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Recommendation ITU-R BT.1305-1
(03/2010)

Digital audio and auxiliary data as ancillary data signals in interfaces conforming to Recommendations ITU-R BT.656 and ITU-R BT.799

BT Series

Broadcasting service (television)

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Note: *This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.*

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RECOMMENDATION ITU-R BT.1305-1*

Digital audio and auxiliary data as ancillary data signals in interfaces conforming to Recommendations ITU-R BT.656 and ITU-R BT.799

(Question ITU-R 39/6)

(1997-2010)

Scope

This Recommendation defines the mapping rules for the carriage of an AES/EBU bit stream as defined in Recommendation ITU-R BS.647 over horizontal ancillary data space of serial digital interfaces conforming to Recommendation ITU-R BS.656 and ITU-R BT.799. The data carried in the bit stream may be two channels of periodically sampled and linearly represented digital audio data, or other data formatted to fit the payload space of the AES/EBU bit stream.

The ITU Radiocommunication Assembly,

considering

a) that many countries are installing digital television production facilities based on the use of digital video components conforming to Recommendations ITU-R BT.601 and ITU-R BT.656;

b) that there exists the capacity within a signal conforming to Recommendation ITU-R BT.656 for additional data signals to be multiplexed with the video data signal;

c) that there are operational and economic benefits to be achieved by the multiplexing of ancillary data signals with the video data signal;

d) that the operational benefits are increased if a minimum of different formats are used for ancillary data signals;

e) that ancillary data signals embedded in the serial interface is already in widespread use;

f) that Recommendation ITU-R BS.647 specifies an interface (commonly known as the Audio Engineering Society/European Broadcasting Union (AES/EBU) interface) for the serial transmission of two channels of digital audio and auxiliary signals,

recommends

1 that, for the inclusion of digital audio and auxiliary data as ancillary data signals in interface signals conforming to Recommendations ITU-R BT.656 and ITU-R BT.799, the specification in Annex 1 should be used;

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* Radiocommunication Study Group 6 made editorial amendments to this Recommendation in 2007 in accordance with Resolution ITU-R 44.

2 that compliance with this Recommendation is voluntary. However, the Recommendation may contain certain mandatory provisions (to ensure e.g. interoperability or applicability) and compliance with the Recommendation is achieved when all of these mandatory provisions are met. The words "shall" or some other obligatory language such as "must" and the negative equivalents are used to express requirements. The use of such words shall in no way be construed to imply partial or total compliance with this Recommendation.

Annex 1

Digital audio and auxiliary data as ancillary data signals

1 Introduction

This specification defines the mapping of digital audio and auxiliary data conforming with Recommendation ITU-R BS.647, the signal may also contain non PCM data, and associated control information into the ancillary data space of serial digital video conforming to Recommendations ITU-R BT.656 and ITU-R BT.799. Non-PCM data may be present as part of the AES/EBU bit-stream payload.

Audio sampled at 48 kHz and clock locked (isochronous) to video is the preferred implementation for intra-studio applications. As an option, this specification supports AES/EBU audio at isochronous or asynchronous sampling rates from 32 to 48 kHz.

The minimum, or default, operation of this specification supports 20 bits of audio data as defined in § 3.5. As an option, this specification supports 24-bit audio or 4 bits of AES/EBU auxiliary data as defined in § 3.10.

This specification provides a minimum of 2 audio channels and a maximum of 16 audio channels based on available ancillary data space. Audio channels are transmitted in pairs combined, where appropriate, into groups of 4. Each group is identified by a unique ancillary data ID.

Several modes of operation are defined, identified by letter suffixes to facilitate convenient identification of interoperation between equipment with various capabilities. The default form of operation is 48 kHz isochronous audio sampling carrying 20 bits of AES/EBU audio data and defined in a manner to ensure reception by all equipment conforming to this specification.

