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INTERNATIONAL STANDARD

colour inside

Consumer audio/video equipment – Digital interface – Part 6: Audio and music data transmission protocol

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

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Part 6: Audio and music data transmission protocol

FOREWORD

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International Standard IEC 61883-6 has been prepared by technical area 4: Digital system interfaces and protocols, of IEC technical committee 100: Audio, video and multimedia systems and equipment.

This third edition cancels and replaces the second edition, published in 2005, and constitutes a technical revision.

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

a) AM824 sequence adaptation layer for Blu-ray Disc application is added.
b) Blocking transmission method becomes normative.
c) Previously defined protocols have been included for the sake of backwards compatibility.

The text of this standard is based on the following documents:

FDIS	Report on voting
100/2341/FDIS	100/2372/RVD

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

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

A list of all parts in the IEC 61883 series, published under the general title *Consumer audio/video equipment – Digital interface*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn,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

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CONSUMER AUDIO/VIDEO EQUIPMENT – DIGITAL INTERFACE –

Part 6: Audio and music data transmission protocol

1 Scope

This part of IEC 61883 describes a protocol for the transmission of audio and music data employing IEEE 1394 and specifies essential requirements for the application of the protocol.

This protocol can be applied to all modules or devices that have any kind of audio and/or music data processing, generation and conversion function blocks. This standard deals only with the transmission of audio and music data. The control, status and machine-readable description of these modules or devices should be defined outside of this standard according to each application area.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 60958-3, *Digital audio interface – Part 3: Consumer applications*

IEC 61883-1, *Consumer audio/video equipment – Digital interface – Part 1: General*

IEEE 754:1985, *Standard for Binary Floating-Point Arithmetic*

IEEE 1394, *Standard for a High Performance Serial Bus*

IEEE 1394A, *Standard for a High Performance Serial Bus – Amendment 1*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61883-1, together with the following, apply.

3.1.1
32-bit floating-point data
data type which is defined in IEEE 754

3.1.2
AM824 data
32-bit data consisting of an 8-bit label and 24-bit data

3.1.3
A/M protocol
protocol for the transmission of audio and music data over IEEE 1394

Note 1 to entry: IEEE 1394 describes the Audio and Music Data Transmission Protocol.

3.1.4
embedded synchronization clock
signal that carries information that is used by a sampling device to derive a sample clock

Note 1 to entry: In the context of A/M protocol, this synchronization clock is embedded in the SYT field of the CIP and carries timing information that refers to local CYCLE_TIME register values.

3.1.5
non-sampling device
devices that do not use clock timing in a way that may modify the analogue or digital audio signal

Note 1 to entry: Any clocks that the non-sampling devices use do not affect the accuracy of that data in normal operation. (See also 3.1.9, sampling device.)

3.1.6
reserved
keyword used to describe objects or the code values assigned to these objects

Note 1 to entry: Objects are: bit, byte, quadlet, octet, and field.

Note 2 to entry: The object or the code value are set aside for future standardization by the IEC.

3.1.7
sample clock
reference used at a sampling device to define the instant at which an audio data sample word is valid

Note 1 to entry: For over-sampled conversion systems, the sample clock is multiplied up to the over-sampling rate. Inside an asynchronous sampling frequency converter (ASFC), one sample clock is represented numerically by the relationship it has to another sample clock.

3.1.8
sample clock timing transfer
mechanism by which the sample clock of one device can be derived from a clock on another device such as by using an embedded synchronization clock

3.1.9
sampling device
device that depends on the timing of a sample clock to modify an audio signal in some way as it is being converted between the analogue and digital domains, or between two independent sampling frequencies

Note 1 to entry: Examples of a sampling device are an analogue-to-digital converter (ADC), a digital-to-analogue converter (DAC) and an ASFC.

3.1.10
sampling frequency
F_{S}
frequency of the sample clock

3.1.11
stream
uni-directional data transmission

3.1.12
synchronization clock frequency
F_{sync}
embedded synchronization clock frequency using the A/M protocol has to be less than the isochronous cycle rate of 8 kHz

Note 1 to entry: The rate is defined as follows:

$F_{sync} = F_s$ / SYT_INTERVAL

The SYT_INTERVAL value is defined in the CIP header for each sampling frequency.

3.1.13
synchronization clock source
device that supplies an embedded synchronization clock that another device uses to derive a sample clock

Note 1 to entry: A synchronization clock source does not need to be a source device for audio data.

3.1.14
synchronization clock destination

3.1.15.1
clock jitter definition
deviation in the timing of clock transitions when compared to an ideal clock

Note 1 to entry: The ideal clock can be considered to have a frequency of exactly the same long-term average frequency and aligned for zero mean phase offset from the real clock. For a sample clock, the jitter amplitude defined in this way is directly related to the amplitude of the jitter modulation products produced in a sampling device.

3.1.15.2
embedded synchronization clock jitter
jitter in the embedded synchronization clock includes the effect of errors (including limited precision) in the embedded SYT data and jitter in the CYCLE_TIME register used to decode the SYT

3.1.15
time stamp
quantized timing in which an event occurs based on a reference clock

Note 1 to entry: The reference clock is CYCLE_TIME unless otherwise specified in this standard.

3.2 Abbreviations

ASID — Audio Software Information Delivery
See http://riaj.japan-music.or.jp/tech/asid/e.html

AV/C — Audio Video Control

DVD — Digital Versatile Discs
See http://www.dvdforum.org/index.htm

MIDI — Musical Instrument Digital Interface

NOTE The complete MIDI 1.0 detailed specification, Version 96.1, March 1996, is a specification for the interconnection of digital music processing devices (for example, keyboards and signal processors) and computers.

SACD — SACD Super Audio CD
See http://www.licensing.philips.com/

4 Reference model for data transmission

4.1 General

This clause describes a reference model for data transmission.

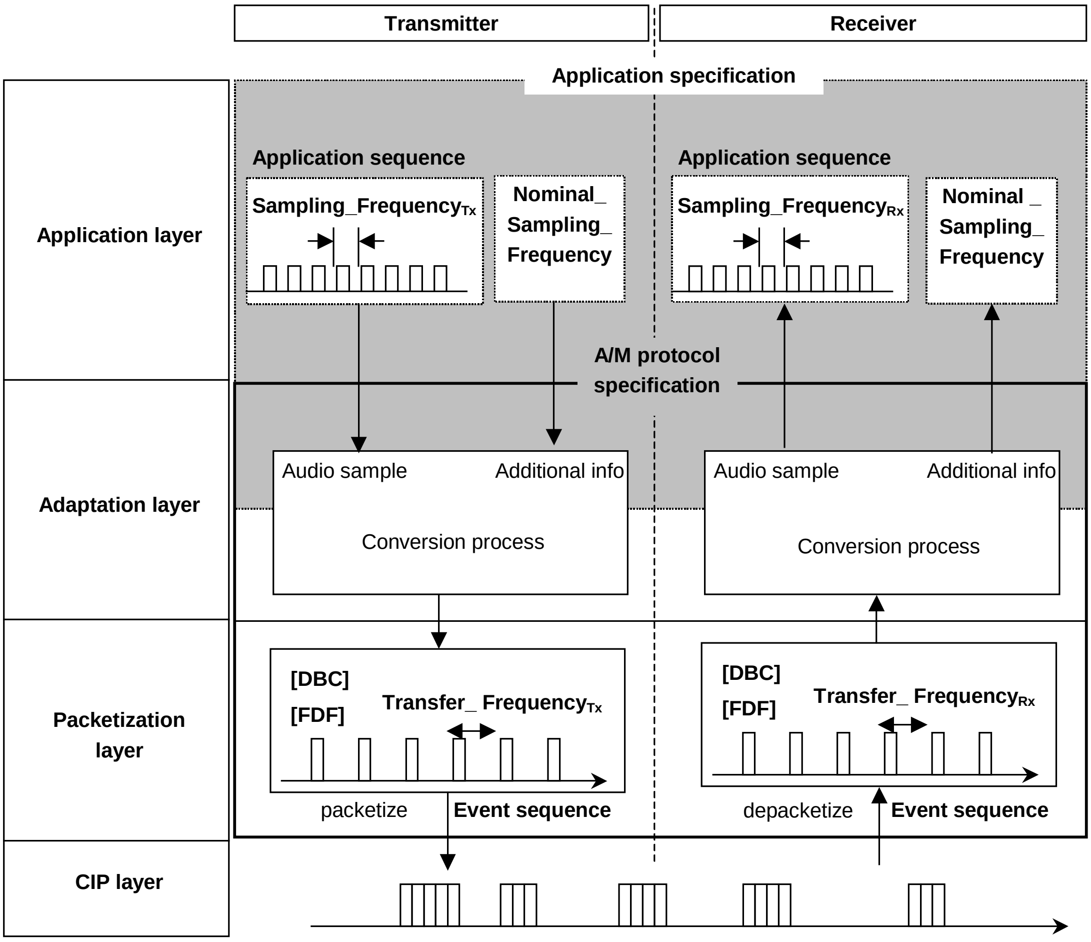

Figure 1 – Reference model for audio and music data transmission

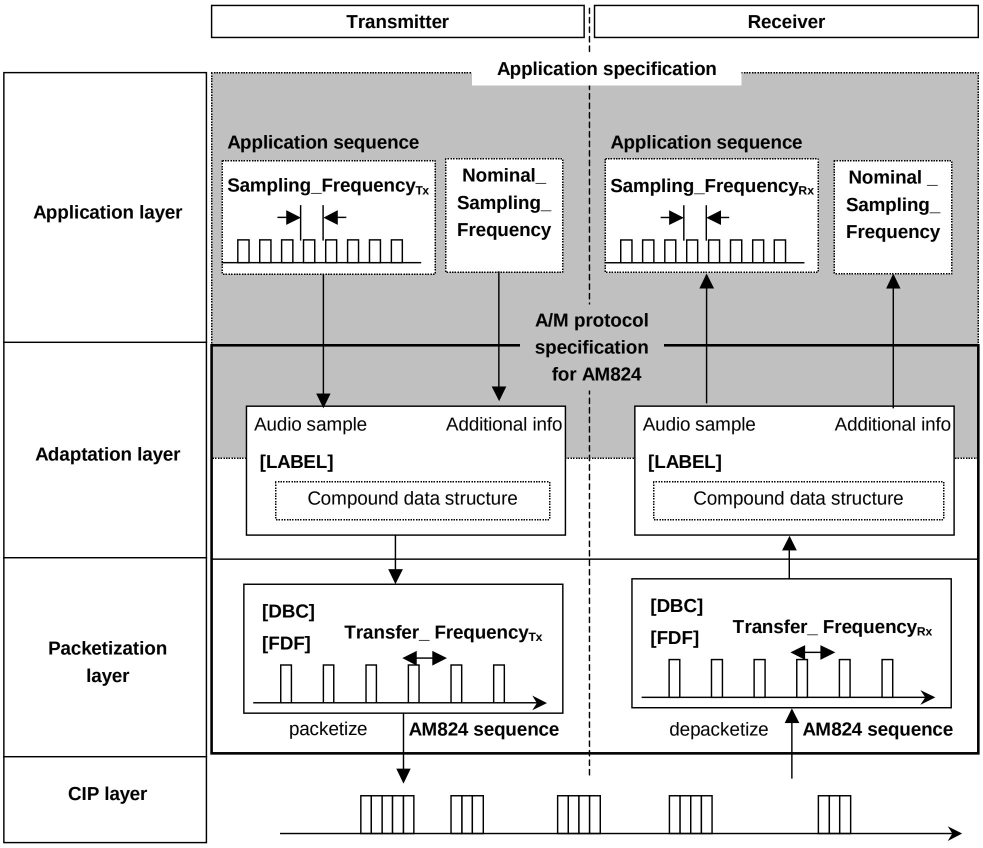

Figure 2 – Reference model for AM824 data transmission

Figure 1 gives an outline for audio data transmission from a transmitter to a receiver. It has four major layers denoted as CIP (common isochronous packet) layer, packetization layer, adaptation layer and application layer.

4.2 Application layer

Each application defines its own application sequence and the interface to the adaptation layer. The application sequence in Figure 1 is data in a format such as an audio signal format. The Nominal_Sampling_Frequency is the ideal sampling frequency for the application sequence. The range of *Sampling_Frequency* should be defined by the application. The audio signal at Nominal_Sampling_Frequency can be reproduced at the actual rate of Sampling_Frequency in operation. This means that the value of Sampling_Frequency may have some deviation and/or may vary in time in contrast with Nominal_Sampling_Frequency.

Additional information in Figure 1 is any information other than events of a sequence (audio samples) being transmitted at a given rate.

4.3 Adaptation layer

The adaptation layer defines a process to convert an application sequence to an event sequence and vice versa. The conversion process may not be required if an application sequence and an event sequence have the same structure. If an event sequence consists of events of 24-bit payload, such as AM824 data defined in 8.2, and if the bit length of an audio sample of the application sequence is not 24-bit, some conversion between Sampling_Frequency and Transfer_Frequency may be required (see Figure 2 and Clause 11). The Transfer_Frequency represents the frequency of occurrence of a data block, which is equivalent to a cluster event. The Transfer_Frequency is used for describing a conceptual transmission model.

The transfer rate of an event sequence is 24 × Transfer_ Frequency [bit/s] in the case of AM824.

Generally, the adaptation layer is designed in such a way that both the application sequence at Sampling_Frequency and its Nominal_Sampling_Frequency are carried. In this specification, Nominal_Sampling_Frequency, which would usually be one of the ancillary data items, is carried by SFC (sampling frequency code) which is defined in Clause 10. The information in Nominal_Sampling_Frequency is necessary for using command based rate control or making a copy. On the other hand, Sampling_Frequency is necessary for clock-based rate control. Although Sampling_Frequency is not explicitly transmitted, it can be estimated from SYT_INTERVAL and time stamps by the algorithm specified for the AM824 data type.

An application specification defines the process (shown in the grey shaded area of Figure 1) to convert the application's signal (application sequence) to an event sequence. This standard assumes that the application specification is an external document using the definition of an event sequence for the adaptation process. For several generic data types this standard also defines the adaptation layer.

The adaptation to an event sequence is the point at which the packetization process interfaces to the application. The packetization process can be described as IEEE 1394 adaptation from the point of view that the data stream utilizes IEEE 1394 as its transport.

More details of this layer are described in Clause 12.

4.4 Packetization layer

The AM824 sequence is directly packetized to CIP or depacketized from CIP in the packetization layer.

The Transfer_Frequency can be implicitly expressed by the output of a locked PLL circuit, as shown in Figure 3, instead of being explicitly denoted in the packetization layer.

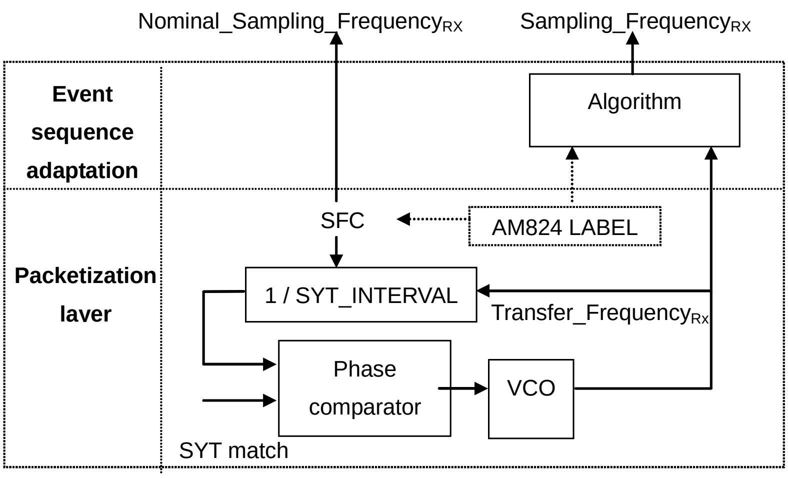

Figure 3 – Implementation example of receiver

5 Transport requirements

5.1 Arbitrated short bus reset

All modules or devices which implement this A/M protocol should have the capability of "arbitrated short-bus reset" in order to prevent the interruption of audio and music data transmission when a bus reset occurs.

5.2 Bit, byte, and quadlet ordering

This standard adopts the ordering of bit, byte, and quadlet for bus packets in accordance with IEEE 1394.

6 Packet header for audio and music data

6.1 General

This clause defines the packet format in the CIP layer described in Figure 1.

6.2 Isochronous packet header format

The header for an isochronous packet which conforms to the A/M protocol shall have the same format given in Figure 4, which is part of the isochronous packet format defined in IEEE 1394.

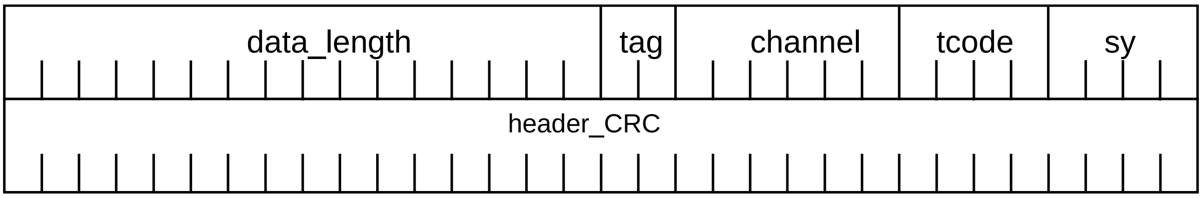

Figure 4 – Isochronous packet header

The isochronous packet header fields are defined with unique values that are specified in Table 1.

Table 1 – Isochronous packet header fields

Field	Value	Comments
Tag	01_2	This value indicates that a CIP header is included in the packet.
Tcode	A_{16}	This value indicates that this is an isochronous data packet.
Sy	xx	This field is reserved. The transmitter shall set this field to 0_{16} unless specified by another application.

6.3 CIP header format

IEC 61883-1 defines a two-quadlet CIP header for a fixed length source packet with SYT field, repeated here for clarity as in Figure 5. The CIP header format for an isochronous packet, which conforms to the audio and music data transmission protocol, shall use the CIP header.

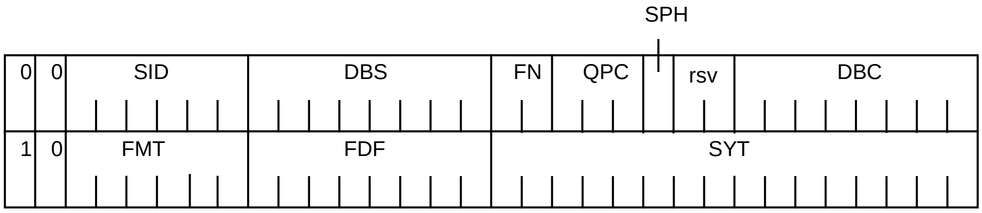

Figure 5 – Common isochronous packet (CIP) format

Table 2 defines the fields with unique values that are specified by this protocol.

Table 2 – CIP fields

Field	Value	Comments
FMT	10_{16}	This value indicates that the format is for audio and music
FN	0_{16}	
QPC	0_{16}	
SPH	0_{16}	
SYT	xx	This field shall contain the time when the specified event shall be presented at a receiver
FDF	xx	This field is defined in Clause 10.

7 Packetization

7.1 Packet transmission method

When a non-empty CIP is ready to be transmitted, the transmitter shall transmit it within the most recent isochronous cycle initiated by a cycle start packet. The behaviour of packet transmission depends on the definition of the condition in which “a non-empty CIP is ready to be transmitted”. There are two situations in which this condition is defined.

a) In order to minimize TRANSFER_DELAY, the condition of a non-empty CIP being ready for transmission is defined to be true if one or more data blocks have arrived within an isochronous cycle. This transmission method is called non-blocking transmission and is described in detail in 7.4.

b) The condition of “non-empty CIP ready” can also be defined as true when a fixed number of data blocks have arrived. This transmission method is called blocking transmission and is described in Annex A.

7.2 Transmission of timing information

A CIP without a source packet header (SPH) has only one time stamp in the SYT field. If a CIP contains multiple data blocks, it is necessary to specify which data block of the CIP corresponds to the time stamp.

The transmitter prepares the time stamp for the data block which meets this condition:

$$\textbf{mod}(\text{data block count, SYT\_INTERVAL}) = 0 \quad (1)$$

where

data block count is the running count of transmitted data blocks;

SYT_INTERVAL denotes the number of data blocks between two successive valid SYTs, which includes one of the data blocks with a valid SYT. For example, if there are three data blocks between two valid SYTs, then the SYT_INTERVAL would be 4.

The receiver can derive the index value from the DBC field of a CIP with a valid SYT using the following formula:

$$\text{index} = \textbf{mod}((\text{SYT\_INTERVAL} - \textbf{mod}(\text{DBC}, \text{SYT\_INTERVAL})), \text{SYT\_INTERVAL} \quad (2)$$

where

index is the sequence number;

SYT_INTERVAL denotes the number of data blocks between two successive valid SYTs, which includes one of the data blocks with a valid SYT;

DBC is the data block count field of a CIP.

The receiver is responsible for estimating the timing of data blocks between valid time stamps. The method of timing estimation is implementation-dependent.

7.3 Time stamp processing

A data block contains all data arriving at the transmitter within an audio sample period. The data block contains all data which make up an “event”.

The transmitter shall specify the presentation time of the event at the receiver. A receiver for professional use shall have the capability of presenting events at the time specified by the transmitter. A consumer-use or cost-sensitive receiver is not required to support this presentation-time adjustment capability.

If a function block receives a CIP, processes it and subsequently re-transmits it, the SYT of the outgoing CIP shall be the sum of the incoming SYT and the processing delay.

The transmitter shall add TRANSFER_DELAY to the quantized timing of an event to construct the SYT. The TRANSER_DELAY value is initialized with the DEFAULT_TRANSFER_DELAY value. For professional use, TRANSFER_DELAY may be changed to achieve a shorter TRANSFER_DELAY value, according to the bus configuration. Products for consumer use are not required to support the modification of TRANSFER_DELAY.

The DEFAULT_TRANSFER_DELAY value is (354,17 + 125)μs, which accommodates the maximum latency time of CIP transmission through an arbitrated short bus reset.

7.4 Transmission control

7.4.1 Non-blocking transmission method

Figure 6 illustrates the non-blocking transmission method.

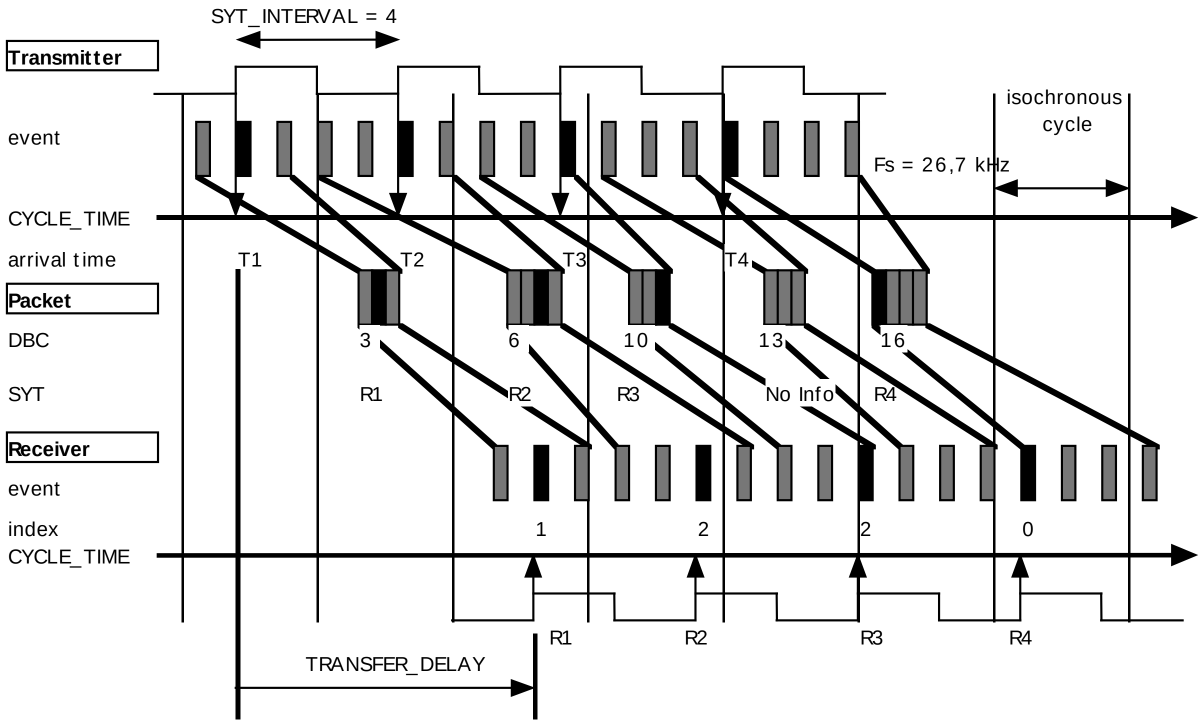

Figure 6 – Non-blocking transmission method

The transmitter shall construct a packet in every nominal isochronous cycle. Each packet shall comply with the following constraint:

$$0 <= N <= \text{SYT\_INTERVAL} \quad (3)$$

where N is the number of events in the packet.

