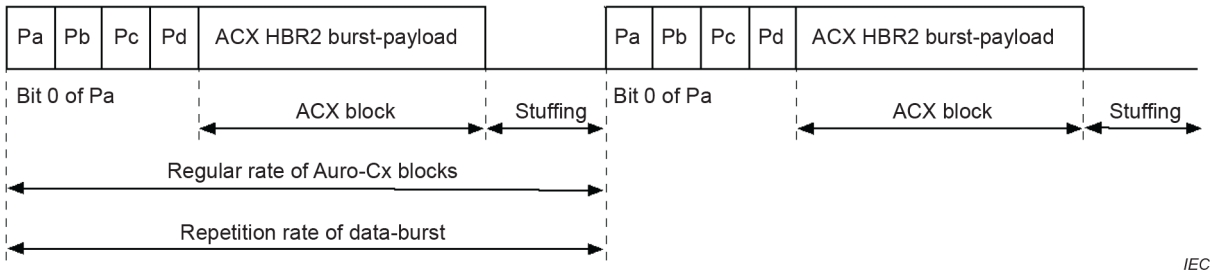


Figure 3 – Auro-Cx HBR2 data-burst

The data-type dependent information for ACX HBR2 is specified in Table 9.

Table 9 – Data-type-dependent information for ACX HBR2

Bits of Pc LSB..MSB	Value	Meaning
8–12	See Table 10.	Repetition period of the data-burst in IEC 60958 frames

The ACX HBR2 burst-payload always contains a single Auro-Cx block. The transmitter therefore shall make sure that the ACX HBR2 burst-payload is constructed from a single Auro-Cx block only. It is not allowed to transmit a single Auro-Cx block using multiple data-bursts. The length of the ACX HBR2 data-burst will depend on the encoded block size.

The reference point of an ACX HBR2 data-burst is bit 0 of Pa. The block size of the Auro-Cx bit stream defines the repetition period of the ACX HBR2 data-burst. The IEC 60958 frame rate shall be equal to twice the sample rate of the Auro-Cx bit stream. Because Auro-Cx supports multiple block sizes that match commonly used video frame rates, the transmitter shall ensure that the selected ACX data-burst repetition rate is equal to the block size, multiplied by the HBR factor 2, as specified in Table 10.

Table 10 – ACX HBR2 data-burst: meaning of Pc bits 8 – 12

Value	Audio sample rate in kHz	IEC 60958 frame rate in kHz	Auro-Cx block size	Repetition period of Auro-Cx data-burst in IEC 60958 frames	Auro-Cx audio frame rate in fps
0	48	96	256	512	187,5
1			400	800	120
2			400 / 402 (see Table 12)	800 / 804 (see Table 12)	119,88
3			480	960	100
4			500	1 000	96
5			512	1 024	93,75
6			768	1 536	62,5
7			800	1 600	60
8			800 / 802 (see Table 12)	1 600 / 1 604 (see Table 12)	59,94
9			960	1 920	50
10			1 000	2 000	48
11			1 001	2 002	47,952
12			1 024	2 048	46,875
13			1 536	3 072	31,25
14			1 600	3 200	30
15			1 600 / 1 602 (see Table 12)	3 200 / 3 204 (see Table 12)	29,97
16			1 920	3 840	25
17			2 000	4 000	24
18			2 002	4 004	23,976
19			2 048	4 096	23,438
20			3 072	6 144	15,625
21			3 840	7 680	12,5
22			4 096	8192	11,72
23–31			Reserved	Reserved	-
0	44,1	88,2	256	512	172,27
1–4			Reserved	Reserved	-
5			512	1 024	86,13
6			768	1 536	57,42
7–11			Reserved	Reserved	-
12			1 024	2 048	43,066
13			1 536	3 072	28,71
14–15			Reserved	Reserved	-
16			1 920	3 840	22,97
17–18			Reserved	Reserved	-
19			2 048	4 096	21,53
20			3 072	6 144	14,36
21			3 840	7 680	11,48
22			4 096	8 192	10,76
23–31			Reserved	Reserved	-

For higher audio sample rates (88,2 and 96kHz), the IEC 60958 frame rate and Auro-Cx audio frame rate are multiplied by 2, as shown in Table 11.

