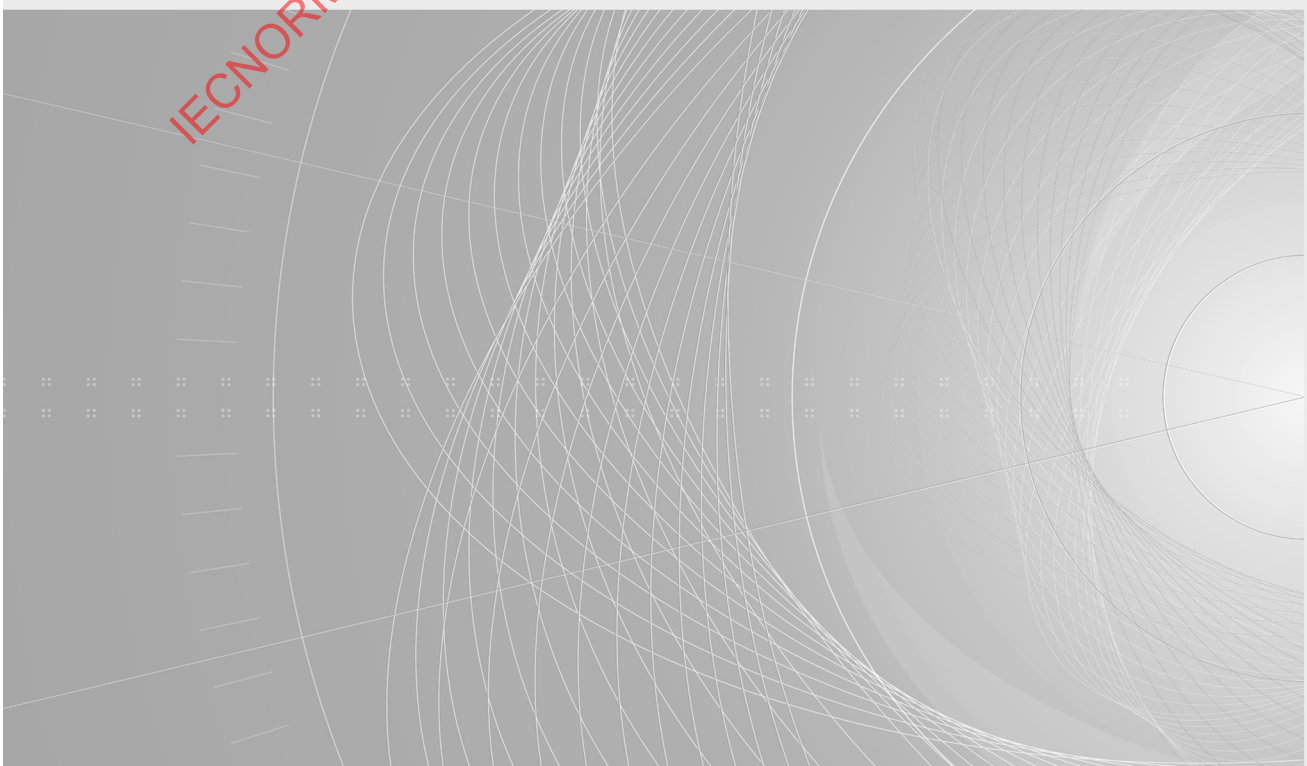
IEC 61937-3

Edition 3.0 2017-07

INTERNATIONAL STANDARD

Digital audio – Interface for non-linear PCM encoded audio bitstreams applying IEC 60958 –
Part 3: Non-linear PCM bitstreams according to the AC-3 and enhanced AC-3 formats



IEC 61937-3:2017-07(en)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 33.160.30

ISBN 978-2-8322-4557-6

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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Part 3: Non-linear PCM bitstreams according to the AC-3 and enhanced AC-3 formats

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International Standard IEC 61937-3 has been prepared by subcommittee technical area 4: Digital system interfaces and protocols, of IEC technical committee 100: Audio, video and multimedia systems and equipment.

