

# INTERNATIONAL STANDARD

**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**

INTERNATIONAL  
ELECTROTECHNICAL  
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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

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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.

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## INTRODUCTION

The Auro-3D®<sup>1</sup> 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®<sup>2</sup>.

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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<sup>1</sup> 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.

<sup>2</sup> 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<sup>3</sup> 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).

<sup>3</sup> 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.

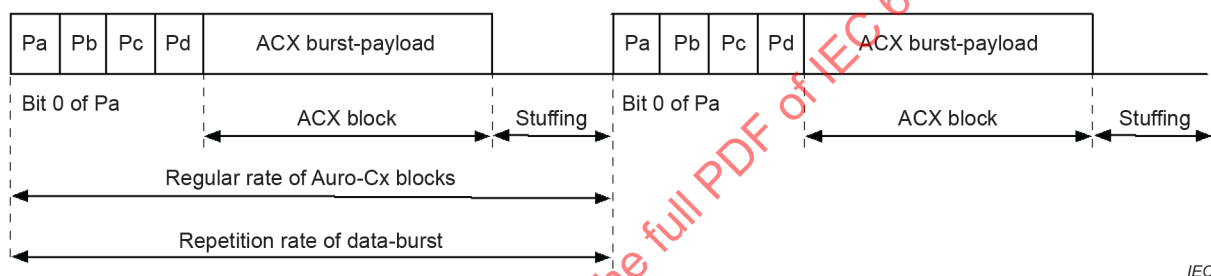


Figure 1 – ACX data-burst

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

Table 4 – Data-type-dependent information for ACX

| Bits of Pc<br>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<br>(see Table 7)     | 400 / 402<br>(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<br>(see Table 7)     | 800 / 802<br>(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<br>(see Table 7) | 1 600 / 1 602<br>(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 ( $P_d$ ) shall be expressed in bytes with a maximum value determined from  $2 \times 16 \text{ bits} \times R_p - (P_{ABCD} + B_s)$ , where

$R_p$  repetition period of data-bursts in IEC 60958 frames

$P_{ABCD} = 4 \times 16 \text{ bits}$  size of preamble words Pa-Pd

$B_s = 4 \times 16 \text{ bits}$  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**

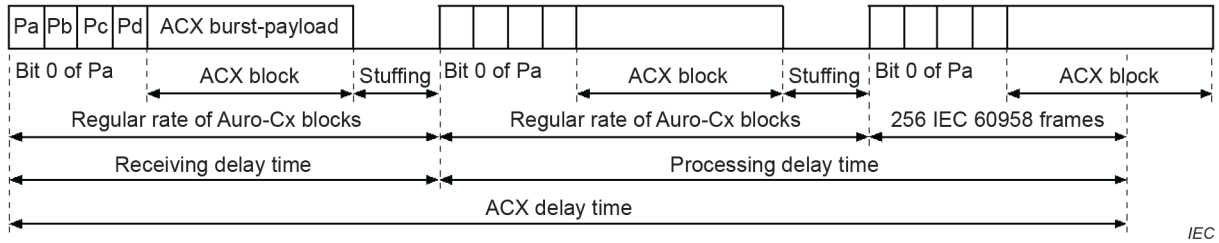
| Auro-Cx block size | Repetition period of the Auro-Cx data-burst in IEC 60958 frames | Maximum burst-length of the Auro-Cx data-burst in bytes | Maximum bit-rate in Mbps<br>(fs = 48 kHz) |
|--------------------|-----------------------------------------------------------------|---------------------------------------------------------|-------------------------------------------|
| 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.