Table 11 – ACX HBR2 IEC 60958 frame rate for high sample rates

Audio sample rate in kHz	IEC 60958 frame rate in kHz
88,2	176,4
96	192

The various Auro-Cx audio frame rates are defined to provide full synchronization with many possible video frame rates. For most video frame rates higher than 30 fps, a one-to-one match exists between the video frames and Auro-Cx blocks. However, for frame rates up to 30 fps, two Auro-Cx blocks are transmitted for each video frame. Note that several block sizes (256 spb, 512 spb, 768 spb, 1 024 spb, 1 536 spb, 2 048 spb, 3 072 spb, 3 840 spb and 4 096 spb) are typically used in audio-only applications.

For Auro-Cx audio frame rates of 29,97 fps, 59,94 fps and 119,88 fps, the duration of an Auro-Cx block does not correspond to an integer number of IEC 60958 frames. To ensure that precise time alignment is maintained between the Auro-Cx data-burst and the Auro-Cx audio frames at these frame rates, the repetition period of data-bursts varies so that over a sequence of 5 data bursts, the Auro-Cx data-bursts are time-aligned with the corresponding 5 audio frames, as specified in Table 12.

Table 12 – ACX HBR2 repetition periods for fractional frame rates 29,97 fps, 59,94 fps and 119,88 fps

Auro-Cx audio frame rate in fps	Repetition period of ACX data-burst sequence in IEC 60958 frames				
	Data-burst 0	Data-burst 1	Data-burst 2	Data-burst 3	Data-burst 4
29,97	3 204	3 204	3 200	3 204	3 204
59,94	1 600	1 604	1 600	1 604	1 600
119,88	800	800	804	800	800

The burst-length (Pd) shall be expressed in bytes with a maximum value determined from 2 × 16 bits × $R_P - (P_{ABCD} + B_S)$, where

R_P repetition period of data-bursts in IEC 60958 frames

P_{ABCD} = 4 × 16 bits size of preamble words Pa-Pd

B_S = 4 × 16 bits burst spacing

The maximum size of an Auro-Cx burst-payload is dependent on the repetition rate of the data-burst and is specified in Table 13. The values shown assume a provision for two IEC 60958 frames for padding between bursts.

Table 13 – Maximum burst-length values per ACX HBR2 data-burst repetition period

Auro-Cx block size	Repetition period of the Auro-Cx data-burst in IEC 60958 frames	Maximum burst-length of the Auro-Cx data-burst in bytes	Maximum bit-rate in Mbps (fs = 48 kHz)
256	512	2 032	3,048
400	800	3 184	3,057
400 / 402	800 / 804	3 184 / 3 200	3,059
480	960	3 824	3,059
500	1 000	3 984	3,060
512	1 024	4 080	3,060
768	1 536	6 128	3,064
800	1 600	6 384	3,064
800 / 802	1 600 / 1 604	6 384 / 6 400	3,064
960	1 920	7 664	3,066
1 000	2 000	7 984	3,066
1 001	2 002	7 992	3,066
1 024	2 048	8 176	3,066
1 536	3 072	12 272	3,068
1 600	3 200	12 784	3,068
1 600 / 1 602	3 200 / 3 204	12 784 / 12 800	3,068
1 920	3 840	15 344	3,069
2 000	4 000	15 984	3,069
2 002	4 004	16 000	3,069
2 048	4 096	16 368	3,069
3 072	6 144	24 560	3,070
3 840	7 680	30 704	3,070
4 096	8 192	32 752	3,071

5.3.4 Latency of the ACX HBR2 Decoder

The latency of the ACX HBR2 decoder is defined as the sum of the receiving delay time and decoding delay time, as shown in Figure 4.

The receiving delay time is the time required to receive the complete Auro-Cx burst-payload and is dependent on the encoded bitrate and audio frame rate of the Auro-Cx bit stream. To maintain synchronisation between audio and video, a constant value of receiving delay time is recommended for each block size and corresponding repetition period. The value is calculated using the size of an Auro-Cx burst-payload and is equal to the time occupied by the duration of the Auro-Cx data-burst in IEC 60958 frames at the IEC 60958 frame rate.

The decoding delay time is equal to the time occupied by the number of PCM samples represented by an Auro-Cx block at the Auro-Cx sample rate, as defined by the Auro-Cx block size, increased with the time occupied by 256 PCM samples at the Auro-Cx sample rate, represented by 512 IEC 60958 frames at the IEC 60958 frame rate.