2 References

Recommendation ITU-R BT.656:	Interface for digital component video signals in 525-line and 625-line television systems operating at the 4:2:2 level of Recommendation ITU-R BT.601.
Recommendation ITU-R BS.647:	A digital audio interface for broadcasting studios.
Recommendation ITU-R BT.799:	Interface for digital component video signals in 525-line and 625-line television systems operating at the 4:4:4 level of Recommendation ITU-R BT.601.
Recommendation ITU-R BT.1364:	Format of ancillary data signals carried in digital component studio interfaces.

3 Definitions

The following definitions apply to terms used in this Recommendation:

3.1 AES/EBU audio

All the data, audio and auxiliary information, associated with an AES/EBU bit stream is defined by Recommendation ITU-R BS.647.

3.2 AES/EBU frame

Two AES/EBU subframes, one with audio data for channel 1 followed by one with audio data for channel 2.

3.3 AES/EBU subframe

All data associated with one AES/EBU audio sample for one channel in a channel pair.

3.4 Audio control packet

An ancillary data packet occurring once in a field and containing data used in the operation of optional features of this specification.

3.5 Audio data

23 bits: 20 bits of AES/EBU audio associated with one audio sample, not including AES/EBU auxiliary data, plus the following 3 bits: Sample Validity (V-bit), Channel Status (C-bit), User Data (U-bit).

3.6 Audio data packet

An ancillary data packet as defined in Recommendation ITU-R BT.1364 containing audio data for one or two channel pairs (two or four channels). An audio data packet may contain audio data for 1 or more samples associated with each channel.

3.7 Audio frame number

A number, starting at 1, for each frame within the audio frame sequence. For the example in § 3.8 the frame numbers would be 1, 2, 3, 4, 5.

3.8 Audio frame sequence

The number of video frames required for an integer number of audio samples in isochronous operation. As an example: the audio frame sequence for isochronous 48 kHz sampling in a 525-line (29.97 frame/s) system is 5 frames and for a 625-line (25 frame/s) system is 1 frame.

3.9 Audio group

Consists of one or two channel pairs which are contained in one ancillary data packet. Audio groups are numbered 1 through 4. Each audio group has a unique ID as defined in § 12.2.

3.10 Auxiliary data

4 bits of AES/EBU audio associated with one sample defined as auxiliary data by Recommendation ITU-R BS.647. The 4 bits may be used to extend the resolution of audio samples.

3.11 Channel pair

Two digital audio channels, generally derived from the same AES/EBU audio source.

3.12 Extended data packet

An ancillary data packet containing auxiliary data corresponding to, and immediately following, the associated audio data packet.

3.13 Sample pair

Two samples of AES/EBU audio as defined in § 3.1.

3.14 Isochronous audio

Audio is defined as being clock isochronous with video if the sampling rate of audio is such that the number of audio samples occurring within an integer number of video frames is itself a constant integer number, as in the following examples:

Audio sampling rate (kHz)	Samples/frame, 29.97 frame/s video	Samples/frame, 25 frame/s video
48.0	8008/5	1920/1
44.1	147147/100	1764/1
32.0	16016/15	1280/1

NOTE 1 – The video and audio clocks must be derived from the same source since simple frequency synchronization could eventually result in a missing or extra sample within the audio frame sequence.