In normal operation the transmitter shall not transmit events late and shall not transmit packets early. The resulting conditions may be expressed as follows:

$$\text{Packet\_arrival\_time\_L} <= \text{Event\_arrival\_time}[0] + \text{TRANSFER\_DELAY} \quad (4)$$

$$\text{Event\_arrival\_time}[N-1] <= \text{Packet\_arrival\_time\_F} \quad (5)$$

where

Packet_arrival_time_F is the time (measured in µs) when the first bit of the packet arrives at the receiver;

Packet_arrival_time_L is the time (measured in µs) when the last bit of the packet arrives at the receiver;

Event_arrival_time[M] is the time (measured in µs) of the arrival at the transmitter of event M of the packet. The first event of the packet has $M = 0$.

Figure 7 illustrates the transmission control rules as described in Clause 7.

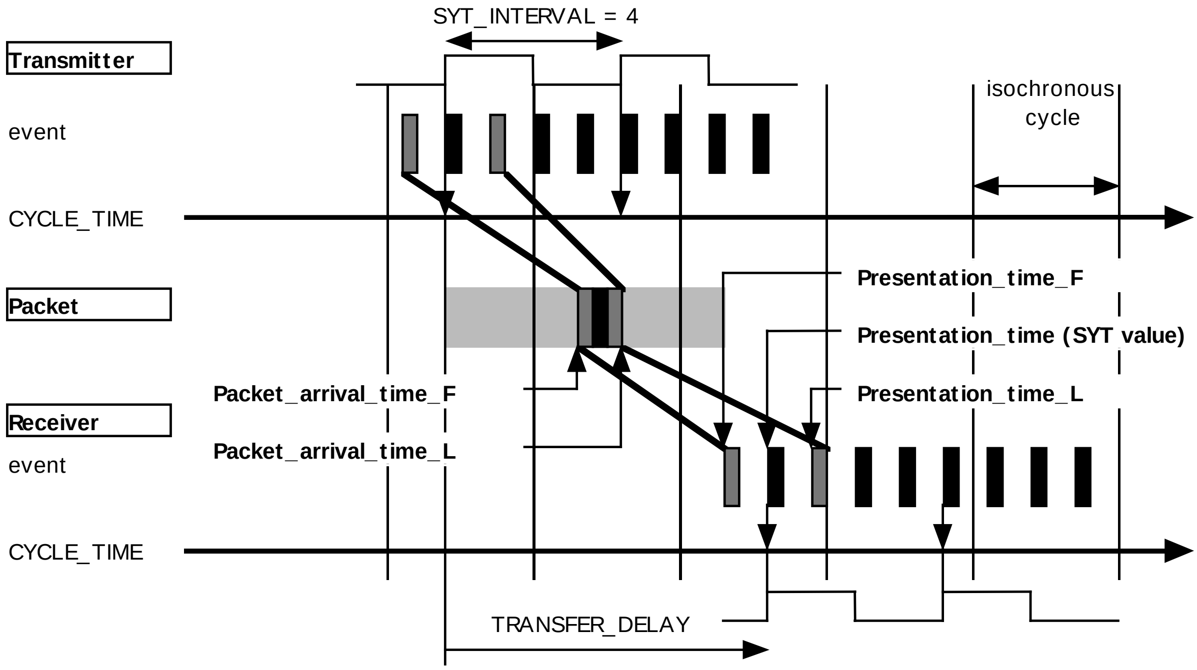

Figure 7 – Transmission parameters

In the event of lost opportunities to transmit non-blocking packets, a method of catching up may be provided (refer to Annex C).

7.4.2 Blocking transmission method

Figure 8 shows a diagram of a blocking transmission method.

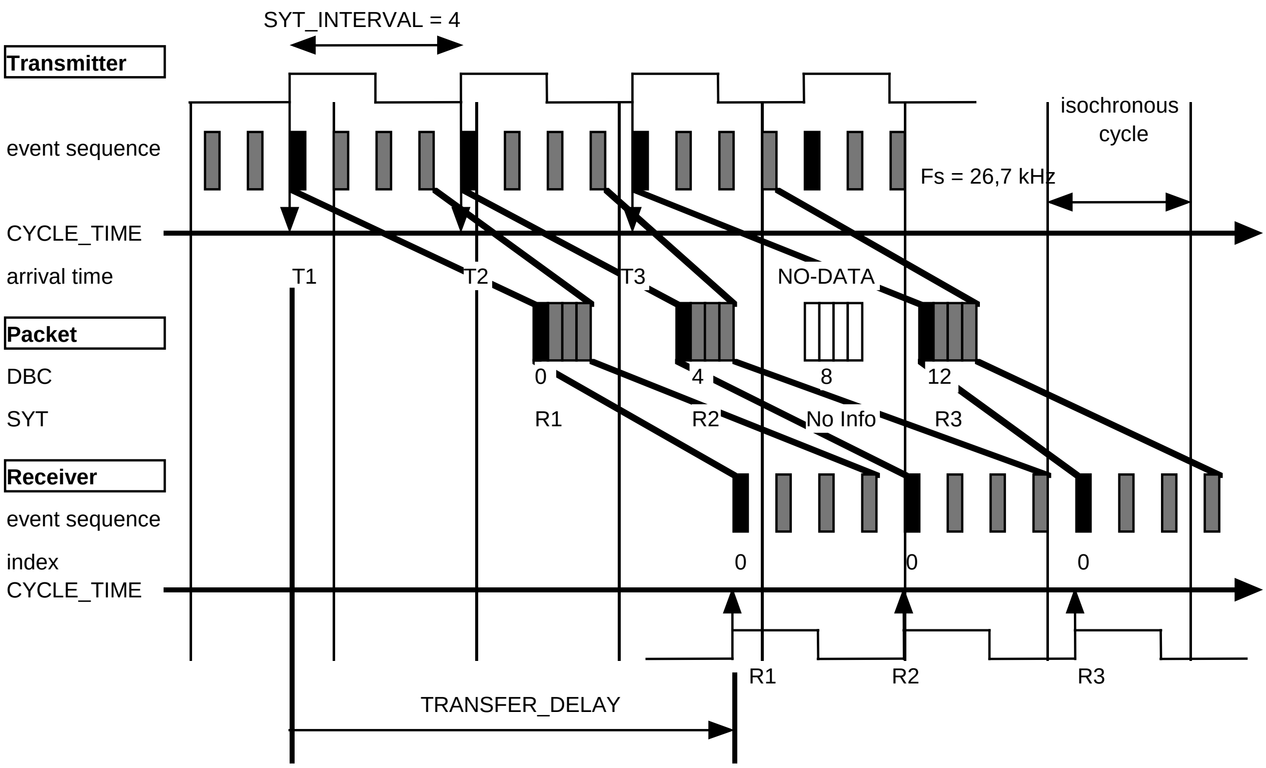

Figure 8 – Blocking transmission method

The blocking method may be used by a transmitter, which has only the ability to transmit packets of the same size. In order to indicate "no data", the transmitter may transmit an empty packet or a special non-empty packet which has the "NO-DATA" code in its FDF and has the same size of dummy data as a non-empty packet. The transmitter shall set the time stamp of the first data block in a packet.

For blocking, the duration of the successive events in a CIP have to be added to DEFAULT_TRANSFER_DELAY.

If a CIP contains N audio samples of a stream at Sampling Transmission Frequency (STF), then:

$$\text{TRANSFER\_DELAY} \geq \text{DEFAULT\_TRANSFER\_DELAY} + 1/\text{STF} \times N \times 1\,000$$

where

TRANSFER_DELAY is the latency of transmission;

DEFAULT_TRANSFER_DELAY is the initialized value of TRANSFER_DELAY;

STF is the sampling transmission frequency;

N is the number of audio samples in a CIP.

The TRANSFER_DELAY for each STF when DEFAULT_TRANSFER_DELAY = 479,17 μs (= 354,17 μs + 125 μs) is defined in Table 21.

It is recommended that the receiver have 250 μs of extra buffer.

8 Event types

8.1 General

All the subformats described in this standard shall use only 32-bit aligned events.

If multiple event sequences are synchronized, it is possible to convert the sequences into a single event which consists of an ordered collection of those sequences which occurred at the same time. The ordered collection is called a cluster. A cluster consists of ordered units. In the case of data, a unit consists of a single sequence. In the case of a pack, the unit may consist of several sequences packed together. The number of units in a single cluster is called the dimension, and is denoted by CLUSTER_DIMENSION. Figure 9 illustrates these concepts.

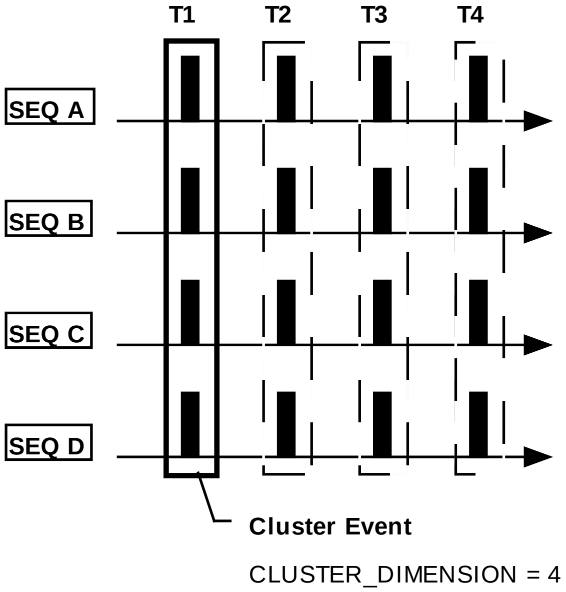

Figure 9 – Cluster events

In order to efficiently cluster non-32-bit aligned sequences which occur at the same time, the pack event type is defined. For example, four events of 24-bit data can be collected into a pack of three quadlets.

An event which is neither a cluster nor a pack is simply called data.

Only the pack and data types can be combined into units to make a cluster. All events in a cluster shall be of the same type.

UNIT_SIZE is the number of quadlets in a unit.

UNIT_DIMENSION is the number of sequences in a unit.

The UNIT_DIMENSION of data is always 1.

Figure 10 illustrates pack and cluster events.

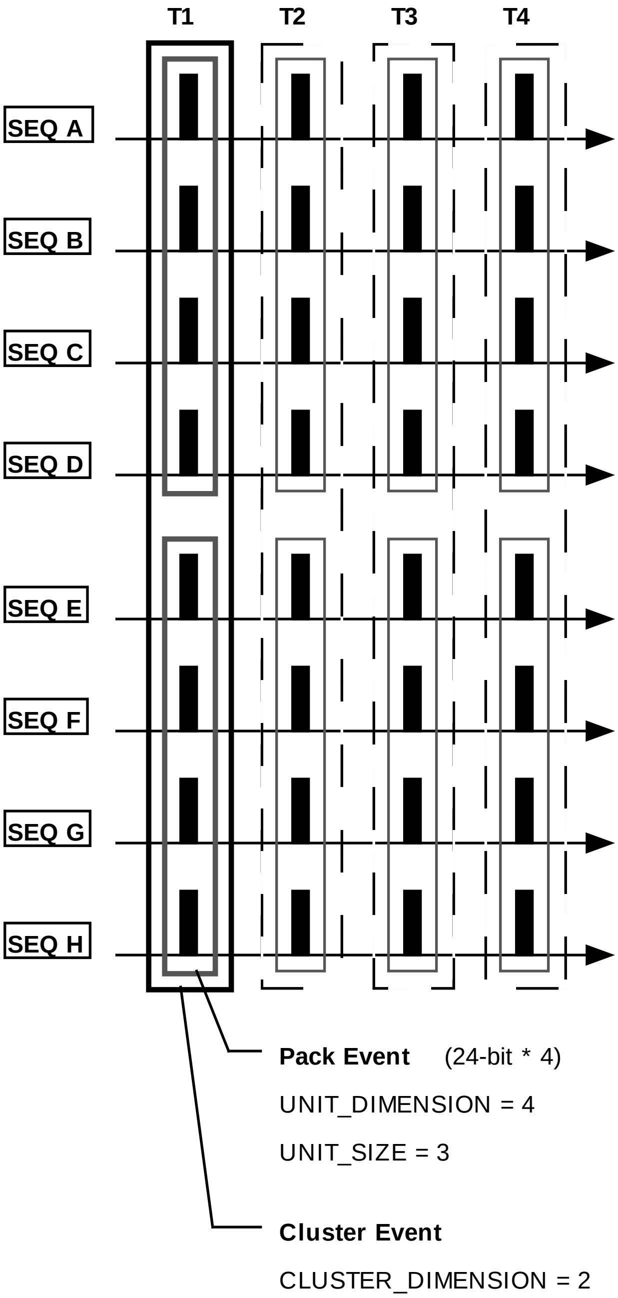

Figure 10 – Pack and cluster events

Figure 11 illustrates the structure of a pack which consists of four 24-bit event sequences (UNIT_DIMENSION = 4, UNIT_SIZE = 3).

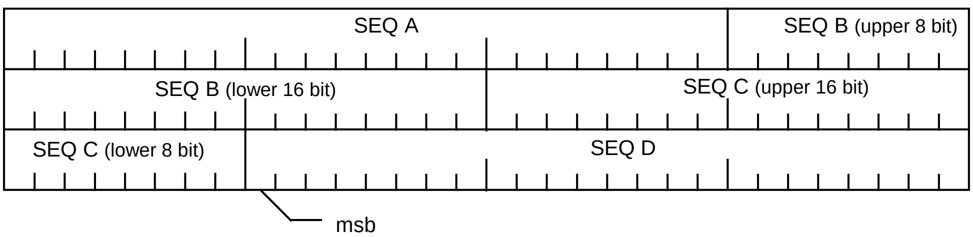

Figure 11 – Pack event with 24-bit event sequence

Since the cluster is an abstract event, only pack or data shall be specified as an event type for a subformat. However, the DBS shall reflect the size in quadlets of all cluster events in a data block. In the case of a clustered sequence:

$$\text{DBS} = \sum_{n=0}^{(\text{clusters}-1)} (\text{Unit\_Size}_n \times \text{CLUSTER\_DIMENSION}_n) \qquad (6)$$

where

clusters	is the number of clusters in the event;
Unit_Size_n	is the number of quadlets per unit of the n^{th} cluster;
$\text{CLUSTER\_DIMENSION}_n$	is the number of units per cluster of the n^{th} cluster.

Generally, the number of elementary sequences in a CIP is given by the following:

$$\text{number of sequences} = \text{DBS} \times \text{UNIT\_DIMENSION} / \text{UNIT\_SIZE} \qquad (7)$$

For the pack illustrated in Figure 9 and Figure 10, DBS = 6, CLUSTER_DIMENSION = 2, UNIT_DIMENSION = 4, UNIT_SIZE = 3.

The number of successive events in a CIP is equal to the number of data blocks in a CIP and given by

$$\text{NEVENTS\_SUCCESSIVE} = (\text{data\_length} / 4 - \text{CIPH\_SIZE}) / \text{DBS} \qquad (8)$$

where

data_length	is the size of the payload of an isochronous packet (in bytes);
CIPH_SIZE	is the size of the CIP header (in quadlets).

The ordering of sequences in an event is application-specific and is not within the scope of this standard. For example, the identification of audio channels in a multichannel transmission will be defined elsewhere.

8.2 AM824 data

8.2.1 Generic format

Figure 12 shows the AM824 format that is used in the following conditions and Table 3 provides a LABEL definition.

NOTE A 32-bit data consisting of an 8-bit label and 24-bit data are called AM824 data.

UNIT_SIZE = 1 quadlet/unit
UNIT_DIMENSION = 1 sequence/unit

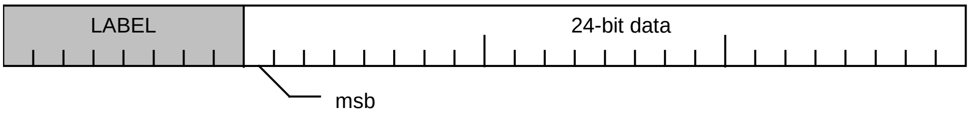

Figure 12 – Generic AM824 format

A receiver capable of processing AM824 data shall check the label for each AM824 data in a sequence being received.

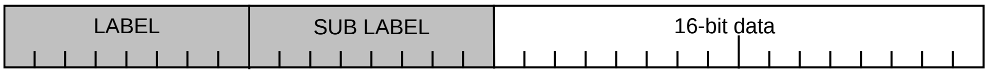

Figure 13 – AM824 data with SUB LABEL

If an application requires many data types, SUB LABEL, as shown in Figure 13, may be used to extend the number of data types defined by LABEL, see Table 3. An application map representation for Table 3 is shown in Figure 14.

Table 3 – LABEL definition

Value	Description
00_{16} – $3F_{16}$	IEC 60958 conformant
40_{16} – $4F_{16}$	Multi-bit linear audio
50_{16} – 57_{16}	One-bit audio (plain)
58_{16} – $5F_{16}$	One-bit audio (encoded)
60_{16} – 67_{16}	High-precision multi-bit linear audio
70_{16} – $7F_{16}$	Reserved
80_{16} – 83_{16}	MIDI conformant
84_{16} – 87_{16}	Reserved
88_{16} – $8B_{16}$	SMPTE time code conformant
$8C_{16}$ – $8F_{16}$	Sample count
90_{16} – BF_{16}	Reserved
$C0_{16}$ – EF_{16}	Ancillary data
$F0_{16}$ – FF_{16}	Reserved

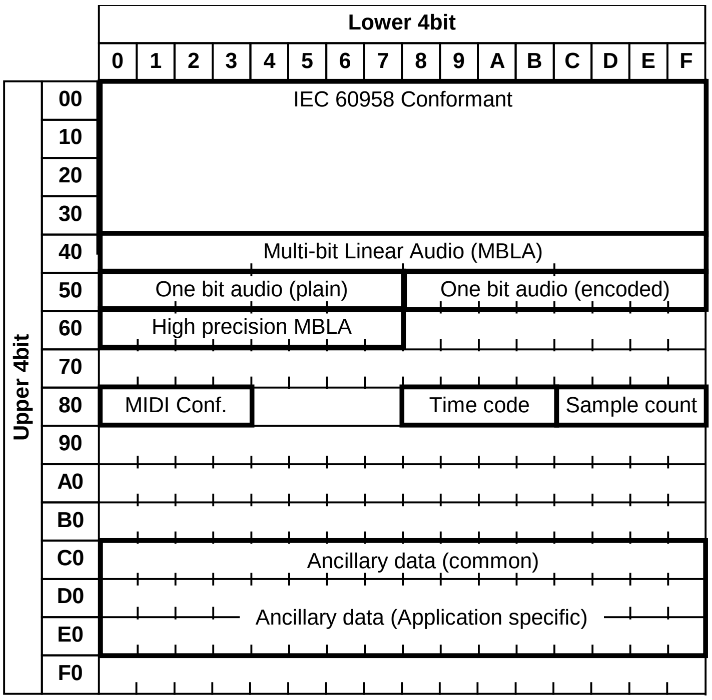

Figure 14 – AM824 LABEL allocation map

8.2.2 IEC 60958 conformant data

IEC 60958 confomant data format is shown in Figure 15.

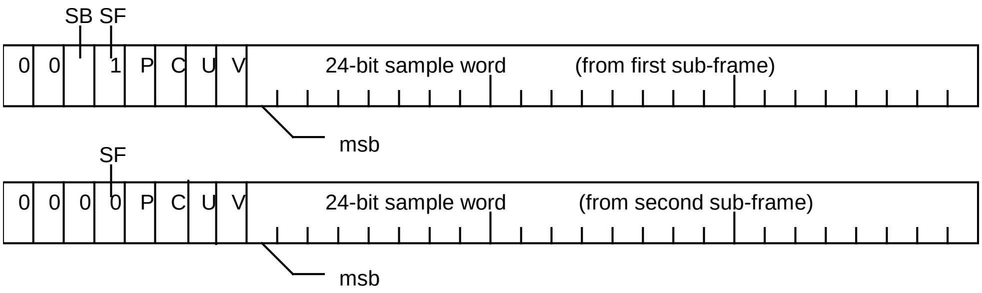

Figure 15 – IEC 60958 conformant data format

Table 4 – SB and SF definitions

SB (start-of-block) and SF (start-of-frame) definitions				
LABEL	**SB**	**SF**	**Description**	**Equivalent IEC 60958 preamble codes**
00_{16} – $0F_{16}$	0	0	Second subframe of IEC 60958 frames 0 to 191	W,Y
10_{16} – $1F_{16}$	0	1	First subframe of IEC 60958 frames 1 to 191	M,X
20_{16} – $2F_{16}$	1	0	Reserved	–
30_{16} – $3F_{16}$	1	1	First subframe of IEC 60958 frame 0	B,Z

All information defined in IEC 60958 is mapped into the data format shown in Figure 14 and Table 4. For each IEC 60958 frame, both sub-frames shall be transmitted together in the same event. The corresponding quadlet may be consecutive or non-consecutive. If multiple IEC 60958 streams are transmitted, then their sub-frames shall not be interleaved. Applications which use this data type shall follow IEC 60958.

8.2.3 Multi-bit linear audio (MBLA)

Multi-bit linear audio (MBLA) is shown in Figure 16.

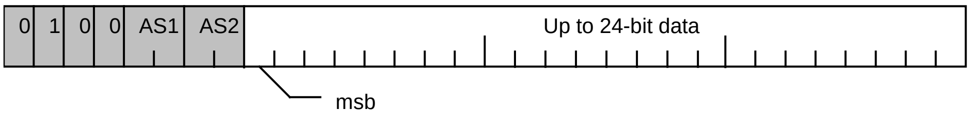

Figure 16 – MBLA data

The label field of MBLA has two fields for ASI (application-specific information). The definition of ASI2 depends on the ASI1 value described in Table 5.

Table 5 – ASI1 definition

Value	Description
00_2	Raw audio. The sample word can be fed directly to a D/A converter. Ancillary data may accompany. The definition of ASI2 is identical to VBL (valid bit length) defined in IEC 61883-6:2002.[a]
01_2 – 11_2	Application-specific information. The sample word may be fed directly to a D/A converter but, in some processing, required according to the application identified by application-specific ancillary data which shall appear in the same data block. The definition of the ASI2 field also shall be given by the application such as DVD-Audio described in 12.2.
[a] This information is given for the convenience of VBL system users.	

Figure 17 shows raw audio format and Table 6 provides a VAL definition.

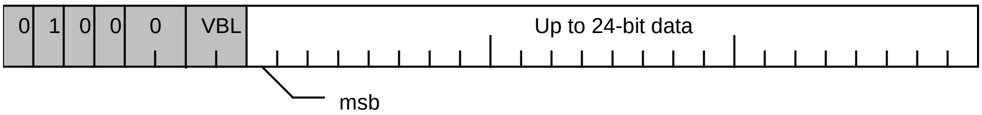

Figure 17 – Raw audio data

Table 6 – VBL (valid bit length code) definition

Value	Description
00_2	24 bit
01_2	20 bit
10_2	16 bit
11_2	Reserved

The audio data shall be expressed in 24-bit 2's complement format. If the data active word length is less than 24 bit, the correct number of zero bit shall be padded below the least significant bit to make a 24-bit data structure.

For example, a 20-bit audio data shall be placed in a 24-bit field as shown in Figure 18 (note the four zero pad bit at the right end of the structure).