This third edition of IEC 61937-3 cancels and replaces the second edition published in 2007. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) removal of support for enhanced AC-3 bitstreams with a sampling frequency of 32 kHz;
b) updates to normative and informative references;
c) clarification of pause data-burst usage for enhanced AC-3 bitstreams.

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

CDV	Report on voting
100/2720/CDV	100/2934/RVC

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 61973 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 "http://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- withdrawn,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.

A bilingual version of this publication may be issued at a later date.

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

Part 3: Non-linear PCM bitstreams according to the AC-3 and enhanced AC-3 formats

1 Scope

This part of IEC 61937 describes the method used to convey non-linear PCM bitstreams encoded according to the AC-3 and enhanced AC-3 formats.

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 61937-1:2007, *Digital audio interface for non-linear PCM encoded audio bit streams applying IEC 60958 – Part 1: General*

IEC 61937-1:2007/AMD1:2011, *Digital audio interface for non-linear PCM encoded audio bit streams applying IEC 60958 – Part 1: General*

IEC 61937-2, *Digital audio interface for non-linear PCM encoded audio bit streams applying IEC 60958 – Part 2: Burst-info*

ETSI TS 102 366, *Digital Audio Compression (AC-3, Enhanced AC-3) Standard*

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
block identification flag
flag used to indicate that the first audio block of an enhanced AC-3 syncframe with a stream type value of two formed the first audio block in the AC-3 syncframe from which it was converted

3.2
converter synchronization flag
flag used for synchronization by a device that converts an enhanced AC-3 bitstream to a bitstream compliant with an AC-3 decoder and indicates that the first block in this enhanced AC-3 syncframe will form the first block of the AC-3 syncframe output by the conversion process

3.3
latency
delay time of an external audio decoder to decode an AC-3 or enhanced AC-3 data-burst, defined as the sum of two values: the receiving delay time and the decoding delay time

3.4
stream type
parameter of an enhanced AC-3 syncframe identifying the type of substream of which the syncframe is a part

Note 1 to entry: An enhanced AC-3 bitstream is constructed from one or more substreams, with each substream being constructed from a sequence of syncframes.

3.5
substream identification
parameter of an enhanced AC-3 syncframe which, in conjunction with the stream type parameter, identifies the substream in the bitstream of which the syncframe is a part

3.6
syncframe
minimum portion of the AC-3 or enhanced AC-3 audio serial bitstream capable of being fully decoded, also known as a synchronization frame

3.7 Abbreviated terms

ATSC	Advanced Television Systems Committee
ETSI	European Telecommunications Standards Institute

4 Mapping of the audio bitstream on to IEC 61937-1

4.1 General

The coding of the bitstream and data-burst is in accordance with IEC 61937-1, IEC 61937-1:2007/AMD1:2011 and IEC 61937-2, including field names such as "Pc", "Pa" and "R".

4.2 AC-3 and enhanced AC-3 burst-info

The 16-bit burst-info contains information about the data that will be found in the data-burst (see Table 1).

Table 1 – Fields of burst-info

Bits of Pc	Data-type bits 0-4	Data-type bits 5-6	Contents	Reference point R	Repetition period of data-burst measured in IEC 60958 frames
0 to 6	1	0	AC-3	R-AC-3	1 536
		1 to 3	Reserved		
	2 to 20	According to IEC 61937			
	21	0	Enhanced AC-3	Bit 0 of Pa	6 144
		1 to 3	According to IEC 61937		
	22 to 31	According to IEC 61937			
7 to 15	According to IEC 61937				

5 Format of AC-3 and enhanced AC-3 data-bursts

5.1 General

This clause specifies the audio data-bursts AC-3 and enhanced AC-3. Specific properties such as reference points, repetition periods, the method of filling stream gaps and decoding latency are specified.