4 Overview and levels of operation

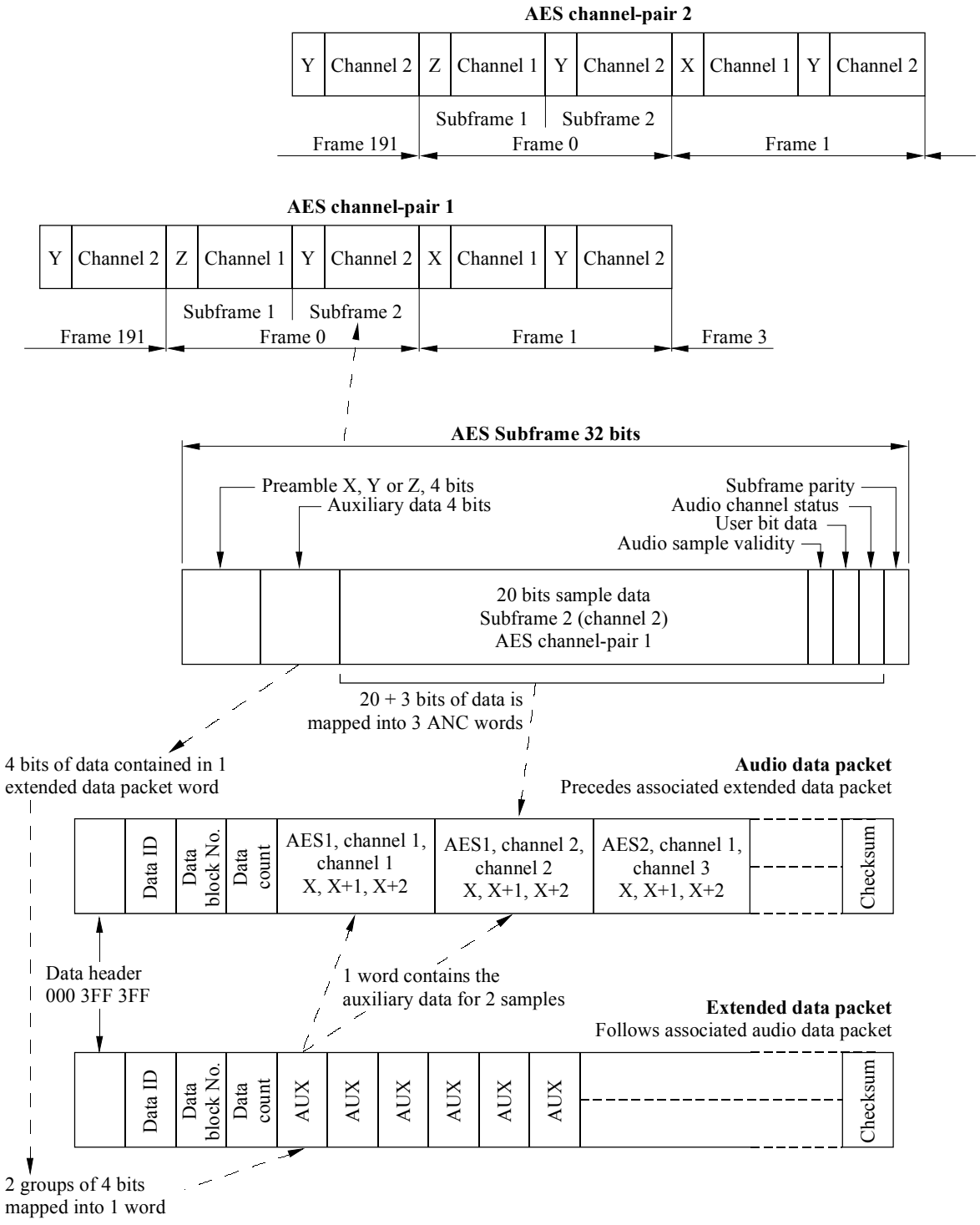
4.1 Configurations

Audio data derived from one or more AES/EBU frames and one or two channel pairs is configured in an audio data packet as shown in Fig. 1. Generally, both channels of a channel pair will be derived from the same AES/EBU audio source, but this is not essential. The number of samples per channel contained in one audio data packet will depend on the distribution of the data in a video field. As an example, the ancillary data space in some television lines may carry three samples, some may carry four samples. Other values are possible.

NOTE 1 – Some existing equipment may transmit other sample counts, including zero. Receiving equipment should handle correctly sample counts from zero to the limits of ancillary data space.

FIGURE 1

Relation between AES data and audio/extended data packets



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4.2 Packet types

Three types of ancillary data packets to carry AES/EBU audio information are defined.