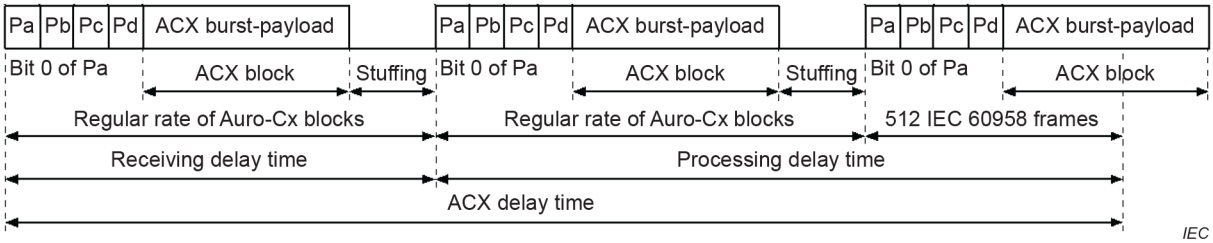


Figure 4 – ACX HBR2 Delay Time

5.3.5 ACX HBR4 data-burst

If the required bitrate for Auro-Cx data exceeds the maximum data rate supported by the ACX data-burst, the ACX HBR4 data type is used instead. An ACX HBR4 bit stream consists of a sequence of Auro-Cx blocks. The ACX HBR4 data-burst is headed with a burst-preamble, followed by the burst-payload and stuffing. The structure of the ACX HBR4 data-burst is shown in Figure 5. The data-type of an ACX HBR4 data-burst is 26 and the subdata-type is 2. When transmitting ACX HBR4 data, the transmitter needs to set both the data-type and subdata-type correctly. The receiving device shall then use both values to make sure that the content of the data-burst is identified as ACX HBR4.

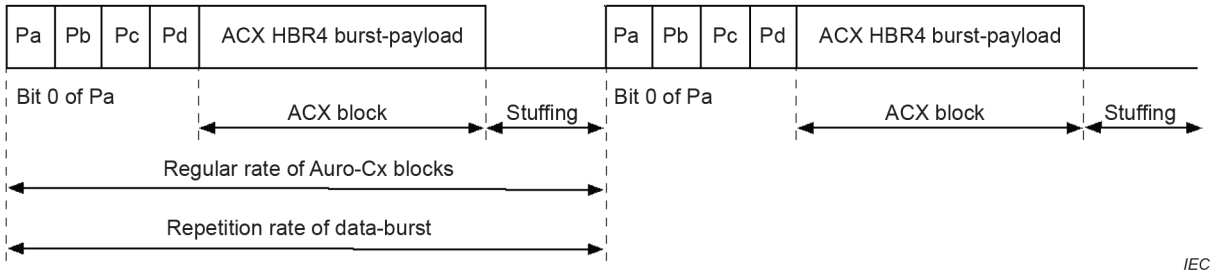


Figure 5 – Auro-Cx HBR4 data-burst

The data-type dependent information for ACX HBR4 is specified in Table 14.

Table 14 – Data-type-dependent information for ACX HBR4

Bits of Pc LSB..MSB	Value	Meaning
8–12	See Table 15.	Repetition period of the data-burst in IEC 60958 frames

The ACX HBR4 burst-payload always contains a single Auro-Cx block. The transmitter shall therefore make sure that the ACX HBR4 burst-payload is constructed from a single Auro-Cx block only. It is not allowed to transmit a single Auro-Cx block using multiple data-bursts. The length of the ACX HBR4 data-burst will depend on the encoded block size.

The reference point of an ACX HBR4 data-burst is bit 0 of Pa. The block size of the Auro-Cx bit stream defines the repetition period of the ACX HBR4 data-burst. The IEC 60958 frame rate shall be equal to four times the sample rate of the Auro-Cx bit stream. As Auro-Cx supports multiple block sizes that match commonly used video frame rates, the transmitter shall ensure that the selected ACX data-burst repetition rate is equal to the block size, multiplied by the HBR factor 4, as specified in Table 15.