The decoding latency (or delay), indicated for the data-type bits 0-4, should be used by the transmitter to schedule data-bursts as necessary to establish synchronization between picture and decoded audio.

5.2 Pause data-burst

Pause data-bursts for AC-3 and enhanced AC-3 are given in Table 2.

Table 2 – Repetition period of the pause data-bursts

Data-type bits 0-4 of audio data-burst	Repetition period of pause data-burst	
	Mandatory	Recommended
AC-3	-	3 IEC 60958 frames
Enhanced AC-3	-	4 IEC 60958 frames

5.3 Audio data-bursts

5.3.1 AC-3 data

The AC-3 bitstream consists of a sequence of AC-3 syncframes. The data-type bits 0-4 of an AC 3 data-burst is 1. An AC-3 syncframe represents 1 536 samples of each encoded audio channel (left, centre, etc.). The data-burst is headed with a burst-preamble followed by the burst-payload. The burst-payload of each data-burst of AC-3 data shall contain one complete AC-3 syncframe. Figure 1 shows the structure of the AC-3 data-burst.

The length of the AC-3 data-burst will depend on the encoded bit rate (which determines the AC-3 syncframe size). The AC-3 bitstream is specified in ETSI TS 102 366 (see also ATSC A/52:2012).

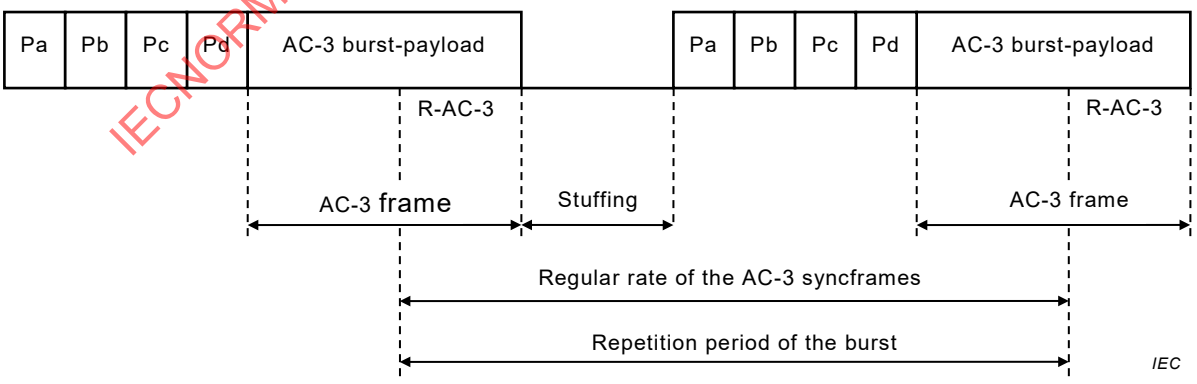

Figure 1 – AC-3 data-burst, with reference point R

The data-type-dependent info for bits 0-4 of AC-3 is given in Table 3.

Table 3 – Data-type-dependent information when data-type bits 0-4 = 1

Bits of Pc LSB..MSB	Data-type bits 0-4 dependent, bit number LSB...MSB	Contents
8 to 10	0 to 2	Value of 'bsmod' parameter in AC-3 elementary stream
11, 12	3 and 4	Reserved

The data-bursts containing AC-3 syncframes shall occur at a regular rate, with the reference point of each AC-3 data-burst beginning (except in the case of a gap) 1 536 frames (IEC 60958 frames) after the reference point of the preceding AC-3 data-burst (of the same bitstream number).

The reference point of an AC-3 data-burst (R-AC-3) is the IEC 60958 frame that occurs two-thirds of the way through the AC-3 burst-payload. The definition of the two-thirds value is the closest integer to the value of the AC-3 syncframe size measured in 32-bit words multiplied by the value 2/3, or:

$$\frac{2}{3} \times \text{AC3syncframesize} = \text{rint}(\frac{2}{3} \times \text{AC3syncframesize32})$$

where:

- AC3syncframesize is "AC-3 syncframe size";
- AC3syncframesize32 is "AC-3 syncframe size in 32-bit words";
- rint() rounds to the nearest integer.