The audio data packet carries all the information in the AES/EBU bit stream excluding the auxiliary data defined by Recommendation ITU-R BS.647. The audio data packets must be located in the horizontal ancillary data space on most of the television lines in a field.

An audio control packet is transmitted once per field, is optional for the default case of 48 kHz isochronous audio (20 or 24 bit) but is required for all other modes of operation.

Auxiliary data is carried in an extended data packet corresponding to, and immediately following, the associated audio data packet.

Data IDs (see § 12 to 14) are defined for four separate packets of each packet type. This allows for up to eight channel pairs. In this specification, the audio groups are numbered 1 to 4 and the channels are numbered 1 to 16. Channels 1 to 4 are in group 1, channels 5 to 8 are in group 2, and so on.

If extended data packets are used they are included on the same video line as the audio data packet which contains data from the same sample pair. The extended data packet follows the audio data packet and contains two 4-bit groups of auxiliary data per ancillary data word as shown in Fig. 1.

4.3 Degrees of compliance

It is not essential that an equipment should have all the possibilities of this Recommendation fully implemented. To indicate the extent to which an equipment may implement these possibilities a suffix letter is added. The suffix letters and the corresponding levels of implementation are shown in Table 1.

TABLE 1

Levels of implementation

Level	Support
A	Isochronous audio at 48 kHz, 20-bit audio data packets. (Distribution of samples on the television lines for level A specifically follows the uniform sample distribution as required by § 9.1 in order to ensure interoperation with receivers limited to level A operation)
B	No longer in use
C	Isochronous audio at 48 kHz, audio and extended data packets
D	Asynchronous audio (48 kHz implied, other frequencies if so indicated)
E	44.1 kHz audio
F	32 kHz audio
G	32-48 kHz continuous sampling rate range
H	Audio frame sequence (see § 14.4)
I	Time delay tracking
J	Non-coincident Z-bits in a channel pair

Examples of compliance nomenclature:

– A transmitter that supports only 20-bit 48 kHz isochronous audio conforms to level A. (Transmitted sample distribution is expected to conform to § 9.)

– A transmitter that supports 20-bit and 24-bit 48 kHz isochronous audio conforms to levels A and C. (In the case of level A operation the transmitted sample distribution is expected to conform to § 9 while a different sample distribution may be used when it is in operation conforming to level C.)

– A receiver which can only accept 20-bit 48 kHz isochronous audio and requiring level A sample distribution conforms to level A.

– A receiver which accepts and utilizes the 24-bit data conforms to level C.

– Equipment that supports only asynchronous audio and only at 32 kHz, 44.1 kHz and 48 kHz conforms to levels D, E and F.

5 Use of ancillary data space

5.1 Ancillary space utilized

Audio and extended data is located in the digital line blanking between end of active video and start of active video and may be on any line except as follows:

Audio and extended data are not transmitted during the horizontal ancillary data space following the normal video switching point; that is, the digital line blanking on line 11/274 (525-line system) or line 7/320 (625-line system).

Audio and extended data are not transmitted during the portion of the horizontal ancillary data space designated for error detection checkwords, lines 9/272 (525-line system) or lines 5/318 and (625-line system).

NOTE 1 – Some existing transmission equipment may not conform to the above restrictions. Receivers should receive audio data transmitted in any ancillary data space.

5.2 Location in ancillary space

Audio and extended data must be inserted immediately after timing reference signal of end of active video in the available ancillary data space (digital line blanking).

6 Audio data packet formatting

6.1 Channel pairs

The four audio channels from audio group 1 are ordered such that channels 1 and 2 make one channel pair and channels 3 and 4 make another. Audio group 2 contains channels 5 and 6 as one channel pair, and so on.

6.2 Transmission sequence

Where the audio data is derived from a single AES/EBU data stream the data is ordered such that data from a subframe 1 is always transmitted before the data from a subframe 2 in the same channel pair. This means that data from subframe 1 would be placed in channel 1 (or 3, 5, ...) and data from subframe 2 would be placed in channel 2 (or 4, 6, ...).