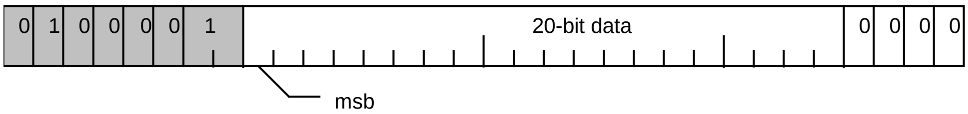

Figure 18 – Alignment of 20-bit data in 24-bit field

For audio data word lengths of less than 24 bit the VBL indication can be used by receivers to determine if the data can be truncated to less than 24 bit without changing the value. If the word length is not known or variable the data should be aligned at the most significant bit and the VBL code for 24-bit indication should be used.

8.2.4 One-bit audio

One-bit audio defines its own sampling frequency code (SFC). Table 7 and Table 8 provide LABEL definitions for one-bit audio (plain) and one-bit audio (encoded), respectively.

Table 7 – LABEL definition for one-bit audio (plain)

Value	Description
50_{16}	One-bit audio stream: multi-channel cluster start data
51_{16}	One-bit audio stream: multi-channel cluster continuation data
52_{16} – 57_{16}	Reserved

Table 8 – LABEL definition for one-bit audio (encoded)

Value	Description
58_{16}	DST: Encoded one-bit audio stream
59_{16} – $5F_{16}$	Reserved

8.2.5 MIDI conformant data

Figure 19 illustrates a MIDI conformant data format and Table 9 provides a C definition.

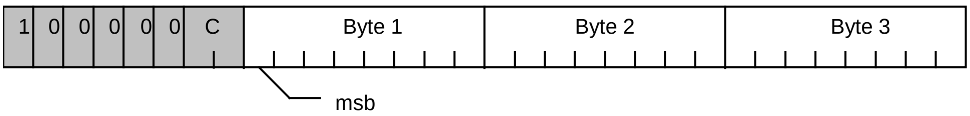

Figure 19 – MIDI conformant data format

Table 9 – C (counter) definition

C (counter) definition	
Value (decimal)	**Description**
0	No data (Byte 1 = Byte 2 = Byte 3 = 0)
1	Byte 1 is valid
2	Byte 1 and 2 are valid
3	Byte 1, 2 and 3 are valid

If the CIP carries only MIDI conformant data or cluster, and there are no MIDI data to be packed into a CIP, the packet should be an empty packet rather than a packet of all no-data codes.

The no-data code defined in MIDI conformant data may be used as no data for other AM824 data types if necessary. The usage of no data described above should be applied to the AM824 data types which use no data.

Figure 20 illustrates the no-data structure.

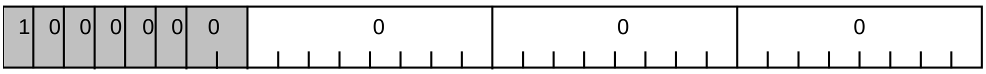

Figure 20 – No-data format

Successful implementation of MIDI conformant data may require additional information. Attention is drawn to MMA/AMEI Recommended Practice 027.

8.2.6 SMPTE time code data

The SMPTE time code is defined in 1394 Trade Association document 1999024, SMPTE Time Code and Sample Count Transmission Protocol Version 1.0.

8.2.7 Sample count data

The Sample count transmission is defined in 1394 Trade Association document 1999024, SMPTE Time Code and Sample Count Transmission Protocol Version 1.0.

8.2.8 High-precision multi-bit linear audio

The multi-bit linear audio (MBLA) is limited to sample words up to 24 bit length. Linear PCM audio data longer than 25 bit length and up to 196 bit length can be transmitted with high-precision multi-bit linear audio, see Figure 21.

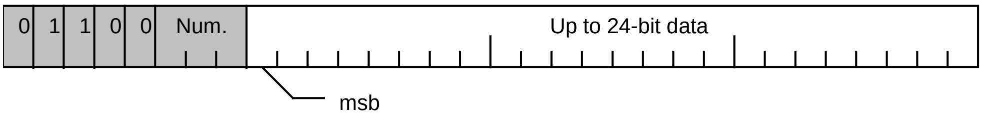

Figure 21 – High-precision multi-bit linear audio data

The high-precision multi-bit linear audio data use the LABEL from 60_{16} to 67_{16}. The label field of the high-precision multi-bit linear audio has Num. (slot number) field. The definition of Num. field is given in Table 10.

Table 10 – Num. (slot number) definition

Value	Description
000_2	1st slot number (Num. = 0)
001_2	2nd slot number (Num. = 1)
010_2	3rd slot number (Num. = 2)
…	…
111_2	8th slot number (Num. = 7)

The high-precision multi-bit linear audio data longer than 25 are divided into more than 2 quadlet sequence slots. The Num. (slot number) shall start with Num. = 0 (LABEL = 60_{16}) and be sequential. Figure 22 shows generic quadlet sequence for the high-precision multi-bit linear audio data.

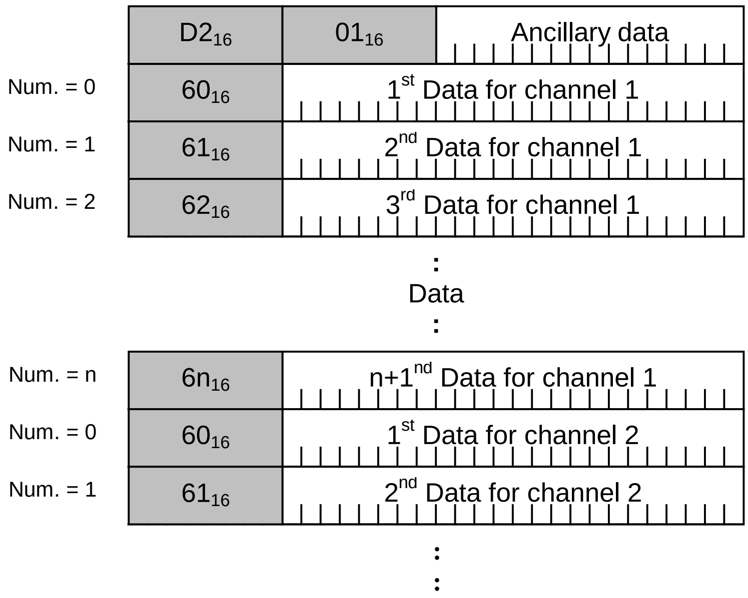

Figure 22 – Generic high-precision quadlet sequence

8.2.9 Ancillary data

8.2.9.1 Generic ancillary data

Generic ancillary data is illustrated in Figure 23 and the definition of LABEL is probided in Table 11. The definition of Byte 1, Byte 2, Byte 3 and transmission method, timing accuracy and interval, for instance, should be given by each instance of ancillary data. It is recommended that all information carried by ancillary data should be transmitted repeatedly in a reasonably short interval of time while the information is valid so that the receiver does not have to wait for the information. It is recommended that Byte 1 is defined as a SUB LABEL that specifies Byte 2 and Byte 3.

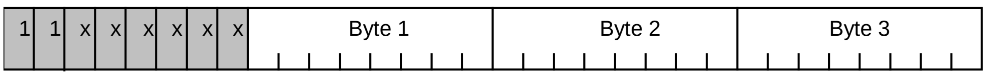

Figure 23 – Generic ancillary data

Table 11 – LABEL definition for ancillary data type

Value	Description
$C0_{16}$ – CF_{16}	Common ancillary data
$D0_{16}$ – EF_{16}	Application-specific ancillary data

8.2.9.2 Common ancillary data

8.2.9.2.1 General

Common ancillary data carries information common to all applications under a category of such as copyright information. The usage of these data are described in 11.4.2.3. Table 12 provides LABEL definition for common ancillary data.

Table 12 – LABEL definition for common ancillary data

Value	Description
$C0_{16}$	ASID
$C1_{16}$ – CE_{16}	Reserved
CF_{16}	Ancillary no-data

8.2.9.2.2 Ancillary no data

Ancillary no-data, shown in Figure 24, provides a no-data event only for AM824 data that does not define its own no data. Table 13 provides a CONTEXT definition. AM824 data types that define their own no data shall not use this ancillary no data.

In order to determine whether the AM824 data type carries valid information, it is required that no data specifies the AM824 data type to which it belongs. For this reason, the AM824 data type derived from a given no data should be identical to the AM824 data that carries valid information. Subclause 8.2.5 allows the use of no data defined in MIDI conformant data.

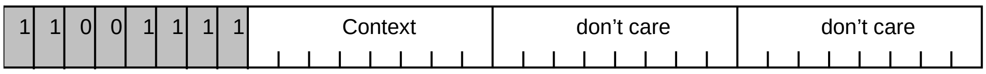

Figure 24 – Ancillary no data

Table 13 – CONTEXT definition

Value	Description
00_{16}	No-data for IEC 60958 conformant
01_{16} – $3F_{16}$	Reserved
40_{16}	No-data for multi-bit linear audio
41_{16} – $4F_{16}$	Reserved
50_{16}	No-data for one-bit audio (plain)
51_{16} – 57_{16}	Reserved
58_{16}	No-data for one-bit audio (encoded)
59_{16} – $5F_{16}$	Reserved
60_{16}	No-data for high-precision multi-bit linear audio
61_{16} – $7F_{16}$	Reserved
80_{16} – 83_{16}	Reserved
84_{16} –87_{16}	Reserved
88_{16} –$8F_{16}$	Reserved
$C0_{16}$ – CE_{16}	No-data for each 7 different common ancillary data
CF_{16}	No-data for unspecified type. This shall be used only for the purpose described in 11.3.
$D0_{16}$ – EF_{16}	No-data for each 32 different application specific ancillary data
$F0_{16}$ – FF_{16}	Reserved

8.2.9.2.3 ASID

ASID (Audio Software Information Delivery) defines transmission methods of ISRC, UPC/EAN and content usage (copyright assertion) information carried by the AM824 data.

The general format for ASID is shown in Figure 25.

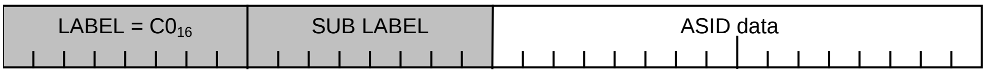

Figure 25 – General format for ASID

The second byte SUB LABEL following the LABEL identifies the particular type of ASID data as shown in Table 14.

Table 14 – SUB LABEL definition for ASID

SUB LABEL	Description
00_{16} – $0F_{16}$	UPC/EAN and ISRC
10_{16} – $1F_{16}$	Content Usage Information
20_{16} – FF_{16}	Reserved

For details, see the ASID specification.

8.2.10 Application specific ancillary data

Application specific ancillary data carries information specific to an application, which is transmitted along with the audio and music data. Examples are mapping of sequence of a compound data block to speaker location, microphone location, or signal name.

Table 15 – LABEL definition for application specific ancillary data

Value	Description
$D0_{16}$	DVD-Audio
$D1_{16}$	SACD
$D2_{16}$	High-precision multi–bit linear audio
$D3_{16}$	Blu-ray Disc
$D4_{16}$	Multi-bit Linear Audio (MBLA)
$D5_{16}$ – EF_{16}	Reserved

The general format for the application-specific ancillary data is shown in Figure 26.

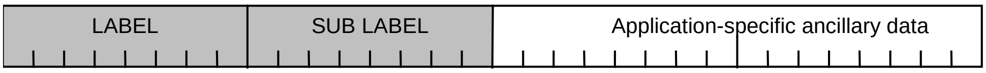

Figure 26 – General format for application-specific ancillary data

The first byte (“LABEL”) indicates that these data are for the application specific ancillary data of the type shown in Table 15. The second byte (“SUB LABEL”) further identifies the particular data that follows. For details, refer to 12.2 for DVD-Audio, 12.3 for SACD, 12.4 for Blu-ray and 12.5 for Multi-bit Linear Audio (MBLA).

8.3 32-bit floating-point data

This data type carries 32-bit floating-point data defined in IEEE 754-1985, Standard for Binary Floating-Point Arithmetic.

UNIT_SIZE = 1 quadlet/unit
UNIT_DIMENSION = 1 sequence/unit

Figure 27 illustrates the structure of 32-bit floating-point data.

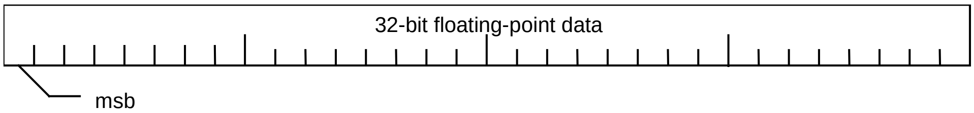

Figure 27 – 32-bit floating-point data format

8.4 24-bit × 4 audio pack

UNIT_SIZE = 3 quadlet/unit
UNIT_DIMENSION = 4 sequences/unit

Figure 28 illustrates the structure of a 24-bit × 4 audio pack.

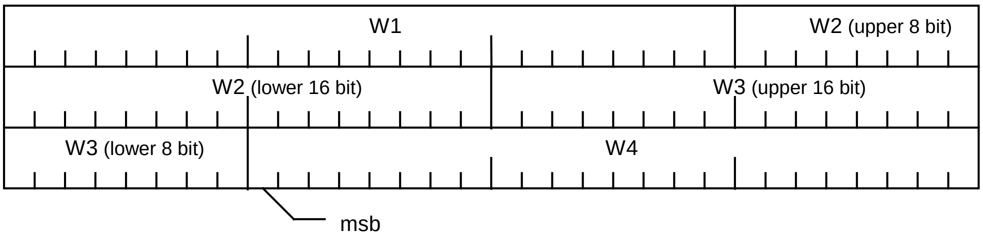

Figure 28 – 24-bit × 4 audio pack format

W1, W2, W3, W4: 24-bit raw audio data

The audio data shall be expressed in 24-bit 2's complement. In case of less than 24 bit, the correct number of zero bit shall be padded below the least significant bit to make a 24-bit data structure. For an example of this, refer to 8.2.3.

8.5 32-bit generic data

UNIT_SIZE = 1 quadlet/unit
UNIT_DIMENSION = 1 sequence/unit

Figure 29 illustrates the structure of 32-bit generic data.

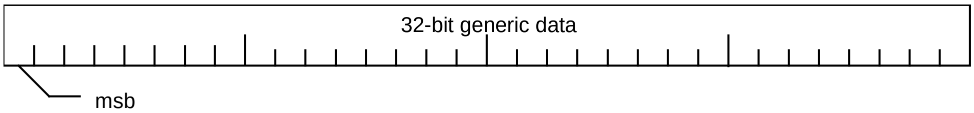

Figure 29 – 32-bit generic data format

9 FDF definition

9.1 Overview

Under the A/M packet format as described in 6.3, format dependent field (FDF) is used for specifying subformat type and additional information described in Clause 4. Table 16 defines the subformat and FDF allocations.

Table 16 – Subformat and FDF allocations

Value	Description
0000 $0xxx_2$	Basic format for AM824
0000 $1xxx_2$	Basic format for AM824.transmission rate may be controlled by an AV/C command set
0001 $0xxx_2$	Basic format for 24-bit×4 audio pack
0001 $1xxx_2$	Reserved
0010 $0xxx_2$	Basic format for 32-bit floating-point data
0010 $1xxx_2$	Reserved
0011 $0xxx_2$	Basic format for 32-bit generic data
0011 $1xxx_2$	Reserved
0100 $0xxx_2$ – 1111 1110_2	Reserved
1111 1111_2	Packet for NO-DATA

Each subformat may use a cluster for synchronized multiple sequences unless otherwise specified.

9.2 Basic format

Table 17 and Table 18 show the DBS for AM824 and 32-bit floating-point data and DBS for 24-bit × 4 audio pack, respectively.

Table 17 – DBS for AM824 and 32-bit floating-point data

DBS for AM824 data and 32-bit floating-point data	
Value	**Description**
0_{10}	CLUSTER_DIMENSION = 256
1 – 255_{10}	CLUSTER_DIMENSION = DBS

Table 18 – DBS for 24-bit × 4 audio pack

DBS for 24-bit × 4 audio pack	
Value	**Description**
3 – 255_{10}	CLUSTER_DIMENSION = DBS/3

Figure 30 illustrates a generic FDF definition. Table 19 and Table 20 provide EVT and SFC definitions, respectively. The TRANSFER_DELAY for the given SFC definition is provided in Table 21.

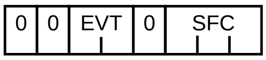

Figure 30 – Generic FDF definition

Table 19 – Event type (EVT) code definition

Value	Description
0_{10}	AM824 data
1_{10}	24-bit × 4 audio pack
2_{10}	32-bit floating-point data
3_{10}	Reserved

Table 20 – Default SFC table

Value	Description	
	SYT_INTERVAL	Nominal_Sampling_Frequency
00_{10}	8	32 kHz
01_{10}	8	44,1 kHz
02_{10}	8	48 kHz
03_{10}	16	88,2 kHz
04_{10}	16	96 kHz
05_{10}	32	176,4 kHz
06_{10}	32	192 kHz
07_{10}	Reserved	Reserved

Table 21 – TRANSFER_DELAY for blocking transmission

Value	TRANSFER_DELAY µs
00_{10}	479,17 + 250,00 = 729,17
01_{10}	479,17 + 181,41 = 660,58
02_{10}	479,17 + 166,67 = 645,84
03_{10}	479,17 + 181,41 = 660,58
04_{10}	479,17 + 166,67 = 645,84
05_{10}	479,17 + 181,41 = 660,58
06_{10}	479,17 + 166,67 = 645,84
07_{10}	Reserved

If a packet of AM824 data contains only IEC 60958 conformant data and a transmitter functions as a gateway, the transmitter should estimate the sample transmission frequency for the SFC rather than copying the sampling frequency code embedded in the original IEC 60958 data.

Equation (9) can be used to determine the required bus bandwidth allocation. The required isochronous bandwidth is given below:

$$BW = (\text{int}(\max(FS)/8\,000)+1) \times \sum_{n=0}^{\text{clusters-1}} (\text{UNIT\_SIZE}_n \times \text{CLUSTER\_DIMENSION}_n) \times 8\,000 \qquad (9)$$

where

BW	is the required isochronous bandwidth (in quadlet/s);
Fs	is the sample rate (in Hz);
UNIT_SIZE_n	is the number of quadlet in a unit of the nth cluster;
$\text{CLUSTER\_DIMENSION}_n$	is the number of units in the nth cluster;
CLUSTERS	is the number of clusters in an event.

9.3 Special format

1	1	1	1	1	1	1	1

Figure 31 – FDF code for NO-DATA packet

The transmitter shall use the FDF code shown in Figure 31 when a packet is a no-data packet only for blocking transmission. The transmitter shall not use this FDF code for non-blocking transmission. The receiver shall ignore all the data in a CIP with this FDF code.

10 FDF definition for AM824 data

10.1 Definition of N-flag

0	0	0	0	N	SFC		

Figure 32 – Structure of FDF for AM824 data type

The N-flag as shown in Figure 32 shall be used to select the AM824 LABEL space and the adaptation process described in 10.4.

Any AM824 data type shall occupy the same space in both LABEL spaces. An application may use only one of two LABEL spaces by giving a fixed value to the N-flag. Only an AM824 data type that owns the LABEL space or application-specific ancillary data, which is defined in 8.2.10, can inhibit the use of one of the LABEL spaces.

10.2 Supplementary SFC definition

In IEC 61883-6:2002, there is only one SFC table that specifies both Nominal_Sampling_Frequency and SYT_INTERVAL.

For clarification, and in order to enable backwards compatibility, in this standard, the SFC definition is changed so that a new AM824 data type, which was defined in IEC 61883-6:2002, may define its own SFC table. In order to maintain compatibility with IEC 61883-6:2002, in the case of FDF = 0000 $0xxx_2$, the default SFC table shall be identical to the table defined in IEC 61883-6:2002. Only a new AM824 data type may override the default SFC table. Figure 33 shows an SFC interpretation and Figure 34 gives an example of an FDF for AM824 and AM824 LABEL space.

The empty packet defined in IEC 61883-1 shall use the default SFC table.

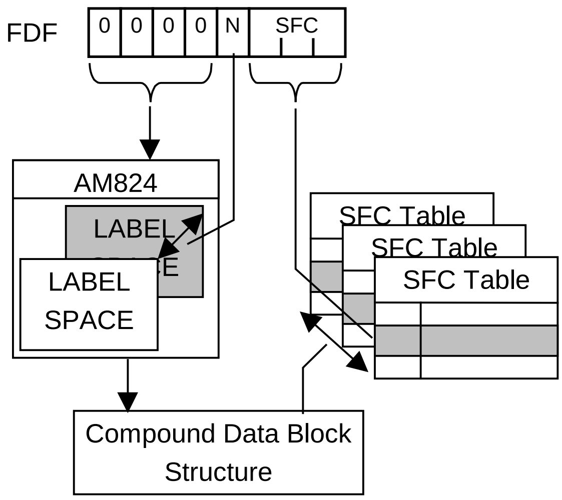

Figure 33 – SFC interpretation

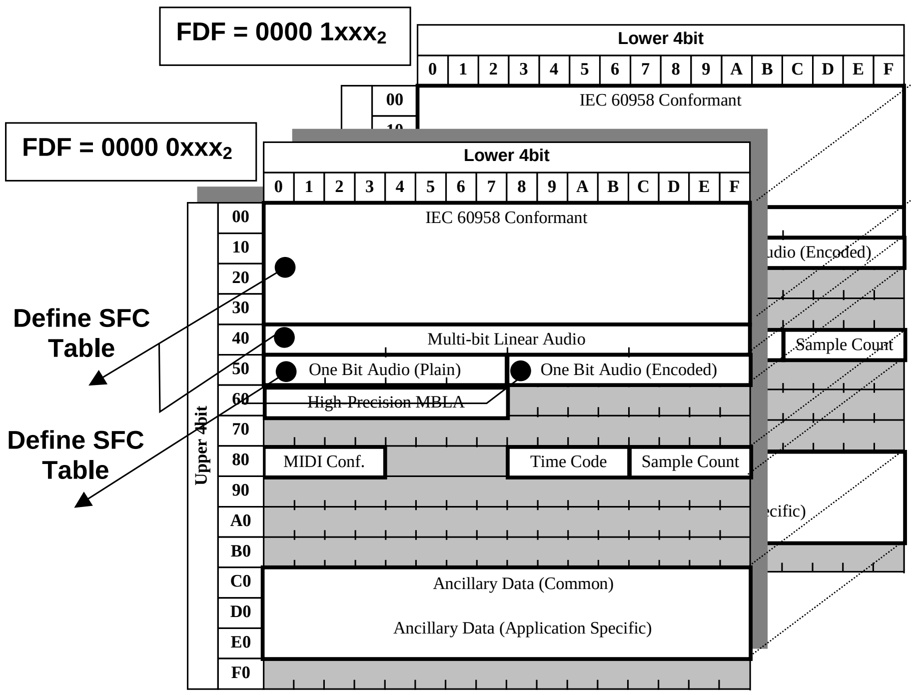

Figure 34 – FDF for AM824 and AM824 LABEL space

10.3 Clock-based rate control mode (FDF = 0000 0xxx$_2$)

10.3.1 Introductory remark

This FDF value, defined in IEC 61883-6:2002, is interpreted to indicate that the data transmission rate is controlled by a transmission clock reproduced by means of a timestamp.

The meaning of this FDF value, as specified in 10.3.2, is not changed.

10.3.2 Default SFC table for (FDF = 0000 0xxx$_2$)

When FDF has 0000 0xxx$_2$, default SFC is defined in Table 22.

Table 22 – Default SFC table for FDF = 0000 0xxx$_2$

Value	Description	
	SYT_INTERVAL	Nominal_Sampling_Frequency
00_{10}	8	32 kHz
01_{10}	8	44,1 kHz
02_{10}	8	48 kHz
03_{10}	16	88,2 kHz
04_{10}	16	96 kHz
05_{10}	32	176,4 kHz
06_{10}	32	192 kHz
07_{10}	Reserved	Reserved

The TRANSFER_DELAY for blocking transmission, in the case of DEFAULT_TRANSFER_ DELAY = 479,17 μs = (354,17 + 125)μs, corresponds to the default SFC table as given in Table 23.

Table 23 – TRANSFER_DELAY for blocking transmission

Value	TRANSFER_DELAY μs
00_{10}	479,17 + 250,00 = 729,17
01_{10}	479,17 + 181,41 = 660,58
02_{10}	479,17 + 166,67 = 645,84
03_{10}	479,17 + 181,41 = 660,58
04_{10}	479,17 + 166,67 = 645,84
05_{10}	479,17 + 181,41 = 660,58
06_{10}	479,17 + 166,67 = 645,84
07_{10}	Reserved

10.4 Command-based rate control mode (FDF = 00001xxx$_2$)

10.4.1 Introductory remark

This FDF value indicates that the data transmission rate is controlled by a command set such as the AV/C command set for the rate control of the isochronous data flow.