5.3.2 Latency of AC-3 decoding

The latency of an AC-3 decoder which receives the signal is specified, with respect to the reference point of the AC-3 burst, to be equal to one AC-3 block time, which is equal to the time occupied by 256 PCM samples at the encoded sampling frequency (5,33 ms for 48 kHz sampling frequency; see Figure 2).

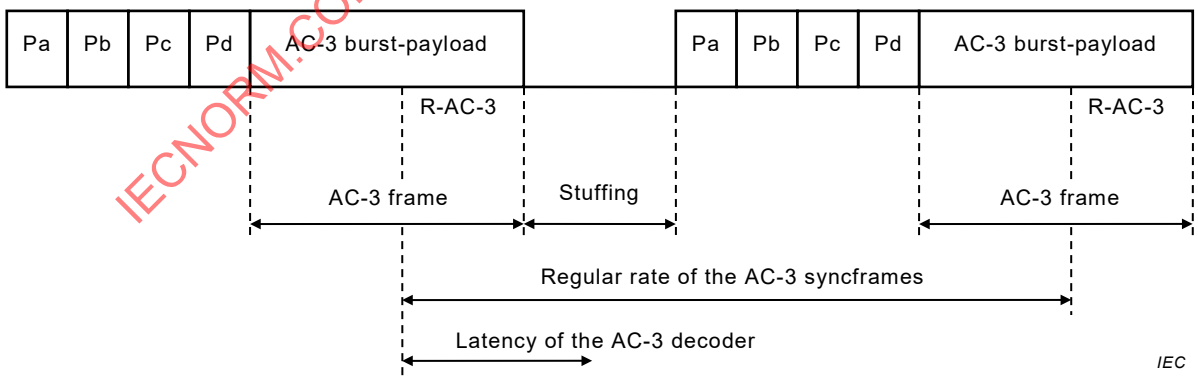

Figure 2 – Latency of AC-3 decoding

It is recommended that pause data-bursts be used to fill stream gaps in the AC-3 bitstream, as described in IEC 61937-1, and that pause data-bursts be transmitted with a repetition period of three IEC 60958 frames, except when other repetition periods are necessary to fill the precise stream gap length (which may not be a multiple of three IEC 60958 frames), or to meet the requirement on burst spacing (see IEC 61937-1:2007, 6.3.3).

When a stream gap in an AC-3 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 AC-3 syncframe. 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 three IEC 60958 frame length of the pause data-burst) the Pa of the first AC-3 data-burst which follows the stream gap.

The gap length parameter contained in the pause data-burst is intended to be interpreted by the AC-3 decoder as an indication of the number of decoded PCM samples which are missing (due to the resulting audio gap). If the sizes of the AC-3 syncframes before and after the stream gap are not equal (due to a bit rate change in the interrupted AC-3 bitstream), this value may differ from the actual number of sampling periods of the audio contained in the stream gap due to the definition of the AC-3 burst reference points.

Some AC-3 decoders may be capable of "concealing" audio gaps. The indication of the audio gap length (gap-length) which may be included in the payload of the pause data-burst allows the decoder to know how long an audio gap will need to be concealed, and thus allow the decoder to optimize the concealment process for the actual audio gap length. AC-3 decoders will most easily conceal audio gaps that have a length equal to an integral multiple of 256 samples. Thus, audio gaps of lengths 256, 512, 768, etc. sampling periods of the audio are strongly preferred, and transmitters should provide stream gaps that represent audio gaps with this granularity.