The order in which the channel pairs are transmitted within a group is not defined. As an example, the channel pair containing channels 3 and 4 could precede the channel pair containing channels 1 and 2.

6.3 Inactive channels

When only one channel of a channel pair is active, both channels must still be transmitted. If the audio signal is not derived from a single AES/EBU audio signal, then the accompanying inactive channel's audio sample bits must be set to all zeros with the V-bit, C-bit, and U-bit set to appropriate values.

6.4 Sampling rates

Audio channels within the same channel pair must have the same sampling rate and are considered to have the same isochronous or non-synchronous status.

Channel pairs may be mixed with respect to their sampling rate and isochronous or non-synchronous status. Each video frame will contain the appropriate number of AES/EBU audio samples for the rate used.

6.5 Packet length

The audio packet length is variable. To meet the requirements of § 8.1, the length must be short enough to allow room in the remaining ancillary data space for the extended data packet if auxiliary data is present.

7 Audio control packet

7.1 Location

The optional audio control packet will be transmitted in the second horizontal ancillary data space after the video switching point (line 12/275 (525-line system) or line 8/320 (625-line system)). The control packet is transmitted prior to any audio packets within this ancillary data space.

7.2 Default

If the audio control packet is not transmitted, a default operating condition of 48 kHz isochronous audio is assumed. This could include any number of channel pairs up to the maximum of eight. All other audio control parameters are undefined.

8 Extended data packet formatting

8.1 Location

Auxiliary data, if present, must be transmitted as part of an extended data packet in the same ancillary data space as its corresponding audio data. When used, one extended data word will be transmitted for each corresponding sample pair.

8.2 Transmission order

Audio data packets are transmitted before their corresponding extended data packets.

Within a particular ancillary data space, all of the audio and auxiliary data from one audio group is transmitted together before data from another group is transmitted.

8.3 Asynchronous operation

When a channel pair is operating in asynchronous mode, its corresponding audio frame number (AFn-*n*) in the audio control packet is not used (see § 14.3).

9 Audio data packet distribution

The transmitted data should be distributed as evenly as possible throughout the video field considering the restrictions of § 5 to 8.

10 Audio data structure

10.1 Mapping

The AES/EBU subframe, less the four bits of auxiliary data, is mapped into three contiguous ancillary data words (X, X+1, X+2) as follows.

Bit address	X	X+1	X+2
b_9	Not b_8	Not b_8	Not b_8
b_8	aud 5	aud 14	P
b_7	aud 4	aud 13	C
b_6	aud 3	aud 12	U
b_5	aud 2	aud 11	V
b_4	aud 1	aud 10	aud 19 (MSB)
b_3	aud 0	aud 9	aud 18
b_2	ch 1	aud 8	aud 17
b_1	ch 0	aud 7	aud 16
b_0	Z	aud 6	aud 15

aud(0-19): two’s complement linearly represented audio data

ch(0-1): identifies the audio channel within an audio group:
ch = 00 would be channel 1 (or 5, 9, 13)
ch = 01 would be channel 2 (or 6, 10, 14), ...

P: even parity for the 26 previous bits in the subframe sample (excludes b_9 in the first and second words)

NOTE 1 – The P-bit is not the same as the AES/EBU parity bit.

C: AES/EBU audio channel status bit

U: AES/EBU user bit

V: AES/EBU sample validity bit

MSB: most significant bit.

10.2 Z-bits

Both Z-bits of a channel pair should be set to “1” at the same sample, coincident with the beginning of a new AES/EBU channel status block (which only occurs on frame 0), otherwise they should be set to “0”. This is the required form when a channel pair is derived from a single AES/EBU data stream.

Optionally the Z-bits may be set independently to “1” allowing embedding audio from two AES/EBU sources whose Z preambles (channel status blocks) are not coincident. This constitutes operation at level J (see § 4.3).