This transmission mode can be used for reproducing an application sequence at a receiver or for high-speed data transfer without using a timestamp in the SYT field.

If the timing information is available, the transmitter should provide the correct timestamp in the SYT field according to the integer multiplier *n* so that the clock-based rate controlled receiver can receive the data transmitted in this mode.

$$\text{SYT\_INTERVAL}_{\text{N-flag=1}} = \text{SYT\_INTERVAL}_{\text{N-flag=0}} \times n \ (n >= 1)$$

where $\text{SYT\_INTERVAL}_{\text{N-flag=1}}$ and $\text{SYT\_INTERVAL}_{\text{N-flag=0}}$ denote SYT_INTERVAL specified by the SFC table in the cases in which FDF = 0000 1xxx$_2$ and FDF = 0000 0xxx$_2$, respectively. The integer multiplier *n* is obtained by a command.

10.4.2 Default SFC table for (FDF = 0000 $1xxx_2$)

When FDF has 0000 $1xxx_2$, default SFC is defined in Table 24.

Table 24 – Default SFC table for FDF = 0000 $1xxx_2$

Value	Nominal_Sampling_Frequency	SYT_INTERVAL	Sampling_Frequency
0_{10}	32 kHz	8 × *n*	32 kHz × *n*
1_{10}	44,1 kHz	8 × *n*	44,1 kHz × *n*
2_{10}	48 kHz	8 × *n*	48 kHz × *n*
3_{10}	88,2 kHz	16 × *n*	88,2 kHz × *n*
4_{10}	96 kHz	16 × *n*	96 kHz × *n*
5_{10}	176,4 kHz	32 × *n*	176,4 kHz * *n*
6_{10}	192 kHz	32 × *n*	192 kHz × *n*
7_{10}	Reserved	Reserved	Reserved

The DBS of an event is independent of the transfer speed.

11 AM824 adaptation process

11.1 Introductory remark

This clause describes typical methods of adaptation to an AM824 sequence.

11.2 Basic sequence conversion

Transfer_Frequency is identical to Sampling_Frequency (transfer frequency of the application sequence such as audio) to be packetized if each event in the application sequence (each audio sample) is stored in one unit such as one AM824 data of an AM824 sequence.

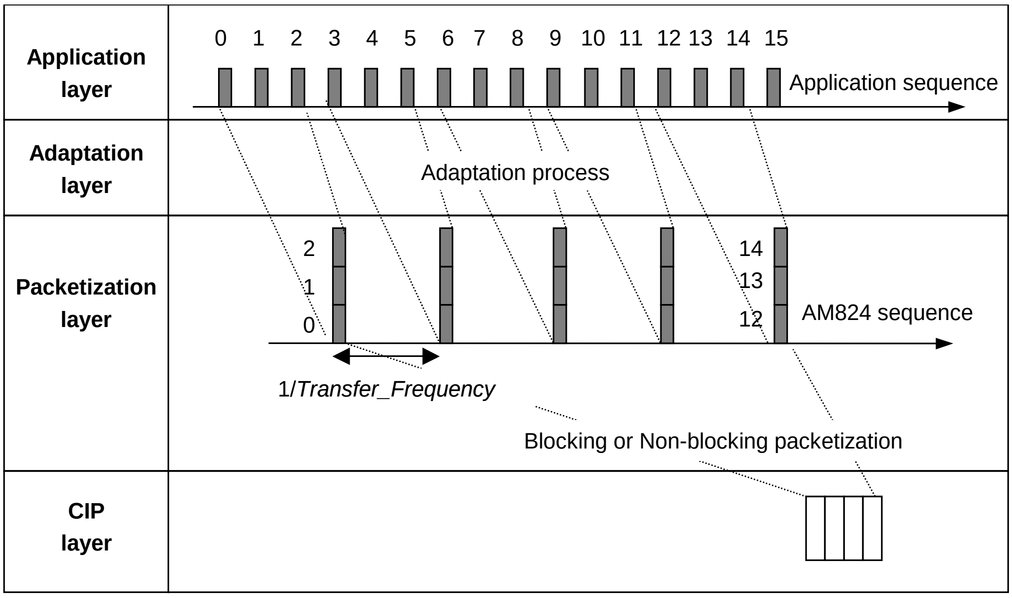

Figure 35 – Adaptation to AM824 sequence

Figure 35 describes an example of an adaptation process in which each event of the application sequence is 8 bit in length and three events are stored in a single AM824 data which has a 24-bit payload. In this case, the relation between Sampling_Frequency and Transfer_Frequency is expressed by

$$\text{Sampling\_Frequency} = L \times \text{Transfer\_Frequency}$$

where $L = 3$.

The parameters Sampling_Frequency, Transfer_Frequency and L cannot be specified independently. All of them are specified by the SFC code selected by the AM824 data type.

11.3 Sequence multiplexing

If the event occurrence rate of an application sequence is less than half of the rate of the compound data block, one single event sequence can carry more than one application sequence by multiplexing the application sequence into a single event sequence assigned to the compound data block. In this case, each multiplexed application sequence is identified by its DBC (data block count). An example of asynchronous sequence multiplexing is shown in Figure 36.

If the AM824 sequence defines no-data for padding, even an application sequence, which is asynchronous to Transfer_Frequency can be adapted to the AM824 sequence. One significant example of this case is the adaptation of a MIDI data stream (application sequence) to a MIDI conformant sequence (AM824 sequence).

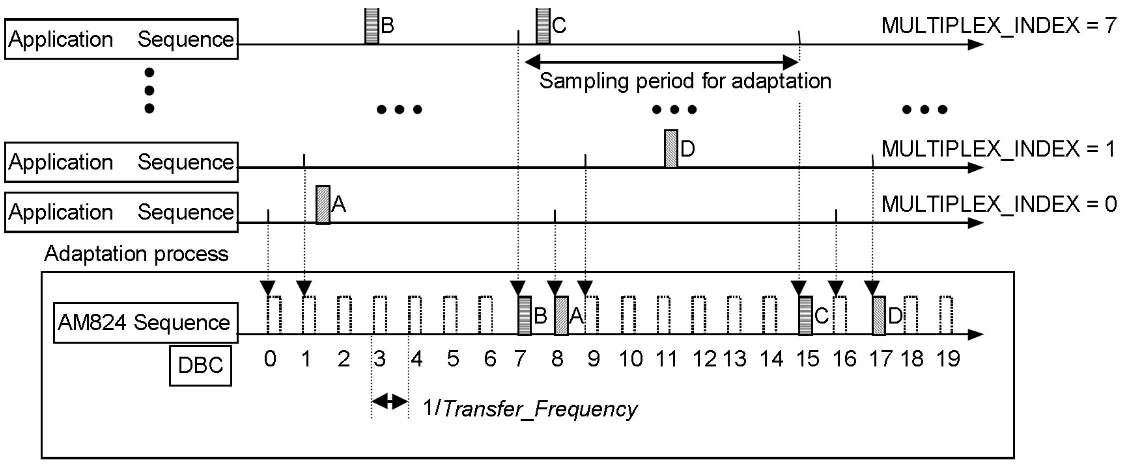

Figure 36 – Asynchronous sequence multiplexing

An application that uses this multiplexing shall define MULTIPLEX_NUMBER to be a power of 2, such as 2, 4, 8, 16 and so on. The MULTIPLEX_NUMBER is defined in conjunction with the LABEL definition because the place for carrying the MULTIPLEX_NUMBER information is not defined in this standard. This definition will be overridden by a future specification if it defines a method of carrying the MULTIPLEX_NUMBER.

The identifier for a multiplexed sequence denoted by MULTIPLEX_INDEX is given by MULTIPLEX_INDEX = mod (DBC, MULTIPLEX_NUMBER).

11.4 Compound data block structure

11.4.1 General

Compound data block is the name for the data block that consists of AM824 data in any combination, if all the AM824 data in the data block specify the same SFC table. (Note that the SFC value in a CIP specifies the entry of the SFC table selected according to the AM824 data type that defines the SFC table.)

Thus the cluster, which is equivalent to a data block in the context of AM824 data, can be referred to as a compound cluster.

Each sequence carried by a compound data block is uniquely identified by the location of events in the compound block.

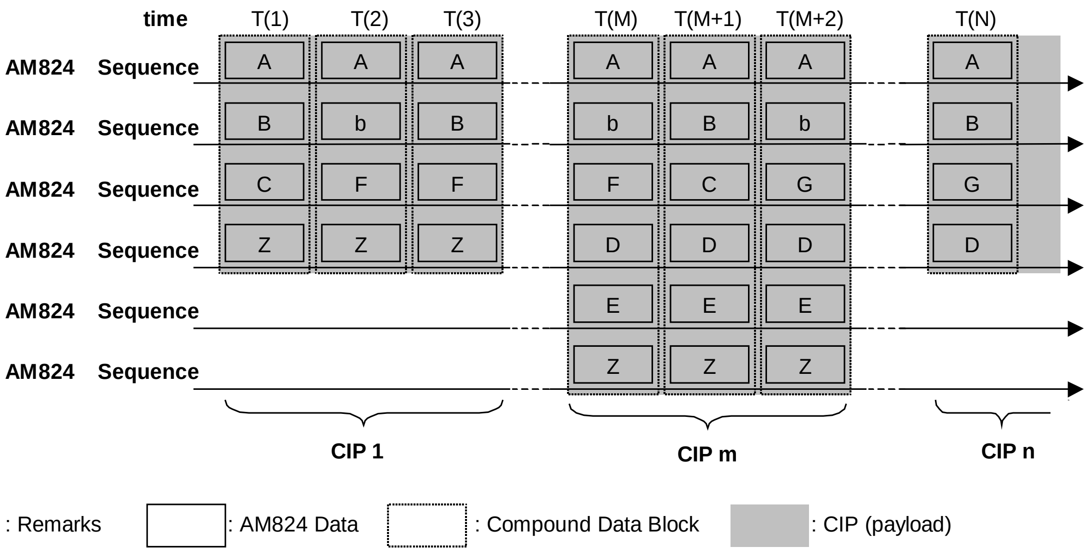

Figure 37 – Example of compound data block

An example of usage of compound data block is illustrated in Figure 37.

The capital letter, 'B' for example, in the box of AM824 data, represents the box's data type. The small letter, 'b' for example, in the box of AM824 data, denotes no-data for same data type.

DBS (data block size) or CLUSTER_DIMENSION may vary in time. Also, the AM824 data type described in the LABEL field of each event may vary in time.

11.4.2 Compound data structure rule

11.4.2.1 General

IEC 61883-6:2002 allows any order of AM824 data type in a compound data block. In order to maintain minimum connectivity, this subclause defines rules for the compound data structure, or, in other words, a rule for the AM824 sequence configuration. A flowchart of the rule is shown in Figure 38. Also, some recommendations for implementation are described.

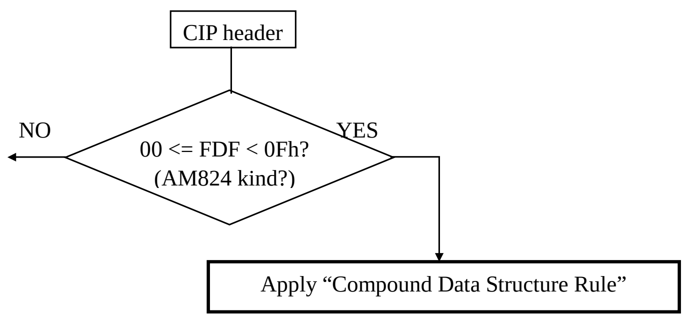

Figure 38 – Condition of AM824 rule

11.4.2.2 Size rule definition

The size of compound data should be an even number of quadlet.

If the number of quadlet in a sequence required by an application is not an even number, an unspecified sequence (sequence of ancillary no-data with CONTEXT = CF_{16}) should be added to make the number of quadlets in the sequence even. Figure 37 shows a compound data block compliant to this rule where the event denoted by “Z” is interpreted as ancillary no-data with CONTEXT = CF_{16}. As long as the number of quadlets in a sequence is even, any number of unspecified sequences may be added.

11.4.2.3 Order rule definition

An application specifier is either application-specific ancillary data or any common ancillary data except ancillary no-data for non-ancillary data. The content data is any AM824 data other than the application specifier.

A compound data block starts with zero or only one unspecified region followed by zero or one or more specified region(s), see Figure 39 and an example shown in Figure 40. An unspecified region includes only content data. A specified region starts with one or more application specifiers followed by one or more content data before encountering the next application specifier or the end of the compound data block.

A sequence of application specifiers may contain both common ancillary data and application-specific ancillary data by multiplexing.

The order of the content data in an unspecified region shall be determined by the following formula.

IEC 60958 Conformant Data < Multi-bit Linear Audio < MIDI Conformant Data < SMPTE Time Code < Sample Count.

Within an unspecified region, the same data type should occupy a contiguous area.

The order inside a specified region is defined by the application specified in the application-specific ancillary data. The specified region shall have none or only one common ancillary data or one or more application-specific data for the same application.

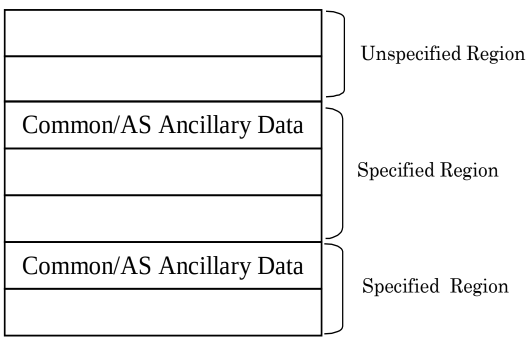

Figure 39 – Generic compound data block structure

IEC 60958 Conformant L-ch
IEC 60958 Conformant R-ch
MBL Audio Data 1-ch
MBL Audio Data 2-ch
MBL Audio Data 3-ch
MBL Audio Data 4-ch
MIDI Conformant Data

Figure 40 – Example of unspecified region structure

11.4.2.4 Recommendation: general

Because 2-channel stereo audio is widely accepted, it is highly recommended that for devices, which transmit audio in any format, the first two sequences be linear audio either in IEC 60958 conformant or raw audio. The first sequence should be left and the second should be right. If a transmitter is a monaural audio device, it may send the audio in the left channel and silent data in the right, or send the audio in both left and right. It is implementation-dependent.

If a transmitter is a multi-channel audio device, it may send down-mixed in 2-channel stereo audio in addition to the multi-channel audio.

11.4.2.5 Recommendation for transmitter

The following recommendations for transmitters apply.

a) The DBS (data block size in quadlet) should be greater than, or equal to, 2. An even number is preferable.

   At the top of the data block of mixed audio and music data, the stereo left channel, then the right channel should be transmitted.

b) In data blocks of multichannel audio data, the first two quadlets should be the main channels corresponding to stereo left and right channel.

c) Recommendation for stream change method is as follows:

   When the contents of stream are changed, it is preferable to insert ancillary no-data or empty packets at the change point of the stream.

   The change point of the stream is not a pause of each tune in the CD album, but it implies that at the point, some change of, for example, compression methods, occurs.

   The purpose of inserting ancillary no data or empty packets is to prevent losing the end portion of the previous stream and the beginning of the next stream.

   The general recommendation method is described as follows.

   It is desirable to output ancillary no data with the previous CONTEXT of 10 ms or more following the previous stream.

   Afterwards, when the next stream can be recognized beforehand, the insertion of ancillary no-data with the next CONTEXT is recommended.

   Otherwise, the insertions of ancillary no data with the next CONTEXT are not needed.

   That is, the ancillary no data with the previous CONTEXT can be changed to the following stream directly.

   And, when the transmission device does not have the capability of outputting the ancillary no data with the previous CONTEXT and the ancillary no data with next CONTEXT, the transmission device can output MIDI no data or empty packets or stop the stream output.

When the empty packets are output to prevent losing the beginning of the following content, it is preferable to add time stamp information in SYT.

11.4.2.6 Recommendation for receiver

The following recommendations for receivers apply.

a) Stereo products that receive multichannel streams with DBS >= 2 should reproduce the sound of the first two channels of the data block as stereo left and right channels.

b) Stereo products which have no non-linear PCM decoder should reproduce no sound (muted) when they receive validity flag = '1' in IEC 60958 conformant data.

12 AM824 sequence adaptation layers

12.1 Overview

12.1.1 General

The transport mechanism using CIP may be used as an alternative transport layer for an existing data transmission protocol such as IEC 60958 and MIDI.

This adaptation layer definition defines only one-to-one mapping between an application data structure and an AM824 data structure and a procedure for transporting the application data only with a constant time shift.

The definition of the adaptation to CIP can be described and maintained by either organization responsible for the adaptation.

The adaptation layer definition described in this standard provides only an alternative transport. The meaning of the data carried by the transport should be given in the original specification. Also, the transmission rate should be identical to that which is originally specified when the “non-identical to sampling frequency” indication flag is off.

The adaptation layer definition falls into two categories. One is generic that can be used in applications and does not define application-specific ancillary data. Another is application-specific that defines the structure of the compound data block and application-specific ancillary data.

12.1.2 IEC 60958 bitstream

12.1.2.1 General

All the information defined in IEC 60958 is mapped into this data format. Application, which uses IEC 60958 conformant data, shall follow the IEC 60958 standard.

12.1.2.2 Sampling frequency in IEC 60958-3

In IEC 60958-3, six new sampling frequencies of 22,05 kHz, 24 kHz, 88,2 kHz, 96 kHz, 176,4 kHz and 192 kHz are defined by bit 24 to 27 "sampling frequency" of channel status, as shown in Table 25. All other combinations are reserved and shall not be used until further defined.

Table 25 – Sampling frequency in IEC 60958-3

State of bit 24 25 26 27	Sampling frequency
"0 0 0 0"	44,1 kHz
"1 0 0 0"	Sampling frequency not indicated
"0 1 0 0"	48 kHz
"1 1 0 0"	32 kHz
"0 0 1 0"	22,05 kHz
"0 1 1 0"	24 kHz
"0 0 0 1"	88,2 kHz
"0 1 0 1"	96 kHz
"0 0 1 1"	176,4 kHz
"0 1 1 1"	192 kHz

12.1.2.3 Original sampling frequency

Bit 36 to 39 is defined as the "original sampling frequency", as shown in Table 26.

Table 26 – Original sampling frequency

State of bit 36 37 38 39	Original sampling frequency
"0 0 0 0"	Original sampling frequency not indicated
"1 0 0 0"	192 kHz
"0 1 0 0"	12 kHz
"1 1 0 0"	176,4 kHz
"0 0 1 0"	Reserved
"1 0 1 0"	96 kHz
"0 1 1 0"	8 kHz
"1 1 1 0"	88,2kHz
"0 0 0 1"	16 kHz
"1 0 0 1"	24kHz
"0 1 0 1"	11,025 kHz
"1 1 0 1"	22,05 kHz
"0 0 1 1"	32 kHz
"1 0 1 1"	48 kHz
"0 1 1 1"	Reserved
"1 1 1 1"	44,1 kHz

12.1.2.4 Relation of sampling frequency and original sampling frequency

The sampling frequencies in IEC 60958-3 have relations of multiple of integer number as follows.

- 32 kHz line: (8 kHz, 16 kHz), 32 kHz
- 44,1 kHz line: (11,025 kHz), 22,05 kHz, 44,1 kHz, 88,2 kHz, 176,4 kHz
- 48 kHz line: (12 kHz), 24 kHz, 48 kHz, 96 kHz, 192 kHz

Sampling frequencies in parenthesis are defined only in original sampling frequency. Original sampling frequency is recorded in disc or transmitted by broadcasting and supplied from source devices, e.g. players or tuners.

12.1.2.5 Up or down sampling ratio

Original sampling frequency can be up-sampled or down-sampled. When the up- or down-sampling ratio is defined, the relation of sampling frequency and original sampling frequency is expressed using the following formula.

$$\text{Sampling frequency} = \text{original sampling frequency} * \text{up or down sampling ratio} \quad (10)$$

Examples of sampling ratio are shown in Table 27, Table 28 and Table 29.

Table 27 – Up or down sampling ratio of 32 kHz line

Original sampling frequency	Sampling frequency
	32 kHz
8 kHz	4
16 kHz	2
32 kHz	1

Table 28 – Up or down sampling ratio of 44,1 kHz line

Original sampling frequency	Sampling frequency			
	22,05 kHz	44,1 kHz	88,2 kHz	176,4 kHz
11,025 kHz	2	4	8	16
22,05 kHz	1	2	4	8
44,1 kHz	1/2	1	2	4
88,2 kHz	1/4	1/2	1	2
176,4 kHz	1/8	1/4	½	1

Table 29 – Up or down sampling ratio of 48 kHz line

Original sampling frequency	Sampling frequency			
	24 kHz	48 kHz	96 kHz	192 kHz
12 kHz	2	4	8	16
24 kHz	1	2	4	8
48 kHz	1/2	1	2	4
96 kHz	1/4	1/2	1	2
192 kHz	1/8	1/4	1/2	1

12.1.2.6 Clock accuracy in IEC 60958-3

In IEC 60958-3, “11” in bit 28-29 of channel status is defined as “interface frame rate not matched to sampling frequency”, as shown in Table 30.

Table 30 – Clock accuracy in IEC 60958-3

State of bit 28 29	Clock accuracy
"0 0"	Level II
"1 0 "	Level I
"0 1"	Level III
"1 1"	Interface frame rate not matched to sampling frequency

12.1.2.7 High-speed transmission ratio and interface frame rate

High-speed transmission can be executed over IEC 60958 digital audio interface. Original sampling frequency, high-speed transmission ratio and interface frame rate is expressed using the following formula.

Interface frame rate = original sampling frequency × up or down sampling ratio × high-speed transmission ratio (11)

Clock accuracy “11” in Table 30 means that high-speed transmission is executed. When clock accuracy is “11”, there are two cases as follows:

a) the sampling frequency is equal to the original sampling frequency;

b) the sampling frequency is not equal to the original sampling frequency.

The former case means that there is no up or down sampling process and the latter case means that there is an up or down sampling process. When clock accuracy is “11”, the interface frame rate may be different from the sampling frequency.

Clock accuracy “00”, “01” or “10” means that there is no high-speed transmission. When clock accuracy is “00”, “01” or “10”, there are two cases as follows:

1) the sampling frequency is equal to the original sampling frequency;

2) the sampling frequency is not equal to the original sampling frequency.

The latter case means there is an up or down sampling process and the former case means that there is neither up or down sampling nor high-speed transmission. When the clock accuracy is “00”, “01” or “10”, the interface frame rate is the same as sampling frequency.

These cases are illustrated in Table 31.

Table 31 – Cases

Clock accuracy	Original sampling frequency	Sampling frequency	Interface frame rate	Case
11	Original sampling frequency	Not equal to original sampling frequency	Not equal to sampling frequency	High-speed transmission and up or down sampling
11	Original sampling frequency	Equal to original sampling frequency	Not equal to sampling frequency	High-speed transmission
00, 01, 10	Original sampling frequency	Not equal to original sampling frequency	Equal to sampling frequency	Up or down sampling
00, 01, 10	Original sampling frequency	Equal to original sampling frequency	Equal to sampling frequency	Original

In Table 32, some examples of cases are described.

Table 32 – Examples

Source device condition					Interface condition		
Original sampling frequency	**Up or down sampling ratio**	**Sampling frequency**	**High-speed transmission ratio**	**Interface frame rate**	**Clock accuracy**	**Original sampling frequency**	**Sampling frequency**
					Bit 28, 29	**Bit 36-39**	**Bit 24-27**
44,1 kHz	2	88,2 kHz	1	88,2 kHz	00,01,10	1111	0001
	1	44,1 kHz	1	44,1 kHz	00,01,10		0000
			2	88,2 kHz	11		
			4	176,4 kHz	11		
96 kHz	1	96 kHz	1	96 kHz	00,01,10	1010	0101
			2	192 kHz	11		
	1/2	48 kHz	1	48 kHz	00,01,10		0100
			2	96 kHz	11		
			4	192 kHz	11		
192 kHz	1	192 kHz	1	192 kHz	00,01,10	1000	0111
	1/2	96 kHz	1	96 kHz	00,01,10		0101
			2	192 kHz	11		
	1/4	48 kHz	1	48 kHz	00,01,10		0100
			2	96 kHz	11		
			4	192 kHz	11		

NOTE If the interface frame rate is equal to the original sampling frequency, there may be an up or down sampling process and a high-speed transmission process.