It is possible that an audio gap in an AC-3 stream is carried over this interface without there also being a stream gap. This can happen when the audio gap length is small and there is a bit rate change in the interrupted AC-3 bit stream, and the bit rate following the gap is larger than the bit rate prior to the gap. Because of the definition of the reference point of the AC-3 data-burst, it is possible for the Pa of the first burst following a bitstream interruption to be less than one data-burst repetition period of the audio following the Pa of the burst preceding the gap, while the reference point of the first burst following the bit stream interruption is more than one data-burst repetition period of the audio after the reference point of the burst preceding the gap. When this case occurs, since there is no stream gap to fill with pause bursts, there is no need to send any pause bursts. The audio decoder will never be starved for data and can calculate the length of the audio gap based on the reference points of the received AC-3 bursts.

5.3.3 Enhanced AC-3 data

An enhanced AC-3 bitstream is constructed from one or more substreams, with each substream being constructed from a sequence of enhanced AC-3 syncframes. An enhanced AC-3 syncframe is constructed from blocks of audio data, each block representing 256 samples of audio of each encoded audio channel (left, centre, etc.). An enhanced AC-3 syncframe can consist of one, two, three, or six blocks of audio data. The number of blocks per enhanced AC-3 syncframe is the same for all substreams present in the bitstream and is constant for the duration of the bitstream.

The data-burst is headed with a burst-preamble, followed by the burst-payload. The data-type bits 0-4 of an enhanced AC-3 data-burst is 21, and the data-type bits 5-6 is 0. When enhanced AC-3 data is being transmitted, the transmission device shall ensure that both the data-type bits 0-4 and data-type bits 5-6 values are set correctly. Additionally, the receiving device shall utilize both the data-type bits 0-4 and data-type bits 5-6 values to ensure that the content of the data-burst is correctly identified as enhanced AC-3. The structure of the enhanced AC-3 data-burst is shown in Figure 3.

The enhanced AC-3 burst-payload shall always contain six blocks of coded audio data, representing 1 536 samples of PCM audio at the encoded sampling frequency, from every substream present in the bitstream. The transmission device shall ensure that the enhanced AC-3 burst-payload is constructed only from complete enhanced AC-3 syncframes. It is prohibited to transmit a single enhanced AC-3 syncframe using multiple data-bursts.

The transmission device shall ensure that the first enhanced AC-3 syncframe in the burst-payload is the syncframe that has a stream type value of zero or two, and a substream identification value of zero. When the enhanced AC-3 bitstream is constructed from syncframes that consist of six blocks of audio data, one syncframe from every substream present in the bitstream shall be included in the burst-payload.

When the enhanced AC-3 bitstream is constructed from syncframes that consist of less than six blocks of audio, the transmission device shall ensure that the burst-payload contains the number of enhanced AC-3 syncframes required to deliver six blocks of audio data from every substream in the bitstream. For example, when the bitstream is constructed from syncframes that consist of two blocks of audio data, the burst-payload shall contain three enhanced AC-3 syncframes from every substream in the bitstream. Additionally, when the number of blocks per syncframe is less than six, the transmission device shall ensure that when the first substream in the bitstream has a stream type value of zero, the first syncframe in the burst-payload shall be the syncframe where the converter synchronization flag is set to one. When the first substream in the bitstream has a stream type value of two, the first syncframe in the burst-payload shall be the syncframe where the block identification flag is set to one.

The length of the enhanced AC-3 data-burst will depend on the encoded bit rate (which determines the enhanced AC-3 syncframe size). The enhanced AC 3 bitstream is specified in ETSI TS 102 366 (see also ATSC A/52:2012).