NOTE 1 – Some receiving equipment may not accept Z-bits set to "1" at different locations for a given channel pair. This is not a problem when the transmitted channel pair are derived from the same AES/EBU source, but if separate sources are used to develop a channel pair, the transmitter must either reformat the channel status blocks for coincidence, if they are not already synchronized at the block level, or recognize that the signal may cause problems with some receiver equipment.

11 Extended data

11.1 Structure

The extended data are ordered such that the 4 AES/EBU auxiliary bits from each of the two associated subframes of one AES/EBU frame are combined into a single ancillary data word. Where more than four channels are transmitted the relationship of audio and extended data packets according to § 8.2 ensures auxiliary data will be correctly associated with its audio sample data.

Bit address	Ancillary data word
b_9	Not b_8
b_8	a
b_7	y3 (MSB)
b_6	y2
b_5	y1
b_4	y0 (LSB)
b_3	x3 (MSB)
b_2	x2
b_1	x1
b_0	x0 (LSB)

b_9: not b_8
a: address pointer: 0 for channels 1 and 2
1 for channels 3 and 4
y(0-3): auxiliary data from subframe 2
x(0-3): auxiliary data from subframe 1
MSB: most significant bit
LSB: least significant bit.

12 Audio data packets

12.1 Structure

The 20-bit audio samples as defined in § 10 are combined and arranged in ancillary data packets, the format of the ancillary data packets is defined by Recommendation ITU-R BT.1364. Shown in Fig. 2 is an example of four channels of audio (two channel pairs). The sample pairs may be transmitted in any order and do not need to be transmitted in the order shown. Furthermore, if the sampling rates are different for AES1 and AES2, there may be a different number of sample pairs for AES1 and AES2.

12.2 Data identifiers

The audio data packet data ID (DID) words for audio groups 1 to 4 are: $2FF_h$, $1FD_h$, $1FB_h$ and $2F9_h$ respectively.

13 Extended data packets

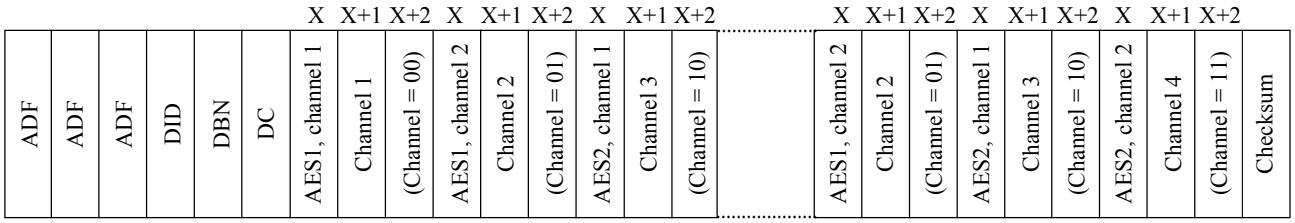
13.1 Structure

If AES/EBU auxiliary data are present, the extended data words containing the AES/EBU auxiliary data as defined in § 11 are combined and arranged in ancillary data packets which immediately follow the corresponding 20-bit audio packets. The packet structure is shown in Fig. 3.

FIGURE 2

Audio data packet structure

(Example of 4 audio channels, 1 audio group)



ADF: ancillary data flag
DID: data ID
DBN: data block number
DC: data count

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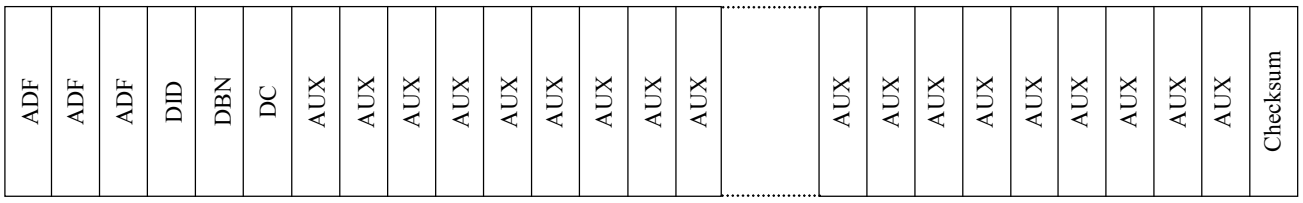
FIGURE 3

Extended data packet structure



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13.2 DID

The extended data packet data ID words (DID) for audio groups 1 to 4 are: $1FE_h$, $2FC_h$, $2FA_h$ and $1F8_h$ respectively.