Table 15 – ACX HBR4 data-burst: meaning of Pc bits 8–12

Value	Audio sample rate in kHz	IEC 60958 frame rate in kHz	Auro-Cx block size	Repetition period of Auro-Cx data-burst in IEC 60958 frames	Auro-Cx audio frame rate in fps
0	48	192	256	1 024	187,5
1			400	1 600	120
2			400 / 402 (see Table 17)	1 600 / 1 608 (see Table 17)	119,88
3			480	1 920	100
4			500	2 000	96
5			512	2 048	93,75
6			768	3 072	62,5
7			800	3 200	60
8			800 / 802 (see Table 17)	3 200 / 3 208 (see Table 17)	59,94
9			960	3 840	50
10			1 000	4 000	48
11			1 001	4 004	47,952
12			1 024	4 096	46,875
13			1 536	6 144	31,25
14			1 600	6 400	30
15			1 600 / 1 602 (see Table 17)	6 400 / 6 408 (see Table 17)	29,97
16			1 920	7 680	25
17			2 000	8 000	24
18			2 002	8 008	23,976
19			2 048	8 192	23,438
20			3 072	12 288	15,625
21			3 840	15 360	12,5
22			4 096	16 384	11,72
23–31			Reserved	Reserved	-
0	44,1	176,4	256	1 024	172,27
1–4			Reserved	Reserved	-
5			512	2 048	86,13
6			768	3 072	57,42
7–11			Reserved	Reserved	-
12			1 024	4 096	43,066
13			1 536	6 144	28,71
14–15			Reserved	Reserved	-
16			1 920	7 680	22,97
17–18			Reserved	Reserved	-
19			2 048	8 192	21,53
20			3 072	12 288	14,36
21			3 840	15 360	11,48
22			4 096	16 384	10,76
23–31			Reserved	Reserved	-

For higher audio sample rates (88,2 kHz and 96 kHz), the IEC 60958 frame rate and Auro-Cx audio frame rate are multiplied by 2, as shown in Table 16.

Table 16 – ACX HBR4 IEC 60958 frame rate for high sample rates

Audio sample rate in kHz	IEC 60958 frame rate in kHz
88,2	352,8
96	384

The various Auro-Cx audio frame rates are defined to provide full synchronization with many possible video frame rates. For most video frame rates higher than 30 fps, a one-to-one match exists between the video frames and Auro-Cx blocks. However, for frame rates up to 30 fps, two Auro-Cx blocks are transmitted for each video frame. Note that several block sizes (256 spb, 512 spb, 768 spb, 1 024 spb, 1 536 spb, 2 048 spb, 3 072 spb, 3 840 spb and 4 096 spb) are typically used in audio-only applications.

For Auro-Cx audio frame rates of 29,97 fps, 59,94 fps and 119,88 fps, the duration of an Auro-Cx block does not correspond to an integer number of IEC 60958 frames. To ensure that precise time alignment is maintained between the Auro-Cx data-burst and the Auro-Cx audio frames at these frame rates, the repetition period of data-bursts varies so that over a sequence of 5 data bursts, the Auro-Cx data-bursts are time-aligned with the corresponding 5 audio frames, as specified in Table 17.

Table 17 – ACX HBR4 repetition periods for fractional frame rates 29,97 fps, 59,94 fps and 119,88 fps

Auro-Cx audio frame rate in fps	Repetition period of ACX data-burst sequence in IEC 60958 frames				
	Data-burst 0	Data-burst 1	Data-burst 2	Data-burst 3	Data-burst 4
29,97	6 408	6 408	6 400	6 408	6 408
59,94	3 200	3 208	3 200	3 208	3 200
119,88	1 600	1 600	1 608	1 600	1 600

The burst-length (Pd) shall be expressed in bytes with a maximum value determined from 2 × 16 bits × $R_P - (P_{ABCD} + B_S)$, where

R_P repetition period of data-bursts in IEC 60958 frames

P_{ABCD} = 4 × 16 bits size of preamble words Pa-Pd

B_S = 4 × 16 bits burst spacing

The maximum size of an Auro-Cx burst-payload is dependent on the repetition rate of the data-burst and is specified in Table 18. The values shown assume a provision for two IEC 60958 frames for padding between bursts.