12.1.2.8 N-flag definition

N-flag is used with AM824 data in general (see 10.1, 10.4 and AV/C command set for rate control of isochronous data flow 1.0).

When N-flag = 1, RATE CONTROL command with BASE CONFIGURE subfunction can execute high-speed transmission of AM824 data over IEEE 1394 and RATE CONTROL command with FLOW CONTROL subfunction can execute flow control of AM824 data. This subclause describes the relation between channel status coding in IEC 60958-3 and N-flag, SFC and SYT-INTERVAL in IEC 60958 conformant data, as shown in Table 33.

With the introduction of IEC 60958-3 and command-based RATE CONTROL, the following cases may happen:

a) real-time transmission of 96 kHz (or 192 kHz) original sampling PCM signal over IEC 60958;
b) real-time transmission of up-sampled 48 kHz original sampling PCM signal by 96 kHz (or 192 kHz) sampling frequency over IEC 60958;
c) high-speed transmission of 48 kHz original sampling PCM signal with 96 kHz (or 192 kHz) sampling frequency over IEC 60958;
d) double (or four times) high-speed transmission of 48 kHz original sampling PCM signal with RATE CONTROL command with BASE CONFIGURE subfunction over the IEEE 1394 bus.

When IEC 60958 signals of a), b) and c) are transmitted over IEEE 1394 with IEC 60958 conformant mode, some mechanisms are necessary to distinguish signals of a), b), c) and d) on isochronous mode.

For cases of a), b) and c), IEC 60958-3 specifies codes in clock accuracy (see Table 30) and original sampling frequency (see Table 26) in channel status. For d), N-flag is set to “1”.

When N-flag = 0, values of SYT_INTERVAL and Nominal_Sampling_Frequency are described in Table 20 for FDF = 0000 $0xxx_2$. When N-flag = 1, values of SYT_INTERVAL and Nominal_Sampling_Frequency are described in Table 20 for FDF = 0000 $1xxx_2$. For IEC 60958 conformant data, the following rules for SYT_INTERVAL and Nominal_Sampling_Frequency are applied.

1) When N-flag = 0, value of Nominal_Sampling_Frequency for IEC 60958 conformant data is set according to interface frame rate and value of SYT_INTERVAL is set corresponding to the Nominal_Sampling_Frequency in Table 21.
2) When N-flag = 1, value of Nominal_Sampling_Frequency for IEC 60958 conformant data is set according to sampling frequency coded in Bit 24-27 of channel status of IEC 60958-3 format.
3) When N-flag = 1 and RATE CONTROL command with BASE CONFIGURE subfunction is executed, value of SYT_INTERVAL is set to *n* multiplexed by SYT_INTERVAL value corresponding to the Nominal_Sampling_Frequency in Table 24.
4) When N-flag = 1 and RATE CONTROL command with BASE CONFIGURE subfunction is executed, clock accuracy, bit 28-29 of channel status, of IEC 60958-3 is set to ‘11’.
5) When N-flag = 1 and RATE CONTROL command with FLOW CONTROL Subfunction is executed, value of SYT_INTERVAL is set corresponding to the Nominal_Sampling_Frequency in Table 23.
6) When N-flag = 1 and RATE CONTROL command with FLOW CONTROL subfunction is executed, clock accuracy, bit 28-29 of channel status, of IEC 60958-3 is set to ‘00’, ‘01’ or ‘10’.

Table 33 – Relation of values in IEC 60958-3 and A/M protocol

	IEC 60958-3				A/M protocol		
	Bit 36-39 Original sampling frequency	Bit 24-27 Sampling frequency	Bit 28 29 Clock accuracy	Interface frame rate	N-flag	SFC	SYT-INTERVAL
Case a) Original IEC 60958-3	96 kHz (192 kHz)	96 kHz (192 kHz)	00,01,10	96 kHz (192 kHz)	–	–	–
Case b) Up sampling IEC 60958-3	48 kHz	96 kHz (192 kHz)	00,01,10	96 kHz (192 kHz)	–	–	–
Case c) High-speed IEC 60958-3	48 kHz	48 kHz	11	96 kHz (192 kHz)	–	–	–
Case a) Original with A/M Protocol	96 kHz (192 kHz)	96 kHz (192 kHz)	00,01,10	96 kHz (192 kHz)	0	96 kHz (192 kHz)	16 (32)
Case b) Up sampling with A/M Protocol	48 kHz	96 kHz (192 kHz)	00,01,10	96 kHz (192 kHz)	0	96 kHz (192 kHz)	16 (32)
Case c) High-speed with A/M Protocol	48 kHz	48 kHz	11	96 kHz (192 kHz)	0	96 kHz (192 kHz)	16 (32)
Case d) Rate control with A/M Protocol	48 kHz	48 kHz	11	96 kHz (192 kHz)	1	48 kHz	$8 * n$ (n = 2, 4)
FLOW CONTROL with A/M Protocol	96 kHz (192 kHz)	96 kHz (192 kHz)	00,01,10	96 kHz (192 kHz)	1	96 kHz (192 kHz)	16 (32)

12.1.3 One-bit audio

12.1.3.1 General

In this subclause, the format of one bit audio is described.

12.1.3.2 One-bit audio (plain)

The data of the one-bit audio (LABEL = 50_{16}-51_{16}) has one-bit length data stream and can be directly played back through the analogue low pass filter bit by bit (MSB first). The data stream is packed in 24-bit data fields of an AM824 quadlet, as shown in Figure 41, with MSB first per audio channel.

The sampling frequency of the one-bit audio (LABEL = 50_{16},51_{16},58_{16}) is defined in Table 34 with its own SFC table.

Table 34 – Sampling frequency definition of one-bit audio

Value of SFC	SYT_INTERVAL	Sampling frequency
00_{10}	16	2,048 MHz
01_{10}	16	2,822 4 MHz
02_{10}	32	3,072 MHz
03_{10}	32	5,644 8 MHz
04_{10}	64	6,144 MHz
05_{10}	64	11,289 6 MHz
06_{10}	128	12,288 MHz
07_{10}	Reserved	Reserved

The TRANSFER_DELAY for blocking transmission, in the case of DEFAULT_TRANSFER_DELAY = 479,17 μs = (354,17 + 125)μs, corresponds to Table 34, as given in Table 35.

Table 35 – TRANSFER_DELAY for blocking transmission in the case of the one-bit audio

Value	TRANSFER_DELAY μs
00_{10}	479,17 + 187,50 = 666,67
01_{10}	479,17 + 136,10 = 615,27
02_{10}	479,17 + 250,00 = 729,17
03_{10}	479,17 + 136,10 = 615,27
04_{10}	479,17 + 250,00 = 729,17
05_{10}	479,17 + 136,10 = 615,27
06_{10}	479,17 + 250,00 = 729,17
07_{10}	Reserved

The one-bit audio (LABEL = 50_{16} – 51_{16}) can transmit multichannel cluster. Each AM824 quadlet carries the data for one channel of the cluster. Two AM824 LABELs are used to indicate the start and continuation of the data in the cluster.

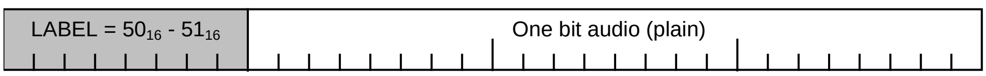

Figure 41 – Generic one-bit audio quadlet

The channel number shall start with No.1 and be sequential. An example is given in Figure 42.

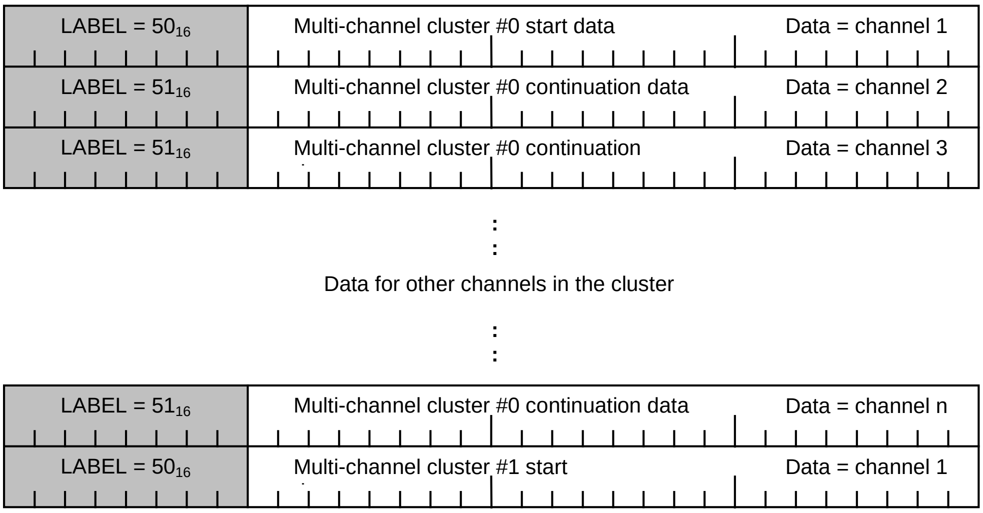

Figure 42 – Generic one-bit audio quadlet sequence

12.1.3.3 One-bit audio (encoded) – DST

The data of the one-bit audio (encoded) is the encoded data stream.

DST (direct stream transfer) is the loss-less coding technique used for one-bit audio in SACD and is defined in super audio CD system description version 1.2.

The encoded data stream is packed in 24-bit data fields of AM824 data, as shown in Figure 43, with MSB first.

For decoding the stream, SACD ancillary data is needed. DST supports multichannel one-bit audio and carries each data stream in one mixed stream.

DST encodes the one-bit audio data stream frame by frame. The frame is defined in super audio CD system description version 1.2.

The sampling frequency of the DST is defined in Table 34 with its own SFC table.

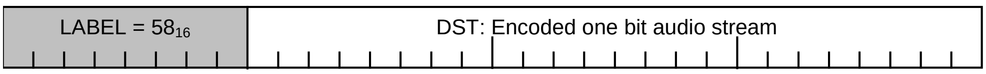

Figure 43 – One-bit audio DST encoded quadlet

12.1.3.4 High-speed transfer for one-bit audio

As far as one-bit audio (LABEL = 50_{16}, 51_{16}, 58_{16}) is concerned, the transfer frequency and SYT_INTERVAL for the high-speed AM824-data transfer are defined depending on the speed shown in Table 36 if the N-flag in the FDF is 1. In Table 36, an integer value of n (>1) indicates the number of times faster than normal speed.

Table 36 – SFC definition of one-bit audio for high-speed AM824 data transfer

Value of SFC	Nominal_Sampling_Frequency	SYT_INTERVAL	Sampling_Frequency
0	2,048 MHz	16 × *n*	2,048 MHz × *n*
1	2,822 4 MHz	16 × *n*	2,822 4 MHz × *n*
2	3,072 MHz	32 × *n*	3,072 MHz × *n*
3	5,644 8 MHz	32 × *n*	5,644 8 MHz × *n*
4	6,144 MHz	64 × *n*	6,144 MHz × *n*
5	11,289 6 MHz	64 × *n*	11,289 6 MHz × *n*
6	12,288 MHz	128 × *n*	12,288 MHz × *n*
7	Reserved	Reserved	Reserved

The DBS of an event is independent of the transfer speed.

12.1.4 Non-linear audio data stream

Any non-linear audio data carried by an IEC 61937 bit-stream can be transmitted by using the IEC 60958 conformant data sequence.

12.1.5 MIDI data stream

Any modification or enhancement is prohibited on this adaptation layer, although increase of transmission rate, for instance, can be easily done. The specification that uses this adaptation layer is given in MMA/AMEI RP-027.

This standard restricts the packetization of MIDI data stream so that a single MIDI conformant sequence can carry multiple MIDI data streams by multiplexing. The MIDI conformant data defines MULTIPLEX_NUMBER = 8.

NOTE The default MULTIPLEX_NUMBER for MIDI conformant AM824 types may be incompatible with some applications conforming to IEC 61883-6:2002.

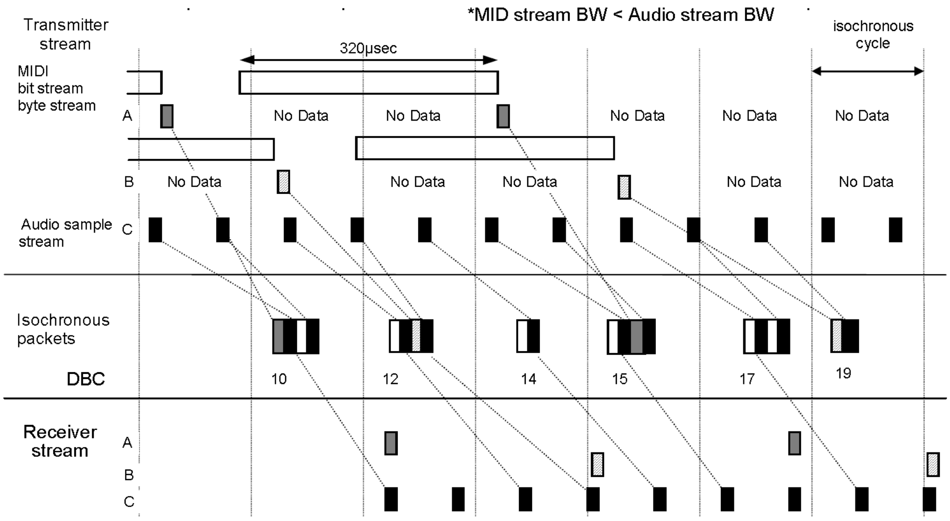

Figure 44 – Multiplexing of MIDI data streams

Figure 44 shows how two MIDI data streams, which should flow in different MIDI cables, are multiplexed in a single MIDI conformant sequence with an audio stream. Figure 44 gives only the sequence multiplexing scheme. The parameters of this example such as the number of multiplexed sequences and the audio sampling rate were chosen so that the figure be readable. Consequently, not all the parameters are valid for this standard (including its previous editions).

12.1.6 SMPTE time code and sample count

SMPTE time code and sample count transmission are defined in TA 1999024 SMPTE Time Code and Sample Count Transmission Protocol Version 1.0.

12.1.7 High-precision and double-precision multi-bit linear audio

12.1.7.1 High-precision specific ancillary sata

This subclause specifies private header data that are carried by high-precision specific ancillary data.

These ancillary data are transmitted at every data block. The data format is shown in Figure 45. Table 37 and Table 38 provide channel and accuracy definitions, respectively.

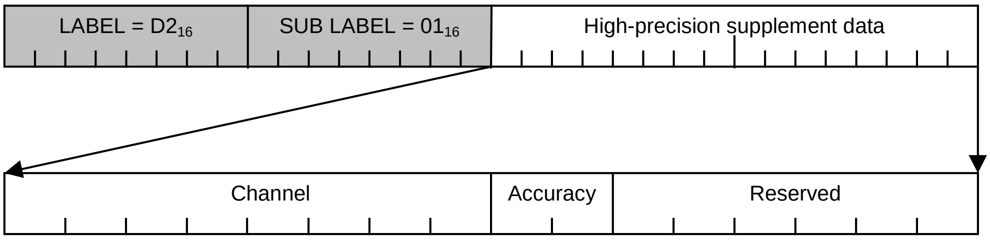

Figure 45 – High-precision first ancillary data

Table 37 – Channel definition

Value	Description
0000 0000_2	1 channel
0000 0001_2	2 channel
0000 0010_2	3 channel
...	...
1111 1110_2	255 channel
1111 1111_2	256 channel

Table 38 – Accuracy definition

Value	Description
00_2	16 bit slot (lower 8 bit = 0)
01_2	20 bit slot (lower 4 bit = 0)
10_2	24 bit slot
11_2	Reserved

With the combination of accuracy and Num. (slot number), any PCM audio data with sample word length up to 192 bit can be transmitted by high-precision multi-bit linear audio. There is a wide redundancy, for example, a 64-bit sample word can be transmitted with 3 slots of a 24-bit slot (acc = 10_2) or 4 slots of a 16-bit slot (acc = 00_2). To eliminate hardware complexity on the decoder side, the following implementation rules are strongly recommended:

a) sample word should be limited to 32, 40, 48, 64, 80, 96, 128, 160 and 192 bit length;

b) number of slots should be limited to 2, 4 and 8.

The accuracy for the above stated sample words should be as specified in Table 39.

Table 39 – Recommended rules

Sample word length	Accuracy		Number of slots
	Value	Slot length	
32 bit	00_2	16 bit	2
40 bit	01_2	20 bit	2
48 bit	10_2	24 bit	2
64 bit	00_2	16 bit	4
80 bit	01_2	20 bit	4
96 bit	10_2	24 bit	4
128 bit	00_2	16 bit	8
160 bit	01_2	20 bit	8
192 bit	10_2	24 bit	8

When a source device sends its own data or auxiliary information to the sink device in high-precision mode, its original data and/or ancillary data can be transmitted between the high-precision first ancillary data and high-precision multi-bit linear audio data.

For example, IEC 60958 conformant data can be transmitted between the high-precision first ancillary data and high-precision multi-bit linear audio data, see Figure 46. For other applications, common and application-specific ancillary data can be transmitted between the high-precision first ancillary data and high-precision multi-bit linear audio data, see Figure 47. Refer to 8.2.9.2.1 and 8.2.10 and each application section.

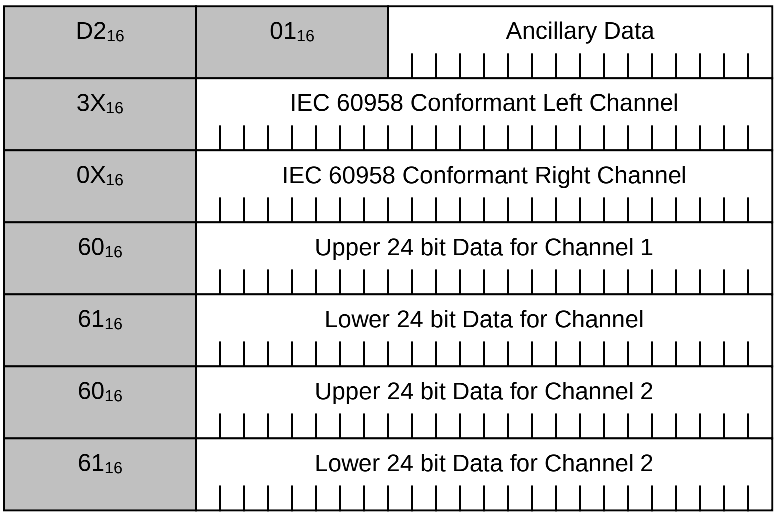

Figure 46 – IEC 60958 conformant data with high-precision data

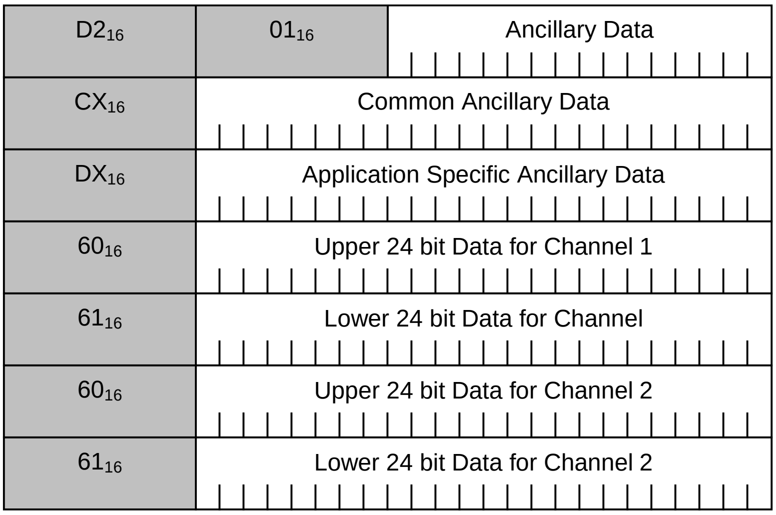

Figure 47 – Common and application-specific ancillary data with high-precision data

These ancillary data are optional and their definition is reserved. Figure 48 shows high-precision channel assignment ancillary data and Table 40 provides a channel assignment definition.

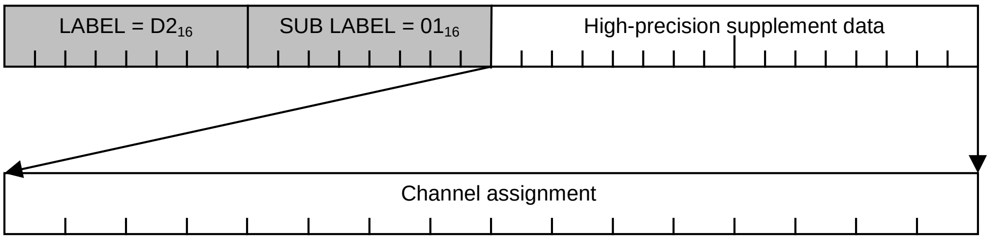

Figure 48 – High-precision channel assignment ancillary data

Table 40 – Channel assignment definition

Channel assignment	Description
0000 0000 0000 0000$_2$	Reserved
0000 0000 0000 0001$_2$	
0000 0000 0000 0010$_2$	
...	
1111 1111 1111 1110$_2$	
1111 1111 1111 1111$_2$	

12.1.7.2 Example of high-precision stream

Figure 49 shows a 2-channel 128-bit sample-word high-precision stream carried over the serial bus. Here, the lower 8 bit are set to "0". High-precision ancillary data are immediately followed by the data block.

0 MSB — Quadlet sequence — 31 LSB

$D2_{16}$	01_{16}	Ancillary Data
60_{16}	1st 16 bit Data for channel 1	
61_{16}	2nd 16 bit Data for channel 1	
62_{16}	3rd 16 bit Data for channel 1	
63_{16}	4th 16 bit Data for channel 1	
64_{16}	5th 16 bit Data for channel 1	
65_{16}	6th 16 bit Data for channel 1	
66_{16}	7th 16 bit Data for channel 1	
67_{16}	8th 16 bit Data for channel 1	
60_{16}	1st 16 bit Data for channel 2	
61_{16}	2nd 16 bit Data for channel 2	
62_{16}	3rd 16 bit Data for channel 2	
63_{16}	4th 16 bit Data for channel 2	
64_{16}	5th 16 bit Data for channel 2	
65_{16}	6th 16 bit Data for channel 2	
66_{16}	7th 16 bit Data for channel 2	
67_{16}	8th 16 bit Data for channel 2	

Figure 49 – Example of high-precision data

12.1.7.3 Example of double-precision stream

Figure 50 shows a 6-channel 48-bit sample-word double-precision stream carried over IEEE 1394.

Note that double precision uses the LABELs from 60_{16} to 61_{16}.

0 MSB — Quadlet sequence — 31 LSB

$D2_{16}$	01_{16}	Ancillary Data
60_{16}	Upper 24 bit Data for channel 1	
61_{16}	Lower 24 bit Data for channel 1	
60_{16}	Upper 24 bit Data for channel 2	
61_{16}	Lower 24 bit Data for channel 2	
60_{16}	Upper 24 bit Data for channel 3	
61_{16}	Lower 24 bit Data for channel 3	
60_{16}	Upper 24 bit Data for channel 4	
61_{16}	Lower 24 bit Data for channel 4	
60_{16}	Upper 24 bit Data for channel 5	
61_{16}	Lower 24 bit Data for channel 5	
60_{16}	Upper 24 bit Data for channel 6	
61_{16}	Lower 24 bit Data for channel 6	

Figure 50 – Example of double-precision data

12.1.7.4 Example of double-precision compound stream

Figure 51 shows a 4-channel 48-bit sample-word double-precision compound stream carried over IEEE 1394.