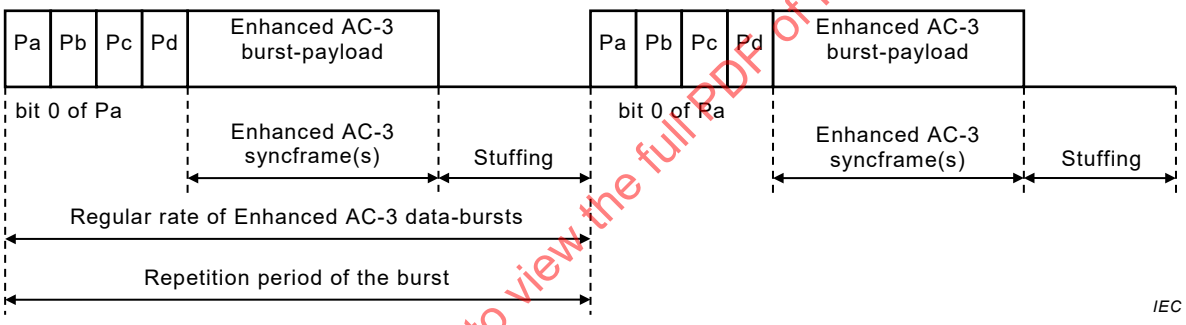

Figure 3 – Enhanced AC-3 data-burst

The data-type-dependent information for bits 0-4 for enhanced AC-3 is given in Table 4.

Table 4 – Data-type-dependent information when data-type bits 0-4 = 21 and data-type bits 5-6 = 0

Bits of Pc LSB...MSB	Data-type bits 0-4 dependent, bit number LSB...MSB	Contents
8-10	0-2	Value of 'bsmod' parameter in independent substream 0 of the enhanced AC-3 elementary stream. If the 'bsmod' parameter is not present in the enhanced AC-3 elementary stream, these bits shall be set to '0'
11, 12	3-4	Reserved

The reference point of an enhanced AC-3 data-burst is bit 0 of Pa. The data-bursts containing enhanced AC-3 syncframes shall occur at a regular rate. The units of burst-length shall be in bytes.

When enhanced AC-3 streams are conveyed via the IEC 61937 interface, the IEC 60958 frame rate shall always be four times the sampling frequency of the enhanced AC-3 bitstream, and the repetition period of the enhanced AC-3 data-burst shall be 6 144 frames (IEC 60958 frames). Table 5 shows the relationship between the frame repetition period and the

IEC 60958 frame rate, and the maximum burst-payload size and maximum data rate for the enhanced AC-3 bitstream.

Table 5 – Maximum enhanced AC-3 burst-payload size and bitstream data rate per sampling frequency and IEC 60958 frame rate

Encoded sampling frequency	IEC 60958 frame rate	Data-burst repetition period	Burst duration	Maximum burst-payload size	Maximum data rate
kHz	kHz	**IEC 60958 frames**	ms	bytes	kbit/s
44,1	176,4	6 144	34,83	24 560	5 641
48	192	6 144	32	24 560	6 140

The maximum burst-payload sizes and data rates shown in Table 5 assume a provision for two IEC 60958 frames for padding between data-bursts.

5.3.4 Latency of the enhanced AC-3 decoder

The latency of an enhanced AC-3 decoder is defined as the sum of the receiving delay time and decoding delay time.

The receiving delay time is the time taken to receive the complete enhanced AC-3 burst-payload and is dependent on the encoded bitrate of the enhanced AC-3 bitstream. For the purposes of maintaining synchronization (for example, with video), it is recommended that a constant value of receiving delay time be assumed. This value is calculated on the basis of the maximum possible size of an enhanced AC-3 burst-payload and is equal to the time occupied by 6 142 frames (IEC 60958 frames) at the IEC 60958 frame rate.

The decoding delay time is equal to the time occupied by 1 792 PCM samples at the encoded sampling frequency or 7 168 frames (IEC 60958 frames) at the IEC 60958 frame rate. See Figure 4.