Table 18 – Maximum burst-length values per ACX HBR4 data-burst repetition period

Auro-Cx block size	Repetition period of the Auro-Cx data-burst in IEC 60958 frames	Maximum burst-length of the Auro-Cx data-burst in bytes	Maximum bit-rate in Mbps (fs = 48 kHz)
256	1 024	4 080	6,120
400	1 600	6 384	6,129
400 / 402	1 600/ 1 608	6 384 / 6 416	6,129
480	1 920	7 664	6,131
500	2 000	7 984	6,132
512	2 048	8 176	6,132
768	3 072	12 272	6,136
800	3 200	12 784	6,136
800 / 802	3 200 / 3 208	12 784 / 12 816	6,136
960	3 840	15 344	6,138
1 000	4 000	15 984	6,138
1 001	4 004	16 000	6,138
1 024	4 096	16 368	6,138
1 536	6 144	24 560	6,140
1 600	6 400	25 584	6,140
1 600 / 1 602	6 400 / 6 408	25 584 / 25 616	6,140
1 920	7 680	30 704	6,141
2 000	8 000	31 984	6,141
2 002	8 008	32 016	6,141
2 048	8 192	32 752	6,141
3 072	12 288	49 136	6,142
3 840	15 360	61 424	6,142

5.3.6 Latency of the ACX HBR4 Decoder

The latency of the ACX HBR4 decoder is defined as the sum of the receiving delay time and decoding delay time, as shown in Figure 6.

The receiving delay time is the time required to receive the complete Auro-Cx burst-payload and is dependent on the encoded bitrate and audio frame rate of the Auro-Cx bit stream. To maintain synchronisation between audio and video, a constant value of receiving delay time is recommended for each block size and corresponding repetition period. The value is calculated using the size of an Auro-Cx burst-payload and is equal to the time occupied by the duration of the Auro-Cx data-burst in IEC 60958 frames at the IEC 60958 frame rate.

The decoding delay time is equal to the time occupied by the number of PCM samples represented by an Auro-Cx Block at the Auro-Cx sample rate, as defined by the Auro-Cx block size, increased with the time occupied by 256 PCM samples at the Auro-Cx sample rate, represented by 1 024 IEC 60958 frames at the IEC 60958 frame rate.

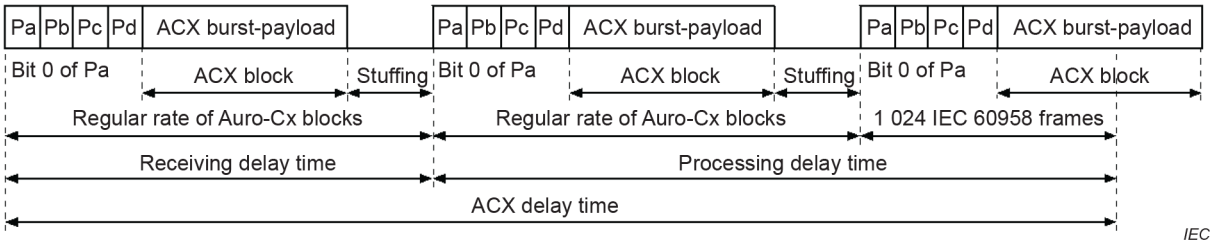


Figure 6 – ACX HBR4 Delay time

5.3.7 ACX HBR8 data-burst

If the required bitrate for Auro-Cx data exceeds the maximum data rate supported by the ACX data-burst, the ACX HBR8 data type is used instead. An ACX HBR8 bit stream consists of a sequence of Auro-Cx blocks. The ACX HBR8 data-burst is headed with a burst-preamble, followed by the burst-payload and stuffing. The structure of the ACX HBR8 data-burst is shown in Figure 7. The data-type of an ACX HBR8 data-burst is 26 and the subdata-type is 3. When transmitting ACX HBR8 data, the transmitter needs to set both the data-type and subdata-type correctly. The receiving device shall then use both values to make sure that the content of the data-burst is identified as ACX HBR8.

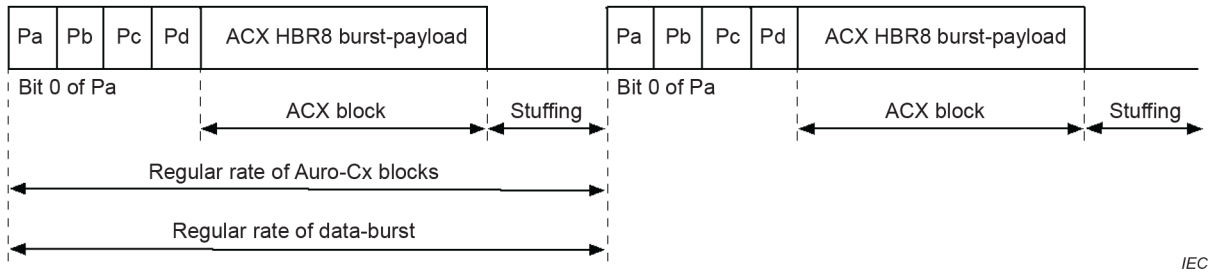


Figure 7 – Auro-Cx HBR8 data-burst

The data-type-dependent information for ACX HBR8 is specified in Table 19.