Quadlet sequence: 0 MSB … 31 LSB

Data Block [m]	$D2_{16}$	01_{16}	Ancillary Data
	60_{16}	Upper 24 bit Data for channel 1	
	61_{16}	Lower 24 bit Data for channel 1	
	60_{16}	Upper 24 bit Data for channel 2	
	61_{16}	Lower 24 bit Data for channel 2	
	60_{16}	Upper 24 bit Data for channel 3	
	61_{16}	Lower 24 bit Data for channel 3	
	60_{16}	Upper 24 bit Data for channel 4	
	61_{16}	Lower 24 bit Data for channel 4	
Data Block [m+1]	$D2_{16}$	01_{16}	Ancillary Data
	60_{16}	Upper 24 bit Data for channel 1	
	61_{16}	Lower 24 bit Data for channel 1	
	60_{16}	Upper 24 bit Data for channel 2	
	61_{16}	Lower 24 bit Data for channel 2	
	60_{16}	Upper 24 bit Data for channel 3	
	61_{16}	Lower 24 bit Data for channel 3	
	60_{16}	Upper 24 bit Data for channel 4	
	61_{16}	Lower 24 bit Data for channel 4	

Figure 51 – Example of double-precision compound data

12.2 DVD-audio

12.2.1 General

The compound data for DVD-Audio consists of multi-bit linear audio data, common ancillary and DVD-Audio specific ancillary data.

12.2.2 DVD-Audio specific ancillary data

12.2.2.1 General

This subclause specifies private header data that are carried by DVD-Audio specific ancillary data, as shown in Table 41.

Table 41 – DVD-Audio specific ancillary data

LABEL	SUB LABEL	Description
$D0_{16}$	01_{16}	Data transmitted at every data block
	02_{16}	Data transmitted at starting-point
	$C0_{16}$	Audio CCI
	$C1_{16}$	ISRC

12.2.2.2 Data transmitted at starting-point

These ancillary data, shown in Figure 52, are used at the starting-point of audio data when performing play start or search for a track number. Table 42 provides definitions of Fs2, Multi-channel type, channel assignment and table parity.

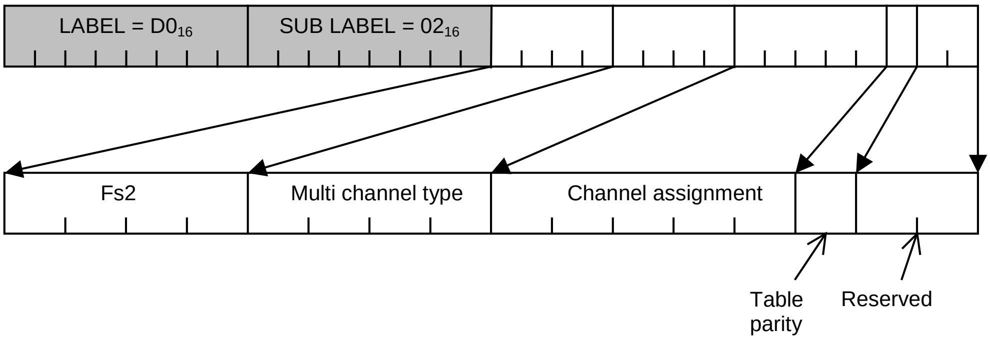

Figure 52 – Data transmitted at data starting-point

Table 42 – Data transmitted at starting-point

Data	Bit	Description
Fs2	4	Sampling frequency group2
Multi-channel type	4	Fs, bit combination table
Channel assignment	5	Channel combination of group1 and 2
Table parity	1	Table parity of audio data

12.2.2.3 Data transmitted at every data block

These ancillary data, shown in Figure 53, are transmitted at every data block. Table 43 provides definitions of dynamic range control, down mix code, emphasis flag, down mix mode and down mix code validity.

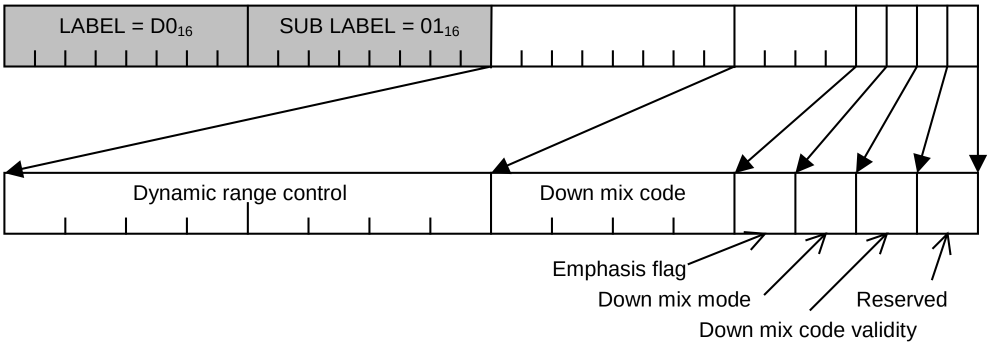

Figure 53 – Data transmitted at every data block

Table 43 – Data transmitted at every data block

Data	Bit	Description
Dynamic range control	8	Adaptive compression coefficient
Down mix code	4	Down mix table number
Emphasis flag	1	Enhances on or off
Down mix mode	1	Down mix permission
Down mix code validity	1	Down mix code validity

12.2.3 Data for CCI

Figure 54 shows ancillary data for CCI.

SUB LABEL $C0_{16}$ is for CCI.

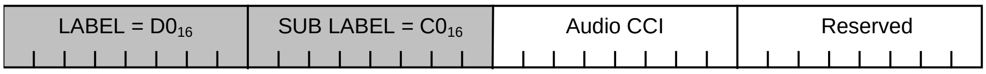

Figure 54 – Ancillary data for CCI

NOTE Audio CCI signifies copy control information for audio.

12.2.4 Data for ISRC

Figure 55 shows ancillary data for ISRC.

SUB LABEL $C1_{16}$ is for ISRC.

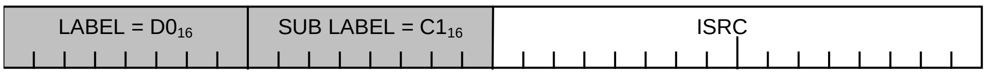

Figure 55 – Ancillary data for ISRC

12.2.5 Example of DVD-Audio stream

Figure 56 illustrates a basic data block of DVD-Audio stream carried over IEEE 1394 in the case of six channels.

$D0_{16}$	01_{16}	Ancillary Data
$D0_{16}$	02_{16}	Ancillary Data
48_{16}	Data channel 1	
48_{16}	Data channel 2	
48_{16}	Data channel 3	
48_{16}	Data channel 4	
48_{16}	Data channel 5	
48_{16}	Data channel 6	

Figure 56 – Basic data block of DVD-Audio stream

Data on the disc is organized into a series of blocks. The data for each channel is packed into one block. Each data block should be ordered by increasing channel number. The data block immediately follows DVD-Audio ancillary data. The first ancillary data is “the data transmitted at every data block,” and the second ancillary data is “the data transmitted at the data starting point” or “table parity” or “DMCT (down mix coefficient table)” or something similar.

Figure 57 illustrates an example of DVD-Audio data stream that carries scaleable contents of DVD-Audio. In this case, the sampling frequency and sample word length may be different between front channels and rear channels, and, in the second data block, previous data hold of ASI2 of DVD-Audio is used.

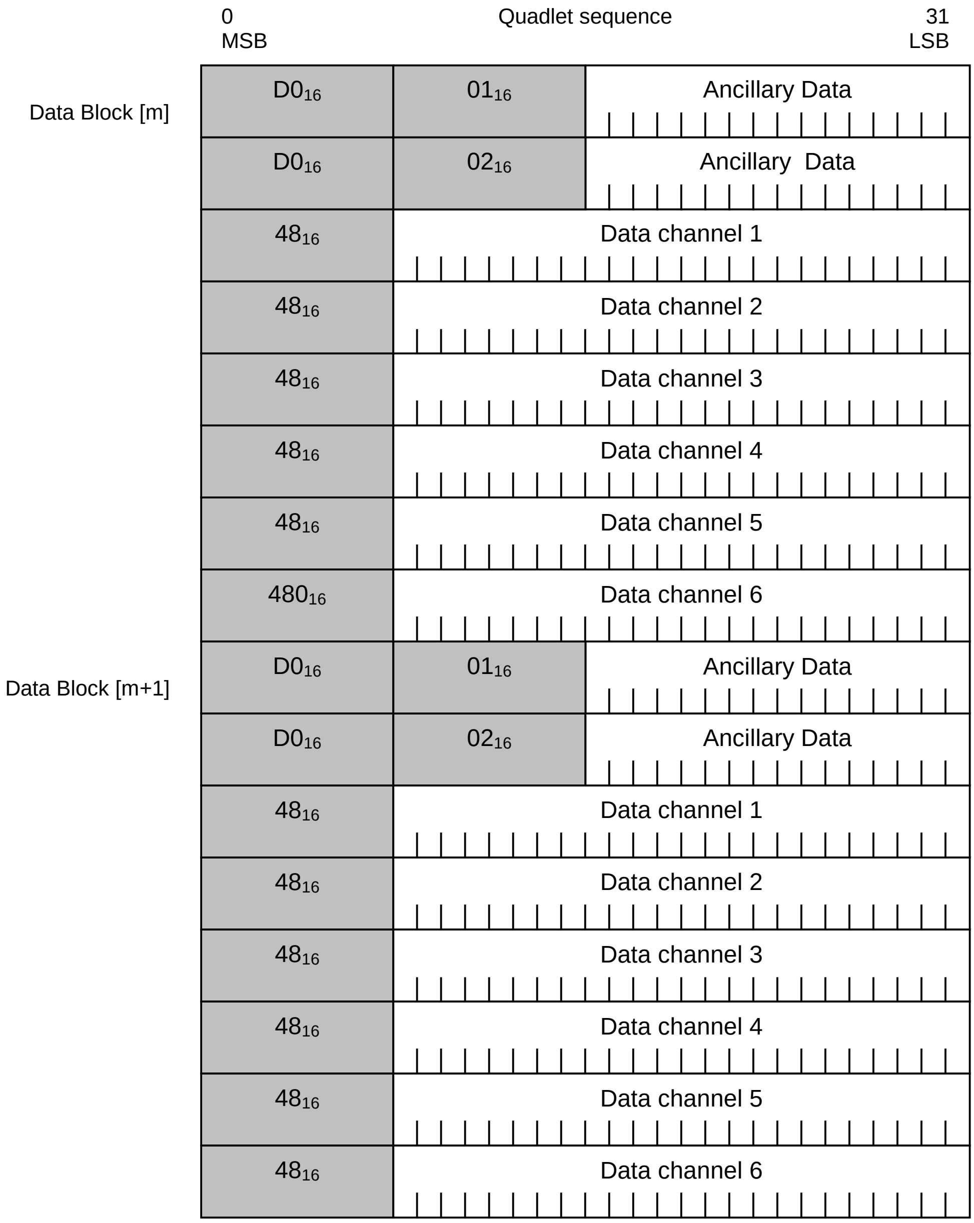

Figure 57 – Example of DVD-Audio data

12.3 SACD definition

12.3.1 General

The data block for SACD consists of one-bit audio data, common ancillary and SACD-specific ancillary data.

12.3.2 SACD ancillary data

The SACD player transmits SACD ancillary data at the starting-point of every frame. The frame is defined in [12] [1]. The SACD ancillary data is shown in Figure 58, and Table 44 provides definitions of validity flag, Track_Attribute, Ch_Bit_n and Loudspeaker_Config.

———————

1 Numbers in square brackets refer to the Bibliography.

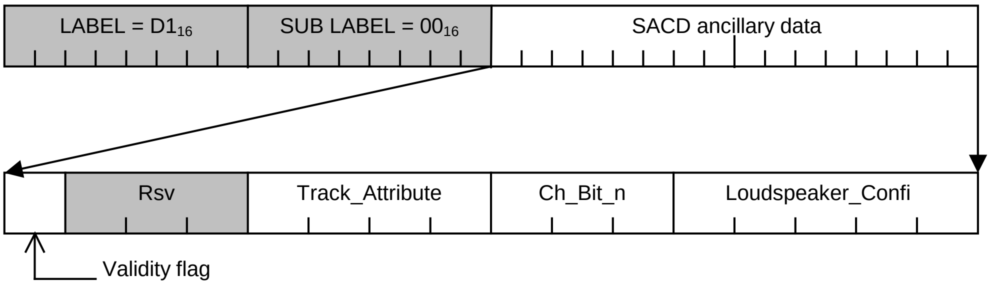

Figure 58 – SACD ancillary data

Table 44 – Data information

Data	Bit	Description
Validity flag	1	Valid or not valid
Track_Attribute	4	Copy control information
Ch_Bit_n	3	Number of channels
Loudspeaker_Config	5	Loudspeaker set-up

The validity flag shows the validity of the data within the frame.

If a disc read error occurs, the SACD player shall replace the error data with safe data, such as a mute signal, and set the validity flag to 1_2, as shown in Table 45.

Table 45 – Validity flag definition

Value	Description
0_2	Valid
1_2	Not valid

Rsv is the reserved area and the default value is 000_2.

The Track_Attribute shows copy control information dedicated to super audio CD, and is defined in [12] [2]. This information shall be copied from the super audio CD track by track.

The Ch_Bit_n shows the total number of channels, and is defined in [12]. This information shall be copied from the super audio CD frame by frame.

The Loudspeaker_Config shows the loudspeaker set-up, and is defined in [12]. This information shall be copied from the super audio CD track by track.

12.3.3 SACD supplementary data

SACD supplementary data is a synchronized stream along with the audio data from the SACD, see Figure 59. It has several data lengths as defined in [12]. Audio data and supplementary data are synchronized on a frame-by-frame basis.

For decoding the stream, SACD ancillary data is needed.

———————

2 Numbers in square brackets refer to the Bibliography.

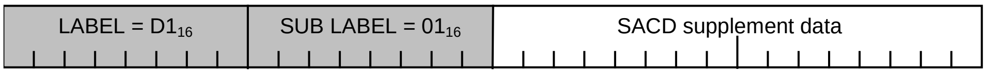

Figure 59 – SACD supplementary data

12.3.4 Multi-bit linear audio data

DVD-Audio data use the LABEL from 48_{16} to $4F_{16}$ of multi-bit linear audio and uses ASI2 for scaleable contents, as shown in Table 46.

Table 46 – ASI2 definition for DVD-Audio

Value	Description
00_2	24 bit
01_2	20 bit
10_2	16 bit
11_2	Previous sample word data hold

12.3.5 SACD Track_Mode&Flags data

SACD Track_Mode&Flags data consists of Track_Mode (1 B) and track flags (1 B) defined in [12]. The relationship between ACD Track_Mode&Flags,Track_Mode and Track_Flags is described in Figure 60.

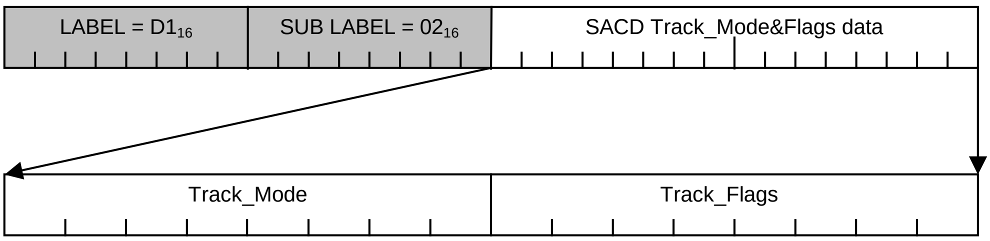

Figure 60 – SACD Track_Mode&Flags data

12.3.6 SACD Track_Copy_Management data

SACD Track_Copy_Management data consists of three AM824 data quadlet and shows the Track_Copy_Management defined in [12]. The data of the Track_Copy_Management (6 B) is divided into three data fields (Part 1, 2, 3) of the AM824 quadlet (AM824 LABEL=$D1_{16}$: SUB LABEL=10_{16}, 11_{16}, 12_{16}) in sequence, see Figure 61.

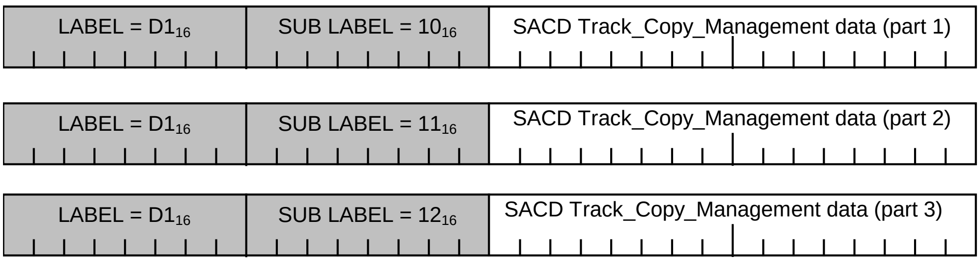

Figure 61 – SACD Track_Copy_Management data

12.3.7 Example of SACD streams

Figure 62 illustrates a typical multi-channel plain one-bit audio stream carried over the 1394 bus from SACD for the case where the value of SFC in FDF is 001_2. The data on the disc is organized into a series of frames, with 75 frames for each second of audio. Each frame contains a total of (1 568 × 3) B of audio cluster data per channel. Quadlets in a data block are organized according to the order rule, so that the order is ancillary data first, multi-channel cluster data next, and an ancillary no data with CONTEXT = CF_{16} last.

The SACD ancillary data starts and is followed by the first group of multi-channel cluster data. In this example, the first quadlet contains the ancillary data for the whole of frame #0. If, for example, there is a disc error, the SACD player sets the validity flag in the ancillary data for this frame (frame #0) which remains valid until the next SACD ancillary data (frame #1). This also applies to the Track_Attribute, Ch_Bit_n and Loudspeaker_Config contained in the ancillary data for frame #0.

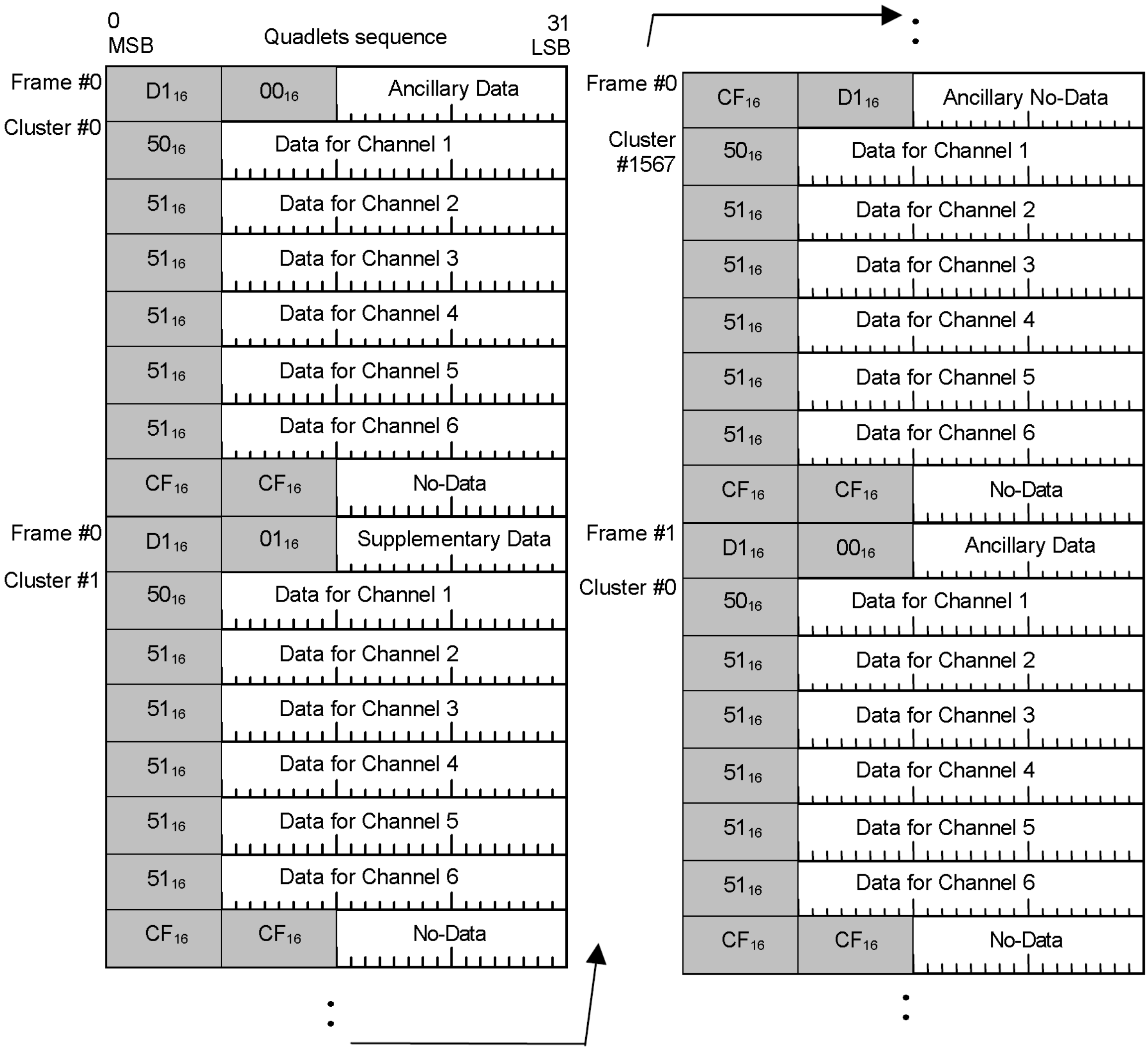

Figure 62 – Example of SACD stream in the case of six channels

In the example of Figure 62, there are six channels in the multi-channel cluster, so an ancillary No-Data with CONTEXT = CF is added to the last of the cluster data so that the total numbers of quadlets in the block is kept even, and therefore DBS = 8. The SACD supplementary data is transmitted at the same location as the SACD ancillary data (after the SACD ancillary data has already been transmitted). After all the SACD supplementary data has been transmitted, an ancillary no data or other ancillary data quadlet may be put in the same location.

Figure 63 shows five channel cases. Here, ancillary no data with CONTEXT = CF is not required, and the DBS = 6.

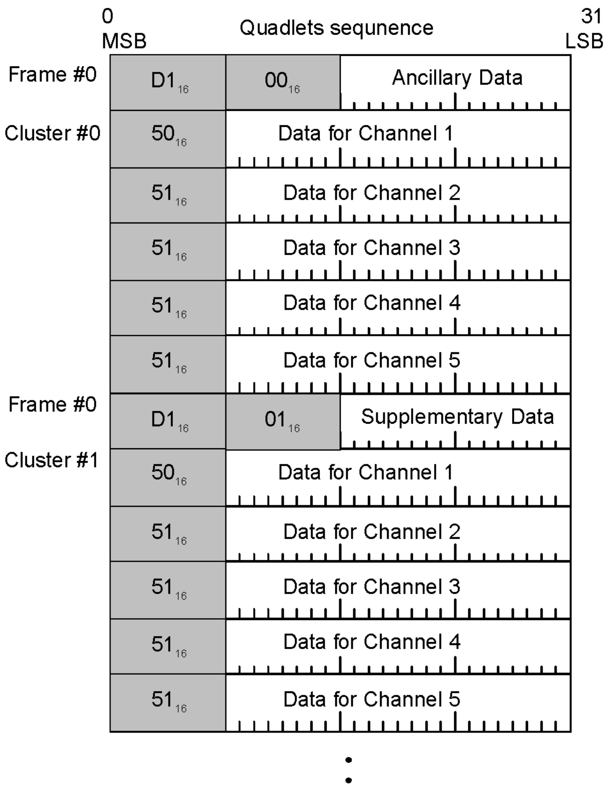

Figure 63 – Example of SACD stream in the case of five channels

12.4 Blu-ray Disc

12.4.1 General

The compound data for Blu-ray Disc consists of multi-bit linear audio data, common ancillary and Blu-ray Disc specific ancillary data.

12.4.2 Structure of sample word for audio transmission

Figure 64 shows basic data blocks of Blu-ray Disc. There are eight sample words in one audio sample.

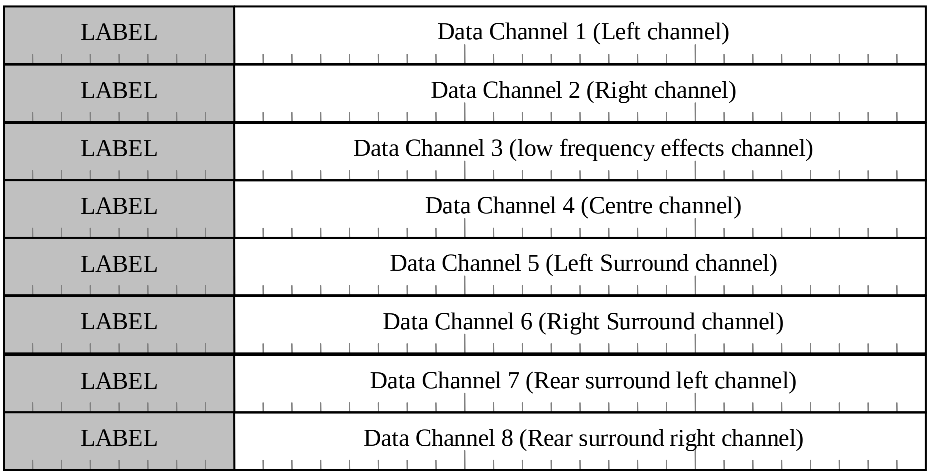

Figure 64 – Basic data blocks of Blu-ray Disc

Channel layout is fixed.