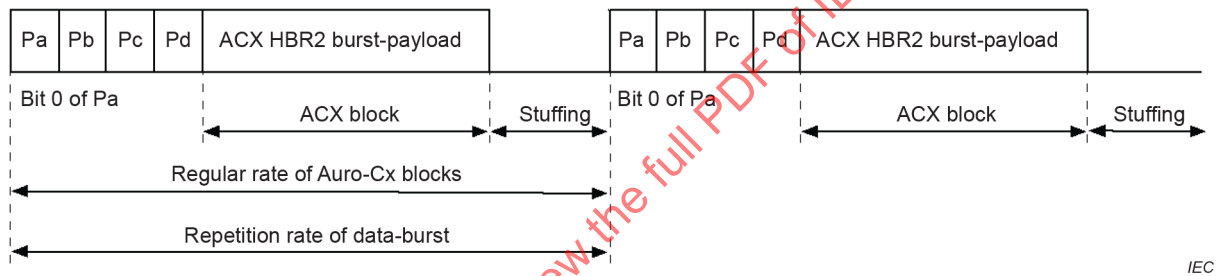
The decoding delay time is equal to the time occupied by the number of PCM samples represented by an Auro-Cx block at the Auro-Cx sample rate, as defined by the Auro-Cx block size, increased with the time occupied by 256 PCM samples at the Auro-Cx sample rate, represented by 256 IEC 60958 frames at the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



**Figure 2 – ACX Delay Time**

### 5.3.3 ACX HBR2 data-burst

If the required bit rate for Aero-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 Aero-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 – Aero-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<br>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 Aero-Cx block. The transmitter therefore shall make sure that the ACX HBR2 burst-payload is constructed from a single Aero-Cx block only. It is not allowed to transmit a single Aero-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 Aero-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 Aero-Cx bit stream. Because Aero-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<br>(see Table 12)     | 800 / 804<br>(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<br>(see Table 12)     | 1 600 / 1 604<br>(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<br>(see Table 12) | 3 200 / 3 204<br>(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                           | 8 192                                                       | 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 ( $P_d$ ) shall be expressed in bytes with a maximum value determined from  $2 \times 16 \text{ bits} \times R_P - (P_{ABCD} + B_S)$ , where

$R_P$  repetition period of data-bursts in IEC 60958 frames

$P_{ABCD} = 4 \times 16 \text{ bits}$  size of preamble words Pa-Pd

$B_S = 4 \times 16 \text{ bits}$  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**

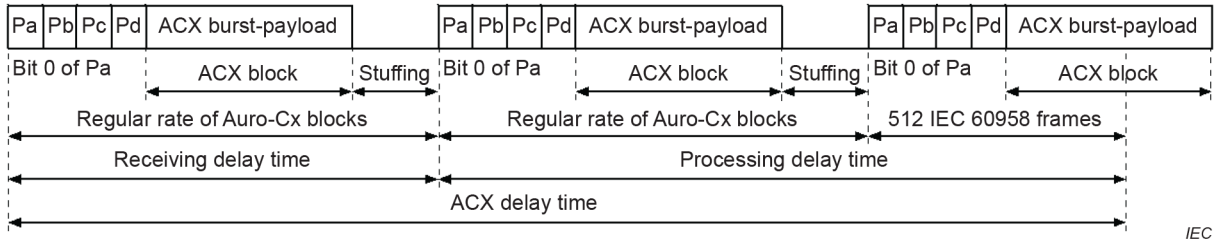
| Auro-Cx block size | Repetition period of the Auro-Cx data-burst in IEC 60958 frames | Maximum burst-length of the Auro-Cx data-burst in bytes | Maximum bit-rate in Mbps<br>(fs = 48 kHz) |
|--------------------|-----------------------------------------------------------------|---------------------------------------------------------|-------------------------------------------|
| 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.