Table 19 – Data-type-dependent information for ACX HBR8

Bits of Pc LSB..MSB	Value	Meaning
8–12	See Table 20.	Repetition period of the data-burst in IEC 60958 frames

The ACX HBR8 burst-payload always contains a single Auro-Cx block. The transmitter shall therefore make sure that the ACX HBR8 burst-payload is constructed from a single Auro-Cx block only. It is not allowed to transmit a single Auro-Cx block using multiple data-bursts. The length of the ACX HBR8 data-burst will depend on the encoded block size.

The reference point of an ACX HBR8 data-burst is bit 0 of Pa. The block size of the Auro-Cx bit stream defines the repetition period of the ACX HBR8 data-burst. The IEC 60958 frame rate shall be equal to eight times the sample rate of the Auro-Cx bit stream. Because Auro-Cx supports multiple block sizes that match commonly used video frame rates, the transmitter shall ensure that the selected ACX data-burst repetition rate is equal to the block size, multiplied by the HBR factor 4, as specified in Table 20.

Table 20 – ACX HBR8 data-burst: meaning of Pc bits 8 – 12

Value	Audio sample rate in kHz	IEC 60958 frame rate in kHz	Auro-Cx block size	Repetition period of Auro-Cx data-burst in IEC 60958 frames	Auro-Cx audio frame rate in fps
0	48	384	256	2 048	187,5
1			400	3 200	120
2			400 / 402 (see Table 22)	3 200 / 3 216 (see Table 22)	119,88
3			480	3 840	100
4			500	4 000	96
5			512	4 096	93,75
6			768	6 144	62,5
7			800	6 400	60
8			800 / 802 (see Table 22)	6 400 / 6 416 (see Table 22)	59,94
9			960	7 680	50
10			1 000	8 000	48
11			1 001	8 008	47,952
12			1 024	8 192	46,875
13			1 536	12 288	31,25
14			1 600	12 800	30
15			1 600 / 1 602 (see Table 22)	12 800 / 12 816 (see Table 22)	29,97
16			1 920	15 360	25
17			2 000	16 000	24
18			2 002	16 016	23,976
19			2 048	16 384	23,438
20			3 072	24 576	15,625
21			3 840	30 720	12,5
22			4 096	32 768	11,72
23–31			Reserved	Reserved	-
0	44,1	352,8	256	2 048	172,27
1–4			Reserved	Reserved	-
5			512	4 096	86,13
6			768	6 144	57,42
7–11			Reserved	Reserved	-
12			1 024	8 192	43,066
13			1 536	12 288	28,71
14–15			Reserved	Reserved	-
16			1 920	15 360	22,97
17–18			Reserved	Reserved	-
19			2 048	16 382	21,53
20			3 072	24 576	14,36
21			3 840	30 720	11,48
22			4 096	32 768	10,76
23–31			Reserved	Reserved	-

For higher audio sample rates (88,2 kHz and 96 kHz), the IEC 60958 frame rate and Auro-Cx audio frame rate are multiplied by 2, as shown in Table 21.

Table 21 – ACX HBR8 IEC 60958 frame rate for high sample rates

Audio sample rate in kHz	IEC 60958 frame rate in kHz
88,2	705,6
96	768

The various Auro-Cx audio frame rates are defined to provide full synchronization with many possible video frame rates. For most video frame rates higher than 30 fps, a one-to-one match exists between the video frames and Auro-Cx blocks. However, for frame rates up to 30 fps, two Auro-Cx blocks are transmitted for each video frame. Note that several block sizes (256 spb, 512 spb, 768 spb, 1 024 spb, 1 536 spb, 2 048 spb, 3 072 spb, 3 840 spb and 4 096 spb) are typically used in audio only applications.

For Auro-Cx audio frame rates of 29,97 fps, 59,94 fps and 119,88 fps, the duration of an Auro-Cx Block does not correspond to an integer number of IEC 60958 frames. To ensure that precise time alignment is maintained between the Auro-Cx data-burst and the Auro-Cx audio frames at these frame rates, the repetition period of data-bursts varies so that over a sequence of 5 data bursts, the Auro-Cx data-bursts are time-aligned with the corresponding 5 audio frames, as specified in Table 22.