The transmitter shall set 000000_{16} on the audio data of MBLA data in the case of a non existing channel.

Valid combinations of the sample word are determined by the permitted channel allocations, as defined in [15].

12.4.3 Multi-bit linear audio data

Blu-ray Disc data use the LABEL from 48_{16} to $4A_{16}$ of multi-bit linear audio. Table 47 and Table 48 provide definitions of ASI1 and ASI2, respectively.

Table 47 – ASI1 definition for Blu-ray Disc

Value	Description
00_2	-
01_2	Reserved
10_2	Ordinary LPCM Fs shown by SFC
11_2	Reserved

Table 48 – ASI2 definition for Blu-ray Disc

Value	Description
00_2	24 bit
01_2	20 bit
10_2	16 bit
11_2	Reserved

12.4.4 Blu-ray Disc specific ancillary data

This subclause specifies private header data that are carried by Blu-ray Disc specific ancillary data and as shown in Table 49.

Table 49 – Blu-ray Disc specific ancillary data

LABEL	SUB LABEL	Description
$D3_{16}$	01_{16}	Data transmitted at every data block
	$C0_{16}$	CCI

The transmission device shall execute the stream change method if the ancillary data is changed except when SUB LABEL is $C0_{16}$.

12.4.5 Data transmitted at every data block

This following ancillary data is transmitted at every data block, see Figure 65 and Table 50.

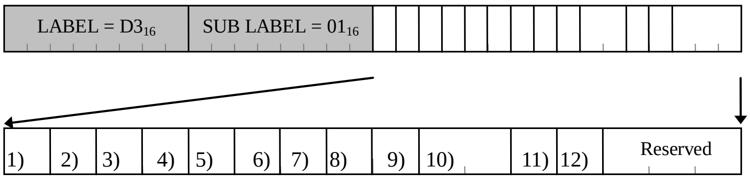

Figure 65 – Data transmitted at every data block

Table 50 – Data transmitted at every data block

Data	Bits	Description
1) reserved	1	Reserved
2) L channel	1	L (left) channel data exist or do not exist
3) R channel	1	R (right) channel data exist or do not exist
4) lfe channel	1	lfe (low frequency effects) channel data exist or do not exist
5) C channel	1	C (centre) channel data exist or do not exist
6) LS channel	1	LS (left surround) channel data exist or do not exist
7) RS channel	1	RS (right surround) channel data exist or do not exist
8) Rls channel	1	Rls (rear surround left) channel data exist or do not exist
9) Rrs channel	1	Rrs (rear surround right) channel data exist or do not exist
10) L/R ch identifier	2	L (left)/R (right) channel identifier defined
11) C ch identifier	1	C (centre) channel identifier defined
12) LS/RS ch identifier	1	LS (left surround)/RS (right surround) channel identifier defined

The L channel shows whether L (left) channel data exist or not, as shown in Table 51.

Table 51 – L channel definition

Value	Description
0_2	L (left) channel data do not exist
1_2	L (left) channel data exist

The R channel shows whether R (right) channel data exist or not, as shown in Table 52.

Table 52 – R channel definition

Value	Description
0_2	R (right) channel data do not exist
1_2	R (right) channel data exist

The lfe channel shows whether lfe (low frequency effects) channel data is existed or not, as shown in Table 53.

Table 53 – lfe channel definition

Value	Description
0_2	lfe (low frequency effects) channel data do not exist
1_2	lfe (low frequency effects) channel data exist

The C channel shows whether C (Centre) channel data is existed or not, as shown in Table 54.

Table 54 – C channel definition

Value	Description
0_2	C (centre) channel data do not exist
1_2	C (centre) channel data exist

The LS channel shows whether LS (left surround) channel data exist or not, as shown in Table 55.

Table 55 – LS channel definition

Value	Description
0_2	LS (left surround) channel data do not exist
1_2	LS (left surround) channel data exist

The RS channel shows whether RS (right surround) channel data exist or not, as shown in Table 56.

Table 56 – RS channel definition

Value	Description
0_2	RS (right surround) channel data do not exist
1_2	RS (right surround) channel data exist

The Rls channel shows whether Rls (rear surround left) channel data exist or not, as shown in Table 57.

Table 57 – Rls channel definition

Value	Description
0_2	Rls (rear surround left) channel data do not exist
1_2	Rls (rear surround left) channel data exist

The Rrs channel shows whether Rrs (rear surround right) channel data exist or not, as shown in Table 58.

Table 58 – Rrs channel definition

Value	Description
0_2	Rrs (rear surround right) channel data do not exist
1_2	Rrs (rear surround right) channel data exist

The L/R ch identifier shows whether L (left)/R (right) channel data is L/R signal (stereo) or M1 (mono) signal or Lo (left output)/Ro (right output) signal or Lt (left total)/Rt (right total) signal.

Note that the sink device shall decrease the M1 (mono) signal to a −3 dB level if the sink device outputs M1 (mono) signal in the L (left)/R (right) channel, as shown in Table 59.

Table 59 – L/R ch identifier definition

Value	Description
00_2	L (left)/R (right) channel data is the L/R (stereo) signal
01_2	L (left)/R (right) channel data is the M1 (mono) signal L (left) channel and R (right) channel data are the same
10_2	L (left)/R (right) channel data is the Lo (left output)/Ro (right output) signal
11_2	L (left)/R (right) channel data is the Lt (left total)/Rt (right total) signal

The C ch identifier shows whether the C (Centre) channel data is the C signal or M1 (mono) signal as shown in Table 60.

Table 60 – C ch identifier definition

Value	Description
0_2	C (centre) channel data is the C signal
1_2	C (centre) channel data is the M1 (mono) signal

The LS/RS ch identifier shows whether LS (left surround)/RS (right surround) channel data is the LS/RS signal or S (surround) signal.

Note that the sink device shall decrease the S (surround) signal to a −3 dB level if the sink device outputs S (surround) signal in the LS (left surround)/RS (right surround) channel as shown in Table 61.

Table 61 – LS/RS ch identifier definition

Value	Description
0_2	LS (left surround)/RS (right surround) channel data is the LS (left surround)/RS (right surround) signal
1_2	LS (left surround)/RS (right surround) channel data is the S (surround) signal LS (left surround) and RS (right surround) channel data are the same

12.4.6 Data for CCI

Figure 66 shows ancillary data for CCI, and a data field definition is provided in Table 62.

SUB LABEL $C0_{16}$ is for CCI.

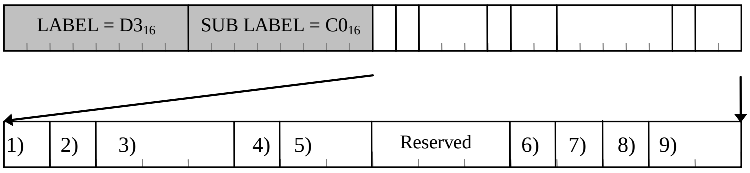

Figure 66 – Ancillary data for CCI

Table 62 – Data transmitted at every data block

Value	Bit
1) reserved	1
2) Retention_Move_Mode	1
3) Retention_State	3
4) EPN	1
5) CCI	2
6) Digital_Only_Token	1
7) Analog_Sunset_Token	1
8) Image_Constraint_Token	1
9) APS	2

NOTE Ancillary data for CCI is for copy control information and is defined in [15].

These data shall be transmitted at least once during 100 ms period.

12.4.7 Example of Blu-ray Disc stream

Figure 67 illustrates a basic data block of the Blu-ray Disc stream carried over the 1394 Bus in the case of eight channels.

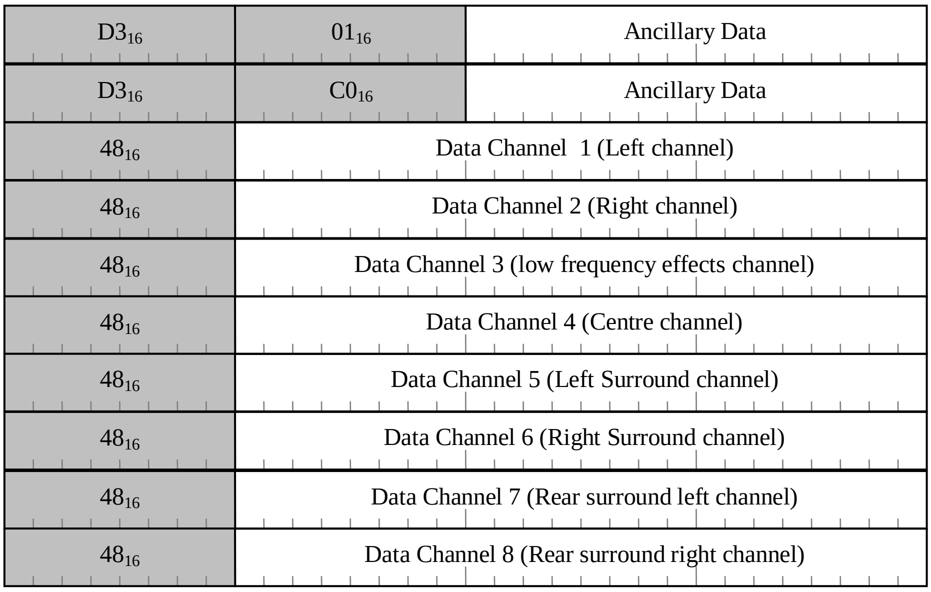

Figure 67 – Basic data block of Blu-ray Disc

Figure 68 shows a one-channel example.

D3$_{16}$	01$_{16}$	Ancillary Data
D3$_{16}$	C0$_{16}$	Ancillary Data
48$_{16}$	Mono	
48$_{16}$	Mono	
48$_{16}$	Set to 000000h	
48$_{16}$	Set to 000000h	
48$_{16}$	Set to 000000h	
48$_{16}$	Set to 000000h	
48$_{16}$	Set to 000000h	
48$_{16}$	Set to 000000h	

a) Example 1

D3$_{16}$	01$_{16}$	Ancillary Data
D3$_{16}$	C0$_{16}$	Ancillary Data
48$_{16}$	Set to 000000h	
48$_{16}$	Set to 000000h	
48$_{16}$	Set to 000000h	
48$_{16}$	Mono	
48$_{16}$	Set to 000000h	
48$_{16}$	Set to 000000h	
48$_{16}$	Set to 000000h	
48$_{16}$	Set to 000000h	

b) Example 1

D3$_{16}$	01$_{16}$	Ancillary Data
D3$_{16}$	C0$_{16}$	Ancillary Data
48$_{16}$	Mono	
48$_{16}$	Mono	

c) Example 3

Figure 68 – Examples of Blu-ray Disc stream of one channel

The channel structure shown in example 3 of Figure 68 appears when only L and R are transmitted.

Figure 69 shows two-channel examples.

$D3_{16}$	01_{16}	Ancillary Data
$D3_{16}$	$C0_{16}$	Ancillary Data
48_{16}	Left	
48_{16}	Right	
48_{16}	Set to 000000h	
48_{16}	Set to 000000h	
48_{16}	Set to 000000h	
48_{16}	Set to 000000h	
48_{16}	Set to 000000h	
48_{16}	Set to 000000h	

a) Example 1

$D3_{16}$	01_{16}	Ancillary Data
$D3_{16}$	$C0_{16}$	Ancillary Data
48_{16}	Left	
48_{16}	Right	

b) Example 2

Figure 69 – Example of Blu-ray Disc stream of two channels

Figure 70 shows a three-channel example.

$D3_{16}$	01_{16}	Ancillary Data
$D3_{16}$	$C0_{16}$	Ancillary Data
48_{16}	Left	
48_{16}	Right	
48_{16}	Set to 000000h	
48_{16}	Centre	
48_{16}	Set to 000000h	
48_{16}	Set to 000000h	
48_{16}	Set to 000000h	
48_{16}	Set to 000000h	

Figure 70 – Example of Blu-ray Disc stream of three channels (3/0)

Figure 71 shows another three -channel structure.

$D3_{16}$	01_{16}	Ancillary Data
$D3_{16}$	$C0_{16}$	Ancillary Data
48_{16}	Left	
48_{16}	Right	
48_{16}	Set to 000000h	
48_{16}	Set to 000000h	
48_{16}	Surround	
48_{16}	Surround	
48_{16}	Set to 000000h	
48_{16}	Set to 000000h	

Figure 71 – Example of Blu-ray Disc stream three channels (2/1)

Figure 72 shows a four-channel structure.

$D3_{16}$	01_{16}	Ancillary Data
$D3_{16}$	$C0_{16}$	Ancillary Data
48_{16}	Left	
48_{16}	Right	
48_{16}	Set to 000000h	
48_{16}	Set to 000000h	
48_{16}	Left Surround	
48_{16}	Right Surround	
48_{16}	Set to 000000h	
48_{16}	Set to 000000h	

Figure 72 – Example of Blu-ray Disc stream of four channels (2/2)

12.5 Multi-bit linear audio (MBLA)

12.5.1 General

The compound data for MBLA (Multi-Bit Linear Audio) consists of multi-bit linear audio data, common ancillary and multi-bit linear audio specific ancillary data.

12.5.2 Structure of sample word for audio transmission

There are two kinds of channel structures in which this condition is defined:

a) the fixed channels' structure; and

b) the variable channels' structure.

12.5.3 Fixed channels' structure of sample word for audio transmission

MBLA specifies thirty-two channels. Thirty-two channels are transmitted by four isochronous channels.

There are eight sample words in one audio sample at each isochronous channel.

Figure 73 shows channels included in each group and channel order.

Group 1

LABEL	Data Channel 1 (Front Left channel)
LABEL	Data Channel 2 (Front Right channel)
LABEL	Data Channel 3 (Low Frequency Effects-1 channel)
LABEL	Data Channel 4 (Front Centre channel)
LABEL	Data Channel 5 (Left Surround channel)
LABEL	Data Channel 6 (Right Surround channel)
LABEL	Data Channel 7 (Back Left channel)
LABEL	Data Channel 8 (Back Right channel)

Group 2

LABEL	Data Channel 1 (Front Left centre channel)
LABEL	Data Channel 2 (Front Right centre channel)
LABEL	Data Channel 3 (Low Frequency Effects-2 channel)
LABEL	Data Channel 4 (Back Centre channel)
LABEL	Data Channel 5 (Side Left channel)
LABEL	Data Channel 6 (Side Right channel)
LABEL	Data Channel 7 (Top Front Left channel)
LABEL	Data Channel 8 (Top Front Right channel)

Group 3

LABEL	Data Channel 1 (Front Left wide channel)
LABEL	Data Channel 2 (Front Right wide channel)
LABEL	Data Channel 3 (Top Front Centre channel)
LABEL	Data Channel 4 (Top Centre channel)
LABEL	Data Channel 5 (Top Back Left channel)
LABEL	Data Channel 6 (Top Back Right channel)
LABEL	Data Channel 7 (Top Side Left channel)
LABEL	Data Channel 8 (Top Side Right channel)

Group 4

LABEL	Data Channel 1 (Top Back Centre channel)
LABEL	Data Channel 2 (Bottom Front Centre channel)
LABEL	Data Channel 3 (Bottom Front Left channel)
LABEL	Data Channel 4 (Bottom Front Right channel)
LABEL	Data Channel 5 (Left Surround direct channel)
LABEL	Data Channel 6 (Right Surround direct channel)
LABEL	Data Channel 7 (Top Left Surround channel)
LABEL	Data Channel 8 (Top Right Surround channel)

Figure 73 – Basic data block of the fixed channels' structure

The channel structure layout is fixed, as shown in Figure 73.

The transmitter shall set to 000000_{16} on the audio data of the MBLA data in the case of a non existing channel. The group does not need to transmit if all channels do not exist in the group. It saves the isochronous channel resource for the group.

12.5.4 Variable channels' structure of sample word for audio transmission

MBLA specifies thirty-two channels. Thirty-two channels are transmitted by one isochronous channel.

Figure 74 shows the channel order.

LABEL	Data Channel 1 (Front Left channel)
LABEL	Data Channel 2 (Front Right channel)
LABEL	Data Channel 3 (Low Frequency Effects-1 channel)
LABEL	Data Channel 4 (Front Centre channel)
LABEL	Data Channel 5 (Left Surround channel)
LABEL	Data Channel 6 (Right Surround channel)
LABEL	Data Channel 7 (Back Left channel)
LABEL	Data Channel 8 (Back Right channel)
LABEL	Data Channel 9 (Front Left centre channel)
LABEL	Data Channel 10 (Front Right centre channel)
LABEL	Data Channel 11 (Low Frequency Effects-2 channel)
LABEL	Data Channel 12 (Back Centre channel)
LABEL	Data Channel 13 (Side Left channel)
LABEL	Data Channel 14 (Side Right channel)
LABEL	Data Channel 15 (Top Front Left channel)
LABEL	Data Channel 16 (Top Front Right channel)

LABEL	Data Channel 17 (Front Left wide channel)
LABEL	Data Channel 18 (Front Right wide channel)
LABEL	Data Channel 19 (Top Front Centre channel)
LABEL	Data Channel 20 (Top Centre channel)
LABEL	Data Channel 21 (Top Back Left channel)
LABEL	Data Channel 22 (Top Back Right channel)
LABEL	Data Channel 23 (Top Side Left channel)
LABEL	Data Channel 24 (Top Side Right channel)

LABEL	Data Channel 25 (Top Back Centre channel)
LABEL	Data Channel 26 (Bottom Front Centre channel)
LABEL	Data Channel 27 (Bottom Front Left channel)
LABEL	Data Channel 28 (Bottom Front Right channel)
LABEL	Data Channel 29 (Left Surround direct channel)
LABEL	Data Channel 30 (Right Surround direct channel)
LABEL	Data Channel 31 (Top Left Surround channel)
LABEL	Data Channel 32 (Top Right Surround channel)

Figure 74 – Basic data block of the variable channels' structure

The non existing channel shall not transmit MBLA data.

The channel order is reduced.

12.5.5 MBLA data

MBLA data use the LABEL from 40_{16} to 42_{16} of MBLA.

12.5.6 MBLA specific ancillary data

This subclause specifies private header data that are carried by MBLA specific ancillary data, as shown in Table 63.

Table 63 – MBLA specific ancillary data

LABEL	SUB LABEL	Description
$D4_{16}$	01_{16}	Data transmitted at every data block of Group 1 for the fixed channels' structure
	02_{16}	Data transmitted at every data block of Group 2 for the fixed channels' structure
	03_{16}	Data transmitted at every data block of Group 3 for the fixed channels' structure
	04_{16}	Data transmitted at every data block of Group 4 for the fixed channels' structure
	05_{16}	Data transmitted at every data block for the variable channels' structure
	06_{16}	Data transmitted at extension channel bit order 1 for the variable channels' structure
	07_{16}	Data transmitted at extension channel bit order 2 for the variable channels' structure
	$C0_{16}$	CCI

The transmission device shall execute stream change method if the ancillary data is changed except when SUB LABEL is $C0_{16}$.

12.5.7 Data transmitted at every data block of Group 1 for the fixed channels' structure

These ancillary data, as shown in Figure 75 and Table 64, are transmitted at every data block of Group 1 for the fixed channels' structure.

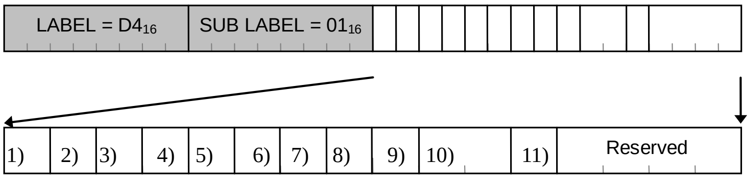

Figure 75 – Data transmitted at every data block of Group 1 for the fixed channels' structure

Table 64 – Data transmitted at every data block of Group 1 for the fixed channels' structure

Data	Bits	Description
1) Emphasis flag	1	Emphasis on or off
2) FL channel	1	FL (front left) channel data exist or do not exist
3) FR channel	1	FR (front right) channel data exist or do not exist
4) LFE1 channel	1	LFE1 (low frequency effects-1) channel data exist or do not exist
5) FC channel	1	FC (front centre) channel data exist or do not exist
6) LS channel	1	LS (left surround) channel data exist or do not exist
7) RS channel	1	RS (right surround) channel data exist or do not exist
8) BL channel	1	BL (back left) channel data exist or do not exist
9) BR channel	1	BR (back right) channel data exist or do not exist
10) FL/FR ch identifier	2	FL (front left)/FR (front right) channel identifier defined
11) FC ch identifier	1	FC (front centre) channel identifier defined

The emphasis flag shows whether de-emphasis is required for the sink device or not, as shown in Table 65.

Table 65 – Emphasis flag definition

Value	Description
0_2	de-emphasis is not required
1_2	de-emphasis is required

The FL channel shows whether FL (front left) channel data exist or not, as shown in Table 66.

Table 66 – FL channel definition

Value	Description
0_2	FL (front left) channel data does not exist
1_2	FL (front left) channel data exist

The FR channel shows whether FR (front right) channel data exist or not, as shown in Table 67.

Table 67 – FR channel definition

Value	Description
0_2	FR (front right) channel data do not exist
1_2	FR (front right) channel data exist

The LFE1 channel shows whether LFE1 (low frequency effects-1) channel data exist or not, as shown in Table 68.

Table 68 – LFE1 channel definition

Value	Description
0_2	LFE1 (low frequency effects-1) channel data do not exist
1_2	LFE1 (low frequency effects-1) channel data exist

The FC channel shows whether FC (front centre) channel data exist or not, as shown in Table 69.

Table 69 – FC channel definition

Value	Description
0_2	FC (front centre) channel data do not exist
1_2	FC (front centre) channel data exist

The LS channel shows whether LS (left surround) channel data is existed or not, as shown in Table 70.

Table 70 – LS channel definition

Value	Description
0_2	LS (left surround) channel data do not exist
1_2	LS (left surround) channel data exist

The RS channel shows whether RS (right surround) channel data exist or not, as shown in Table 71.

Table 71 – RS channel definition

Value	Description
0_2	RS (right surround) channel data do not exist
1_2	RS (right surround) channel data exist

The BL channel shows whether BL (back left) channel data exist or not, as shown in Table 72.

Table 72 – BL channel definition

Value	Description
0_2	BL (back left) channel data do not exist
1_2	BL (back left) channel data exist

The BR channel shows whether BR (back right) channel data exist or not, as shown in Table 73.

Table 73 – BR channel definition

Value	Description
0_2	BR (back right) channel data do not exist
1_2	BR (back right) channel data exist

The FL/FR ch identifier shows whether FL (front left)/FR (front right) channel data is FL/FR signal (stereo) or M1 (mono) signal or Lo (left output)/Ro (right output) signal or Lt (left total)/Rt (right total) signal.

Note that the sink device shall decrease the M1 (mono) signal to a −3 dB level if the sink device outputs M1 (mono) signal in the L (left)/R (right) channel, as shown in Table 74.

Table 74 – FL/FR ch identifier definition

Value	Description
00_2	FL (front left)/FR (front right) channel data is a L/R (stereo) signal
01_2	FL (front left)/FR (front right) channel data is a M1 (mono) signal FL (front left) channel and FR (front right) channel data are the same
10_2	FL (front left)/FR (front right) channel data is Lo (left output)/Ro (right output) signal
11_2	FL (front left)/FR (front right) channel data is a Lt (left total)/Rt (right total) signal

The FC ch identifier shows whether FC (front centre) channel data is a FC signal or a M1 (mono) signal, as shown in Table 75.

Table 75 – FC ch identifier definition

Value	Description
0_2	FC (front centre) channel data is a FC signal
1_2	FC (front centre) channel data is a M1 (mono) signal

12.5.8 Data transmitted at every data block of Group 2 for the fixed channels' structure

These ancillary data, as shown in Figure 76 and Table 76, are transmitted at every data block of Group 2 for the fixed channels' structure.