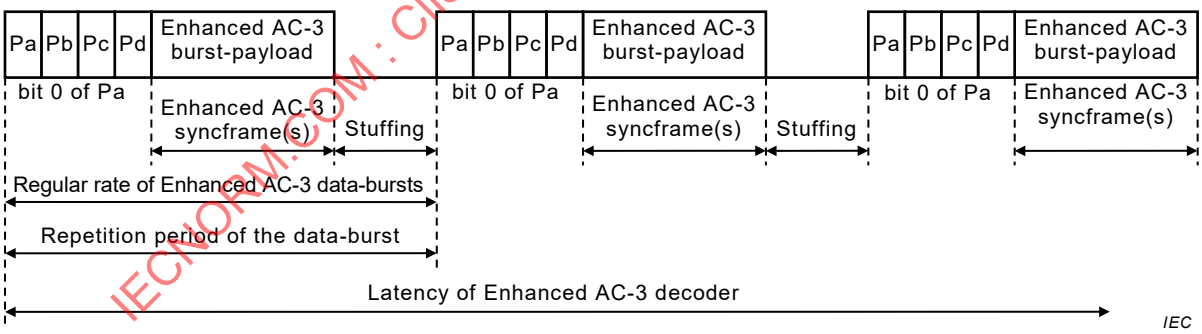

Figure 4 – Latency of enhanced AC-3 decoding

It is recommended that pause data-bursts be used to fill stream gaps in the enhanced AC-3 bitstream, as described in IEC 61937-1, and that pause data-bursts be transmitted with a repetition period of four IEC 60958 frames, except when other repetition periods are necessary to fill the precise stream gap length (which may not be a multiple of four IEC 60958 frames), or to meet the requirement on burst spacing (see IEC 61937-1:2007, 6.3.3).

When a stream gap in an enhanced AC-3 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 enhanced AC-3 data-burst. 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 four IEC 60958 frame lengths of the pause data-burst) the Pa of the first enhanced AC-3 data-burst which follows the stream gap.

The gap length parameter contained in the pause data-burst is intended to be interpreted by the enhanced AC-3 decoder as an indication of the number of decoded PCM samples which are missing (due to the resulting audio gap). The gap length parameter indicates the gap length measured in IEC 60958 frames at the IEC 60958 frame rate. As the frame rate of the IEC 60958 interface is always four times the sampling frequency of the coded audio stream when delivering enhanced AC-3 data, the value of the gap-length parameter is four times the number of PCM audio samples which would be missing in the decoded output signal. For example, a gap-length value of "4" would indicate that one sample is missing in the decoded output signal.

If the sizes of the enhanced AC-3 syncframes before and after the stream gap are not equal (due to a bit rate change in the interrupted enhanced AC-3 bitstream), the number of audio sampling periods indicated by the gap-length parameter may differ from the actual number of sampling periods of the audio contained in the stream gap due to the definition of the enhanced AC-3 burst reference points.

Some enhanced AC-3 decoders may be capable of "concealing" audio gaps. The indication of the audio gap length (gap-length), which may be included in the payload of the pause data-burst, allows the decoder to know how long an audio gap will need to be concealed and, thus, to optimize the concealment process for the actual audio gap length. Enhanced AC-3 decoders will most easily conceal audio gaps that have a length equal to an integral multiple of 256 decoded output samples. Thus, audio gap-length values of 1 024, 2 048, 3 072, etc. IEC 60958 frames are strongly preferred, and transmitters should provide stream gaps that represent audio gaps with this granularity.

It is possible that an audio gap in an enhanced AC-3 stream is carried over this interface without there also being a stream gap. This can happen when the audio gap length is small, there is a bit rate change in the interrupted enhanced AC-3 bit stream, and the bit rate following the gap is larger than the bit rate prior to the gap. Because of the definition of the reference point of the enhanced AC-3 data-burst, it is possible for the Pa of the first data-burst following a bitstream interruption to be less than one data-burst repetition period following the Pa of the data-burst preceding the gap, while the reference point of the first data-burst following the bitstream interruption is more than one data-burst repetition period after the reference point of the data-burst preceding the gap. When this case occurs, since there is no stream gap to fill with pause bursts, there is no need to send any pause bursts. The audio decoder will never be starved for data and can calculate the length of the audio gap based on the reference points of the received enhanced AC-3 data-bursts.