Table 22 – ACX HBR8 repetition periods for fractional frame rates 29,97 fps, 59,94 fps and 119,88 fps

Auro-Cx audio frame rate in fps	Repetition period of ACX data-burst sequence in IEC 60958 frames				
	Data-burst 0	Data-burst 1	Data-burst 2	Data-burst 3	Data-burst 4
29,97	12 816	12 816	12 800	12 816	12 816
59,94	6 400	6 416	6 400	6 416	6 400
119,88	3 200	3 200	3 216	3 200	3 200

The burst-length (Pd) shall be expressed in bytes with a maximum value determined from 2 × 16 bits × $R_P - (P_{ABCD} + B_S)$, where

R_P repetition period of data-bursts in IEC 60958 frames

P_{ABCD} = 4 × 16 bits size of preamble words Pa-Pd

B_S = 4 × 16 bits burst spacing

The maximum size of an Auro-Cx burst-payload is dependent on the repetition rate of the data-burst and is specified in Table 23. The values shown assume a provision for two IEC 60958 frames for padding between bursts.

Table 23 – Maximum burst-length values per ACX HBR8 data-burst repetition period

Auro-Cx block size	Repetition period of the Auro-Cx data-burst in IEC 60958 frames	Maximum burst-length of the Auro-Cx data-burst in bytes	Maximum bit-rate in Mbps (fs = 48 kHz)
256	2 048	8 176	12,264
400	3 200	12 784	12,273
400 / 402	3 200 / 3 216	12 784 / 12 848	12,273
480	3 840	15 344	12,275
500	4 000	15 984	12,276
512	4 096	16 368	12,276
768	6 144	24 560	12,280
800	6 400	25 584	12,280
800 / 802	6 400 / 6 416	25 584 / 25 648	12,280
960	7 680	30 704	12,282
1 000	8 000	31 984	12,282
1 001	8 008	32 016	12,282
1 024	8 192	32 752	12,282
1 536	12 288	49 136	12,284
1 600	12 800	51 184	12,284
1 600 / 1 602	12 800 / 12 816	51 184 / 51 248	12,284
1 920	15 360	61 424	12,285
2 000	16 000	63 984	12,285
2 002	16 016	64 048	12,285
2 048	16 384	65 520	12,285

5.3.8 Latency of the ACX HBR8 Decoder

The latency of the ACX HBR8 decoder is defined as the sum of the receiving delay time and decoding delay time, as shown in Figure 8.

The receiving delay time is the time required to receive the complete Auro-Cx burst-payload and is dependent on the encoded bitrate and audio frame rate of the Auro-Cx bit stream. To maintain synchronisation between audio and video, a constant value of receiving delay time is recommended for each block size and corresponding repetition period. The value is calculated using the size of an Auro-Cx burst-payload and is equal to the time occupied by the duration of the Auro-Cx data-burst in IEC 60958 frames at the IEC 60958 frame rate.

The decoding delay time is equal to the time occupied by the number of PCM samples represented by an Auro-Cx block at the Auro-Cx sample rate, as defined by the Auro-Cx block size, increased with the time occupied by 256 PCM samples at the Auro-Cx sample rate, represented by 2 048 IEC 60958 frames at the IEC 60958 frame rate.

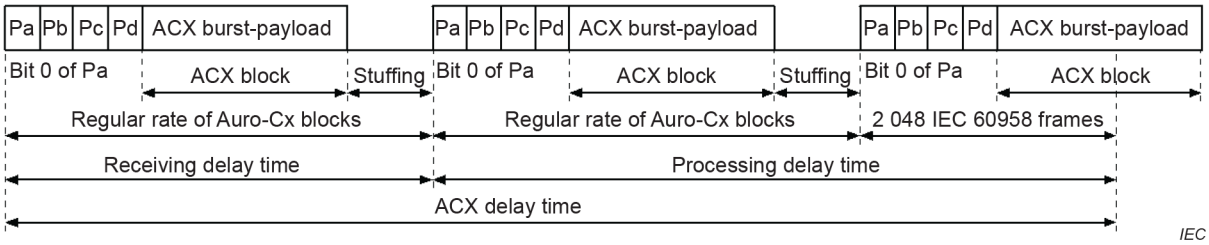


Figure 8 – ACX HBR8 Delay Time

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https://www.auro-3d.com/professional/technical-docs/

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