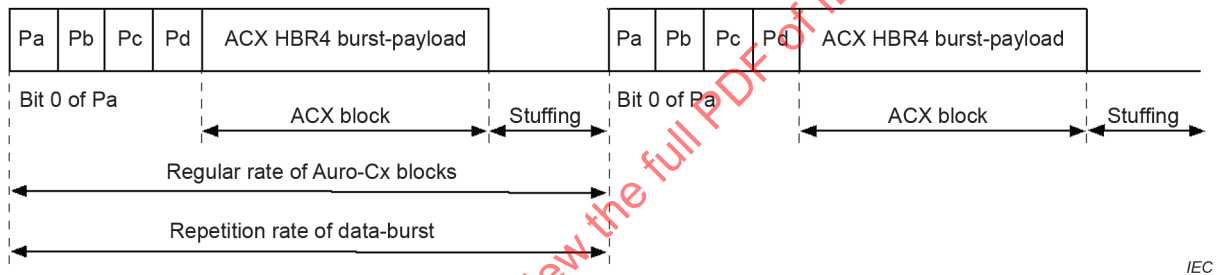
The decoding delay time is equal to the time occupied by the number of PCM samples represented by an Auro-Cx block at the Auro-Cx sample rate, as defined by the Auro-Cx block size, increased with the time occupied by 256 PCM samples at the Auro-Cx sample rate, represented by 512 IEC 60958 frames at the 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<br>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<br>(see Table 17)     | 1 600 / 1 608<br>(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<br>(see Table 17)     | 3 200 / 3 208<br>(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<br>(see Table 17) | 6 400 / 6 408<br>(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 ( $P_d$ ) shall be expressed in bytes with a maximum value determined from  $2 \times 16 \text{ bits} \times R_P - (P_{ABCD} + B_S)$ , where

$R_P$  repetition period of data-bursts in IEC 60958 frames

$P_{ABCD} = 4 \times 16 \text{ bits}$  size of preamble words Pa-Pd

$B_S = 4 \times 16 \text{ bits}$  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**

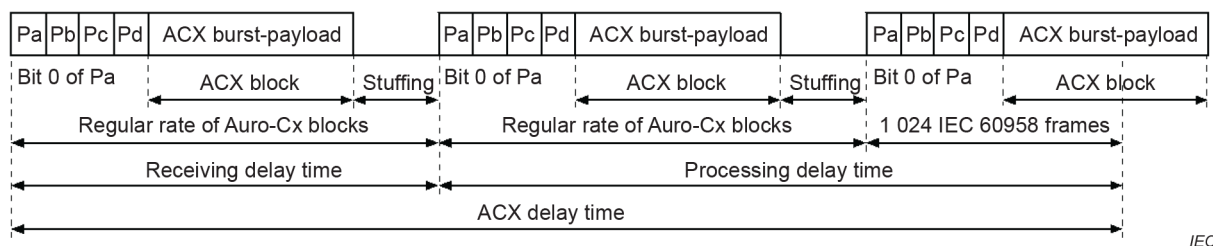
| Auro-Cx block size | Repetition period of the Auro-Cx data-burst in IEC 60958 frames | Maximum burst-length of the Auro-Cx data-burst in bytes | Maximum bit-rate in Mbps<br>(fs = 48 kHz) |
|--------------------|-----------------------------------------------------------------|---------------------------------------------------------|-------------------------------------------|
| 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.

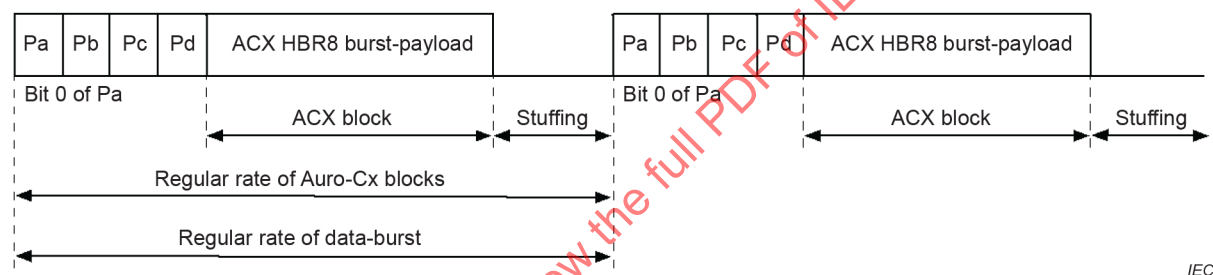
The decoding delay time is equal to the time occupied by the number of PCM samples represented by an Auro-Cx Block at the Auro-Cx sample rate, as defined by the Auro-Cx block size, increased with the time occupied by 256 PCM samples at the Auro-Cx sample rate, represented by 1 024 IEC 60958 frames at 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<br>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<br>(see Table 22)     | 3 200 / 3 216<br>(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<br>(see Table 22)     | 6 400 / 6 416<br>(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<br>(see Table 22) | 12 800 / 12 816<br>(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.