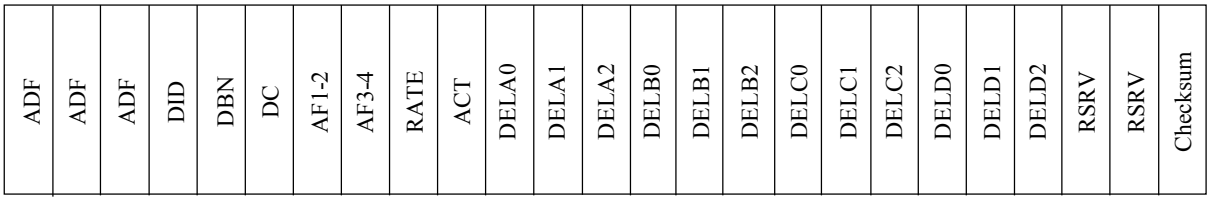
14 Audio control packet structure and data

14.1 Frequency of transmission

The audio control packet is transmitted once per field, at a fixed position defined in § 7.1. The control packet is optional for the default case of 48 kHz isochronous audio. It must be transmitted for all other modes. Structure of the audio control packet is shown in Fig. 4.

FIGURE 4

Audio control packet structure



ADF, DID, DBN, DC: see Fig. 2
AF: audio frame number
RATE: sampling frequency indication
ACT: active channel
DEL: delay indication
RSRV: reserved words

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14.2 Relation to audio groups

There is a separate audio control packet for each audio group thereby accounting for 16 possible audio channels. The audio control packet data ID words (DID) for audio groups 1 to 4 are: $1EF_h$, $2EE_h$, $2ED_h$ and $1EC_h$ respectively.

14.3 Audio frame numbers

Audio frame numbers (AFn-*n*) provide a sequential ordering of video frames to indicate where they fall in the progression of non-integer number of samples per video frame (audio frame sequence) inherent in 29.97 frame/s video systems. The first number in the sequence is always 1 and the final number is equal to the length of the audio frame sequence (see § 3.7, 3.8 and § 3.14). A value of all zeros indicates no frame numbering is available.

AF1-2: Audio frame number for channels 1 and 2 in a given audio group.

AF3-4: Audio frame number for channels 3 and 4 in a given audio group.

14.4 Frame sequence

For correct use of the audio frame number, the audio frame sequence must be defined. Three isochronous sampling rates are defined in this Recommendation (see § 3.14).

All audio frame sequences are based on two integer numbers of samples per frame (m and $m + 1$) with audio frame numbers starting at 1 and proceeding to the end of the sequence. Odd numbered frames (1, 3, ...) have the larger integer number of samples and even numbered frames (2, 4, ...) have the smaller integer number of samples with the exceptions shown in Table 2.

TABLE 2

Exceptions to audio frame sequences

	Basic numbering system			Exceptions	
Sample rate (kHz)	Frame sequence	Samples per odd frame (m)	Samples per even frame ($m + 1$)	Frame number	Number of samples
48.0	5	1 602	1 601	None	
44.1	100	1 472	1 471	23 47 71	1 471 1 471 1 471
32.0	15	1 068	1 067	4 8 12	1 068 1 068 1 068

14.5 Audio frame-word bit addresses

Bit address definition for the audio frame-words AF1-2 and AF3-4 in Fig. 4:

Bit address	Audio frame number	
b_9	Not b_8	
b_8	f8 (MSB)	AFn-n
b_7	f7	
b_6	f6	
b_5	f5	
b_4	f4	
b_3	f3	
b_2	f2	
b_1	f1	
b_0	f0 (LSB)	

When a channel pair is operating in asynchronous mode, its corresponding AFn-n word in the audio control packet is not used. Bits (0-8) should be set to zero to avoid the excluded value 000_h.

(As an option, the MSB of the audio frame number that are not used as the audio frame sequence counter, may be used as a counter to facilitate detection of a vertical interval switch. As an example, if the audio frame sequence is 5, bits 3 to 8 may be used to make a 6-bit counter which the receiver could follow to determine if the sequence 0-63, 0-63, ... were broken. Used in conjunction with the data block number of the ancillary data packet 0-255, 0-255, ... an appropriately designed receiver could, with a high probability, detect a vertical interval switch and process the audio samples to eliminate any undesired transient effects.)

14.6 Sampling frequency indication

The sampling frequency for each channel pair is given by the word (RATE) in Fig. 4. The sync mode bits, asx and asy, when set to 1 indicate that the respective channel pair is operating asynchronously.

Bit address	Rate word
b_9	Not b_8
b_8	Reserved (set to zero)
b_7	y2 (MSB)
b_6	y1 RATE CODE channels 3 and 4 in a given audio group
b_5	y0 (LSB)
b_4	asy
b_3	x2 (MSB)
b_2	x1 RATE CODE channels 1 and 2 in a given audio group
b_1	x0 (LSB)
b_0	asx

The sample rates currently defined for x(0-2) and y(0-2):

Rate code	Sample rate
000	48 kHz
001	44,1 kHz
010	32 kHz
011-110	(Reserved)
111	Undefined (free running)

14.7 Active channel indication

The word ACT indicates the active channels; a(1-4) are set to one for each active channel in a given audio group; p is even parity for b(0-7).

Bit address	Active channel word
b_9	Not b_8
b_8	p
b_7	Reserved (set to zero)
b_6	Reserved (set to zero)
b_5	Reserved (set to zero)
b_4	Reserved (set to zero)
b_3	a4
b_2	a3
b_1	a2
b_0	a1

14.8 Delay indication

The words DELx(0-2) indicate the amount of accumulated audio processing delay relative to video, measured in audio sample intervals, for each of the channels. Since the channels are generally used as channel pairs the words for a given audio group are ordered as follows:

DELAn Delay for channel 1	if DELCn e = "1"
DELAn Delay for channel 1 and channel 2	if DELCn e = "0"
DELBn Delay for channel 3	if DELDn e = "1"
DELBn Delay for channel 3 and channel 4	if DELDn e = "0"
DELCn Delay for channel 2	if DELCn e = "1"
DELCn Invalid audio delay data	if DELCn e = "0"
DELDn Delay for channel 4	if DELDn e = "1"
DELDn Invalid audio delay data	if DELDn e = "0"

When only two channels are used the e-bits in DELCn and DELDn must be set to "0" to indicate invalid while maintaining a constant size for the audio control packet.

The format for the audio delay data is 26-bit two's complement:

Bit address	DELx0	DELx1	DELx2
b_9	Not b_8	Not b_8	Not b_8
b_8	d7	d16	d25 (sign)
b_7	d6	d15	d24 (MSB)
b_6	d5	d14	d23
b_5	d4	d13	d22
b_4	d3	d12	d21
b_3	d2	d11	d20
b_2	d1	d10	d19
b_1	d0 (LSB)	d9	d18
b_0	e	d8	d17

The e-bit is set to "1" to indicate valid audio delay data. The delay words are referenced to the point where the AES/EBU data are input to the formatter. The delay words represent the average delay value, inherent in the formatting process, over a period no less than the length of the audio frame sequence (see § 3.8) plus any pre-existing audio delay. Positive values indicate that the video leads the audio.

14.9 Reserved words

The words RSRV are reserved and should be set to zero, except for bit 9 which is the complement of bit 8.