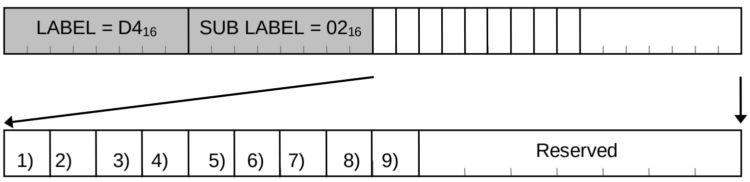

Figure 76 – Data transmitted at every data of Group 2 for the fixed channels' structure

Table 76 – Data transmitted at every data of Group 2 for the fixed channels' structure

Data	Bits	Description
1) Emphasis flag	1	Emphasis on or off
2) FLc channel	1	FLc (front left centre) channel data exist or do not exist
3) FRc channel	1	FRc (front right centre) channel data exist or do not exist
4) LFE2 channel	1	LFE2 (low frequency effects-2) channel data exist or do not exist
5) BC channel	1	BC (back centre) channel data exist or do not exist
6) SiL channel	1	SiL (side left) channel data exist or do not exist
7) SiR channel	1	SiR (side right) channel data exist or do not exist
8) TpFL channel	1	TpFL (top front left) channel data exist or do not exist
9) TpFR channel	1	TpFR (top front right) channel data exist or do not exist

The Emphasis flag shows whether de-emphasis is required for the sink device or not, as shown in Table 77.

Table 77 – Emphasis flag definition

Value	Description
0_2	de-emphasis is not required
1_2	de-emphasis is required

The FLc channel shows whether FLc (front left centre) channel data exist or not, as shown in Table 78.

Table 78 – FLc channel definition

Value	Description
0_2	FLc (front left centre) channel data do not exist
1_2	FLc (front left centre) channel data exist

The FRc channel shows whether FRc (front right centre) channel data exist or not, as shown in Table 79.

Table 79 – FRc channel definition

Value	Description
0_2	FRc (front right centre) channel data do not exist
1_2	FRc (front right centre) channel data exist

The LFE2 channel shows whether LFE2 (low frequency effects-2) channel data exist or not, as shown in Table 80.

Table 80 – LFE2 channel definition

Value	Description
0_2	LFE2 (low frequency effects-2) channel data do not exist
1_2	LFE2 (low frequency effects-2) channel data exist

The BC channel shows whether BC (back centre) channel data exist or not, as shown in Table 81.

Table 81 – BC channel definition

Value	Description
0_2	BC (back centre) channel data do not exist
1_2	BC (back centre) channel data exist

The SiL channel shows whether SiL (side left) channel data exist or not, as shown in Table 82.

Table 82 – SiL channel definition

Value	Description
0_2	SiL (side left) channel data do not exist
1_2	SiL (side left) channel data exist

The SiR channel shows whether SiR (side right) channel data exist or not, as shown in Table 83.

Table 83 – SiR channel definition

Value	Description
0_2	SiR (side right) channel data do not exist
1_2	SiR (side right) channel data exist

The TpFL channel shows whether TpFL (top front left) channel data exist or not, as shown in Table 84.

Table 84 – TpFL channel definition

Value	Description
0_2	TpFL (top front left) channel data do not exist
1_2	TpFL (top front left) channel data exist

The TpFR channel shows whether TpFR (top front right) channel data exist or not, as shown in Table 85.

Table 85 – TpFR channel definition

Value	Description
0_2	TpFR (top front right) channel data do not exist
1_2	TpFR (top front right) channel data exist

12.5.9 Data transmitted at every data block of Group 3 for the fixed channels' structure

These ancillary data, as shown in Figure 77 and Table 86, are transmitted at every data block of Group 3 for the fixed channels' structure.

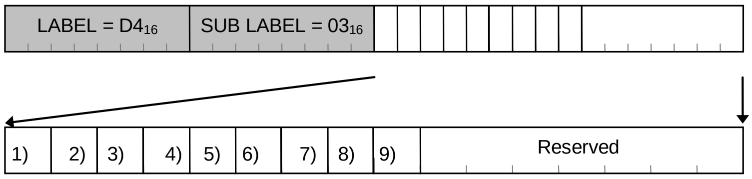

Figure 77 – Data transmitted at every data block of Group 3 for the fixed channels' structure

Table 86 – Data transmitted at every data block of Group 3 for the fixed channels' structure

Data	Bits	Description
1) Emphasis flag	1	Emphasis on or off
2) FLw channel	1	FLw (front left wide) channel data exist or do not exist
3) FRw channel	1	FRw (front right wide) channel data exist or do not exist
4) TpFC channel	1	TpFC (top front centre) channel data exist or do not exist
5) TpC channel	1	TpC (top centre) channel data exist or do not exist
6) TpBL channel	1	TpBL (top back left) channel data exist or do not exist
7) TpBR channel	1	TpBR (top back right) channel data exist or do not exist
8) TpSiL channel	1	TpSiL (top side left) channel data exist or do not exist
9) TpSiR channel	1	TpSiR (top side right) channel data exist or do not exist

The Emphasis flag shows whether de-emphasis is required for the sink device or not, as shown inTable 87.

Table 87 – Emphasis flag definition

Value	Description
0_2	de-emphasis is not required
1_2	de-emphasis is required

The FLw channel shows whether FLw (front left wide) channel data exist or not, as shown in Table 88.

Table 88 – FLw channel definition

Value	Description
0_2	FLw (front left wide) channel data do not exist
1_2	FLw (front left wide) channel data exist

The FRw channel shows whether FRw (front right wide) channel data exist or not, as shown in Table 89.

Table 89 – FRw channel definition

Value	Description
0_2	FRw (front right wide) channel data do not exist
1_2	FRw (front right wide) channel data exist

The TpFC channel shows whether TpFC (top front centre) channel data exist or not, as shown in Table 90.

Table 90 – TpFC channel definition

Value	Description
0_2	TpFC (top front centre) channel data do not exist
1_2	TpFC (top front centre) channel data exist

The TpC channel shows whether TpC (top centre) channel data exist or not, as shown in Table 91.

Table 91 – TpC channel definition

Value	Description
0_2	TpC (top centre) channel data do not exist
1_2	TpC (top centre) channel data exist

The TpBL channel shows whether TpBL (top back left) channel data exist or not, as shown in Table 92.

Table 92 – TpBL channel definition

Value	Description
0_2	TpBL (top back left) channel data do not exist
1_2	TpBL (top back left) channel data exist

The TpBR channel shows whether TpBR (top back right) channel data exist or not, as shown in Table 93.

Table 93 – TpBR channel definition

Value	Description
0_2	TpBR (top back right) channel data do not exist
1_2	TpBR (top back right) channel data exist

The TpSiL channel shows whether TpSiL (top side left) channel data exist or not, as shown in Table 94.

Table 94 – TpSiL channel definition

Value	Description
0_2	TpSiL (top side left) channel data do not exist
1_2	TpSiL (top side left) channel data exist

The TpSiR channel shows whether TpSiR (top side right) channel data exist or not, as shown in Table 95.

Table 95 – TpSiR channel definition

Value	Description
0_2	TpSiR (top side right) channel data do not exist
1_2	TpSiR (top side right) channel data exist

12.5.10 Data transmitted at every data block of Group 4 for the fixed channels' structure

These ancillary data, as shown in Figure 78 and Table 96, are transmitted at every data block of Group 4 for the fixed channels' structure.

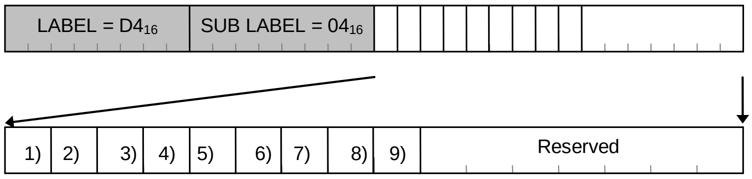

Figure 78 – Data transmitted at every data block of Group 4 for the fixed channels' structure

Table 96 – Data transmitted at every data block of Group 4 for the fixed channels' structure

Data	Bits	Description
1) Emphasis flag	1	Emphasis on or off
2) TpBC channel	1	TpBC (top back centre) channel data exist or do not exist
3) BtFC channel	1	BtFC (bottom front centre) channel data exist or do not exist
4) BtFL channel	1	BtFL (bottom front left) channel data exist or do not exist
5) BtFR channel	1	BtFR (bottom front right) channel data exist or do not exist
6) LSd channel	1	LSd (left surround direct) channel data exist or do not exist
7) RSd channel	1	RSd (right surround direct) channel data exist or do not exist
8) TpLS channel	1	TpLS (top left surround) channel data exist or do not exist
9) TpRS channel	1	TpRS (top right surround) channel data exist or do not exist

The Emphasis Flag shows whether de-emphasis is required for the sink device or not, as shown in Table 97.

Table 97 – Emphasis flag definition

Value	Description
0_2	de-emphasis is not required
1_2	de-emphasis is required

The TpBC channel shows whether TpBC (top back centre) channel data exist or not, as shown in Table 98.

Table 98 – TpBC channel definition

Value	Description
0_2	TpBC (top back centre) channel data do not exist
1_2	TpBC (top back centre) channel data exist

The BtFC channel shows whether BtFC (bottom front centre) channel data exist or not, as shown in Table 99.

Table 99 – BtFC channel definition

Value	Description
0_2	BtFC (bottom front centre) channel data do not exist
1_2	BtFC (bottom front centre) channel data exist

The BtFL channel shows whether BtFL (bottom front left) channel data exist or not, as shown in Table 100.

Table 100 – BtFL channel definition

Value	Description
0_2	BtFL (bottom front left) channel data do not exist
1_2	BtFL (bottom front left) channel data exist

The BtFR channel shows whether BtFR (bottom front right) channel data exist or not, as shown in Table 101.

Table 101 – BtFR channel definition

Value	Description
0_2	BtFR (bottom front right) channel data do not exist
1_2	BtFR (bottom front right) channel data exist

The LSd channel shows whether LSd (left surround direct) channel data exist or not, as shown in Table 102.

Table 102 – LSd channel definition

Value	Description
0_2	LSd (left surround direct) channel data do not exist
1_2	LSd (left surround direct) channel data exist

The RSd channel shows whether RSd (right surround direct) channel data exist or not, as shown in Table 103.

Table 103 – RSd channel definition

Value	Description
0_2	RSd (right surround direct) channel data do not exist
1_2	RSd (right surround direct) channel data exist

The TpLS channel shows whether TpLS (top left surround) channel data exist or not, as shown in Table 104.

Table 104 – TpLS channel definition

Value	Description
0_2	TpLS (top left surround) channel data do not exist
1_2	TpLS (top left surround) channel data exist

The TpRS channel shows whether TpRS (top right surround) channel data exist or not, as shown in Table 105.

Table 105 – TpRS channel definition

Value	Description
0_2	TpRS (top right surround) channel data do not exist
1_2	TpRS (top right surround) channel data exist

12.5.11 Data transmitted at every data block for the variable channels' structure

These ancillary data, as shown in Figure 79 and Table 106, are transmitted at every data block for the variable channels' structure.

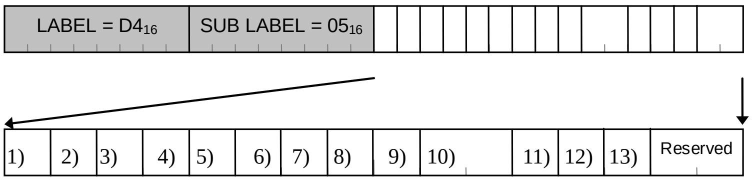

Figure 79 – Data transmitted at every data block for the variable channel's structure

Table 106 – Data transmitted at every data block for the variable channels' structure

Data	Bits	Description
1) Emphasis Flag	1	Emphasis on or off
2) FL channel	1	FL (front left) channel data exist or not exist
3) FR channel	1	FR (front right) channel data exist or not exist
4) LFE1 channel	1	LFE1 (low frequency effects-1) channel data exist or not exist
5) FC channel	1	FC (front centre) channel data exist or not exist
6) LS channel	1	LS (left surround) channel data exist or not exist
7) RS channel	1	RS (right surround) channel data exist or not exist
8) BL channel	1	BL (back left) channel data exist or not exist
9) BR channel	1	BR (back right) channel data exist or not exist
10) FL/FR ch identifier	2	FL (front left)/FR (front right) channel identifier defined
11) FC ch identifier	1	FC (front centre) channel identifier defined
12) Extension ch flag 1	1	Extension channel bit order 1 exists or does not exist
13) Extension ch flag 2	1	Extension channel bit order 2 exists or does not exist

The emphasis flag shows whether de-emphasis is required for the sink device or not, as shown in Table 107.

Table 107 – Emphasis flag definition

Value	Description
0_2	de-emphasis is not required
1_2	de-emphasis is required

The FL channel shows whether FL (front left) channel data exist or not, as shown in Table 108.

Table 108 – FL channel definition

Value	Description
0_2	FL (front left) channel data do not exist
1_2	FL (front left) channel data exist

The FR channel shows whether FR (front right) channel data exist or not, as shown in Table 109.

Table 109 – FR channel definition

Value	Description
0_2	FR (front right) channel data do not exist
1_2	FR (front right) channel data exist

The LFE1 channel shows whether LFE1 (low frequency effects-1) channel data exist or not, as shown in Table 110.

Table 110 – LFE1 channel definition

Value	Description
0_2	LFE1 (low frequency effects-1) channel data do not exist
1_2	LFE1 (low frequency effects-1) channel data exist

The FC channel shows whether FC (front centre) channel data exist or not, as shown in Table 111.

Table 111 – FC channel definition

Value	Description
0_2	FC (front centre) channel data do not exist
1_2	FC (front centre) channel data exist

The LS channel shows whether LS (left surround) channel data exist or not, as shown in Table 112.

Table 112 – LS channel definition

Value	Description
0_2	LS (left surround) channel data do not exist
1_2	LS (left surround) channel data exist

The RS channel shows whether RS (right surround) channel data exist or not, as shown in Table 113.

Table 113 – RS channel definition

Value	Description
0_2	RS (right surround) channel data do not exist
1_2	RS (right surround) channel data exist

The BL channel shows whether BL (back left) channel data exist or not, see Table 114.

Table 114 – BL channel definition

Value	Description
0_2	BL (back left) channel data do not exist
1_2	BL (back left) channel data exist

The BR channel shows whether BR (back right) channel data exist or not, as shown in Table 115.

Table 115 – BR channel definition

Value	Description
0_2	BR (back right) channel data do not exist
1_2	BR (back right) channel data exist

The FL/FR ch identifier shows whether FL (front left)/FR (front right) channel data is FL/FR signal (stereo) or M1 (mono) signal or Lo (left output)/Ro (right output) signal or Lt (left total)/Rt (right total) signal, see Table 116.

Note that the sink device shall decrease the M1 (mono) signal to a −3 dB level if the sink device outputs M1 (mono) signal in the L (left)/R (right) channel.

Table 116 – FL/FR ch identifier definition

Value	Description
00_2	FL (front left)/FR (front right) channel data is the L/R (stereo) signal
01_2	FL (front left)/FR (front right) channel data is the M1 (mono) signal FL (front left) channel and FR (front right) channel data are the same
10_2	FL (front left)/FR (front right) channel data is the Lo (left output)/Ro (right output) signal
11_2	FL (front left)/FR (front right) channel data is the Lt (left total)/Rt (right total) signal

The FC ch identifier shows whether FC (front centre) channel data is the FC signal or the M1 (mono) signal, as shown in Table 117.

Table 117 – FC ch identifier definition

Value	Description
0_2	FC (front centre) channel data is the FC signal
1_2	FC (front centre) channel data is the M1 (mono) signal

The extension ch flag 1 shows whether ancillary data of data transmitted at the extension channel bit order 1 for the variable channels' structure exist or not, as shown in Table 118.

Table 118 – Extension ch flag 1 definition

Value	Description
0_2	Ancillary data of data transmitted at extension channel bit order 1 for the variable channels' structure do not exist
1_2	Ancillary data of data transmitted at extension channel bit order 1 for the variable channels' structure exist

The extension ch flag 2 shows whether ancillary data of data transmitted at extension channel bit order 2 for the variable channels' structure exist or not, as shown in Table 119.

Table 119 – Extension ch flag 2 definition

Value	Description
0_2	Ancillary data of data transmitted at extension channel bit order 2 for the variable channels' structure do not exist
1_2	Ancillary data of data transmitted at extension channel bit order 2 for the variable channels' structure exist

12.5.12 Data transmitted at extension channel bit order 1 for the variable channels' structure

These ancillary data, as shown in Figure 80 and Table 120, are transmitted at extension channel bit order 1 for the variable channels' structure.

These data shall be transmitted as second ancillary data at least once per less than 100 ms when these data exist.

The transmitter should output these ancillary data as soon as possible to clarify the channel assignment as soon as content of the stream has been changed or the stream output has started.

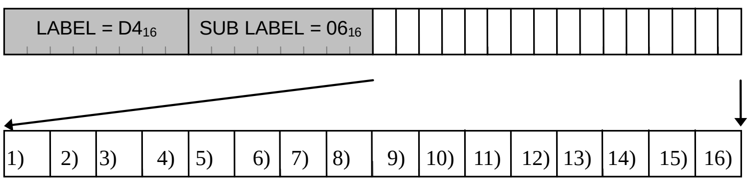

Figure 80 – Data transmitted at extension channel bit order 1 for the variable channels' structure

Table 120 – Data transmitted at extension channel bit order 1 for the variable channels' structure

Data	Bits	Description
1) FLc channel	1	FLc (front left centre) channel data exist or do not exist
2) FRc channel	1	FRc (front right centre) channel data exist or do not exist
3) LFE2 channel	1	LFE2 (low frequency effects-2) channel data exist or do not exist
4) BC channel	1	BC (back centre) channel data exist or do not exist
5) SiL channel	1	SiL (side left) channel data exist or do not exist
6) SiR channel	1	SiR (side right) channel data exist or do not exist
7) TpFL channel	1	TpFL (top front left) channel data exist or do not exist
8) TpFR channel	1	TpFR (top front right) channel data exist or do not exist
9) FLw channel	1	FLw (front left wide) channel data exist or do not exist
10) FRw channel	1	FRw (front right wide) channel data exist or do not exist
11) TpFC channel	1	TpFC (top front centre) channel data exist or do not exist
12) TpC channel	1	TpC (top centre) channel data exist or do not exist
13) TpBL channel	1	TpBL (top back left) channel data exist or do not exist
14) TpBR channel	1	TpBR (top back right) channel data exist or do not exist
15) TpSiL channel	1	TpSiL (top side left) channel data exist or do not exist
16) TpSiR channel	1	TpSiR (top side right) channel data exist or do not exist

The FLc channel shows whether FLc (front left centre) channel data exist or not, as shown in Table 121.

Table 121 – FLc channel definition

Value	Description
0_2	FLc (front left centre) channel data do not exist
1_2	FLc (front left centre) channel data exist

The FRc channel shows whether FRc (front right centre) channel data exist or not, as shown in, as shown in Table 122.

Table 122 – FRc channel definition

Value	Description
0_2	FRc (front right centre) channel data do not exist
1_2	FRc (front right centre) channel data exist

The LFE2 channel shows whether LFE2 (low frequency effects-2) channel data exist or not, as shown in Table 123.

Table 123 – LFE2 channel definition

Value	Description
0_2	LFE2 (low frequency effects-2) channel data do not exist
1_2	LFE2 (low frequency effects-2) channel data exist

The BC channel shows whether BC (back centre) channel data exist or not, as shown in Table 124.

Table 124 – BC channel definition

Value	Description
0_2	BC (back centre) channel data do not exist
1_2	BC (back centre) channel data exist

The SiL channel shows whether SiL (side left) channel data exist or not, as shown in Table 125.

Table 125 – SiL channel definition

Value	Description
0_2	SiL (side left) channel data do not exist
1_2	SiL (side left) channel data exist

The SiR channel shows whether SiR (side right) channel data exist or not, as shown in Table 126.

Table 126 – SiR channel definition

Value	Description
0_2	SiR (side right) channel data do not exist
1_2	SiR (side right) channel data exist

The TpFL channel shows whether TpFL (top front left) channel data exist or not, as shown in Table 127.

Table 127 – TpFL channel definition

Value	Description
0_2	TpFL (top front left) channel data do not exist
1_2	TpFL (top front left) channel data exist

The TpFR channel shows whether TpFR (top front right) channel data exist or not Table 128.

Table 128 – TpFR channel definition

Value	Description
0_2	TpFR (top front right) channel data do not exist
1_2	TpFR (top front right) channel data exist

The FLw channel shows whether FLw (front left wide) channel data exist or not, as shown in Table 129.

Table 129 – FLw channel definition

Value	Description
0_2	FLw (front left wide) channel data do not exist
1_2	FLw (front left wide) channel data exist

The FRw channel shows whether FRw (front right wide) channel data exist or not, as shown in Table 130.

Table 130 – FRw channel definition

Value	Description
0_2	FRw (front right wide) channel data do not exist
1_2	FRw (front right wide) channel data exist

The TpFC channel shows whether TpFC (top front centre) channel data exist or not, as shown in Table 131.

Table 131 – TpFC channel definition

Value	Description
0_2	TpFC (top front centre) channel data do not exist
1_2	TpFC (top front centre) channel data exist

The TpC channel shows whether TpC (top centre) channel data exist or not, as shown in Table 132.

Table 132 – TpC channel definition

Value	Description
0_2	TpC (top centre) channel data do not exist
1_2	TpC (top centre) channel data exist

The TpBL channel shows whether TpBL (top back left) channel data exist or not, as shown in Table 133.

Table 133 – TpBL channel definition

Value	Description
0_2	TpBL (top back left) channel data do not exist
1_2	TpBL (top back left) channel data exist

The TpBR channel shows whether TpBR (top back right) channel data exist or not, as shown in Table 134.

Table 134 – TpBR channel definition

Value	Description
0_2	TpBR (top back right) channel data do not exist
1_2	TpBR (top back right) channel data exist

The TpSiL channel shows whether TpSiL (top side left) channel data exist or not, as shown in Table 135.

Table 135 – TpSiL channel definition

Value	Description
0_2	TpSiL (top side left) channel data do not exist
1_2	TpSiL (top side left) channel data exist

The TpSiR channel shows whether TpSiR (top side right) channel data exist or not, as shown in Table 136.

Table 136 – TpSiR channel definition

Value	Description
0_2	TpSiR (top side right) channel data do not exist
1_2	TpSiR (top side right) channel data exist

12.5.13 Data transmitted at extension channel bit order 2 for the variable channels' structure

These ancillary data, as shown in Figure 81 and Table 137, are transmitted at extension channel bit order 2 for the variable channels' structure.

These data shall be transmitted as second ancillary data at least once per less than 100 ms provided that these data exist.

The transmitter should output these ancillary data as soon as possible to clarify the channel assignment as soon as content of the stream has been changed or the stream output has started.

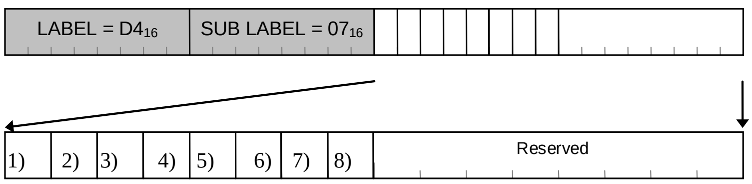

Figure 81 – Data transmitted at extension channel bit order 2 for the variable channels' structure

Table 137 – Data transmitted at extension channel bit order 2 for the variable channels' structure

Data	Bits	Description
1) TpBC channel	1	TpBC (top back centre) channel data exist or do not exist
2) BtFC channel	1	BtFC (bottom front centre) channel data exist or do not exist
3) BtFL channel	1	BtFL (bottom front left) channel data exist or do not exist
4) BtFR channel	1	BtFR (bottom front right) channel data exist or do not exist
5) LSd channel	1	LSd (left surround direct) channel data exist or do not exist
6) RSd channel	1	RSd (right surround direct) channel data exist or do not exist

Data	Bits	Description
7) TpLS channel	1	TpLS (top left surround) channel data exist or do not exist
8) TpRS channel	1	TpRS (top right surround) channel data exist or do not exist

The TpBC channel shows whether TpBC (top back centre) channel data exist or not , as shown in Table 138.

Table 138 – TpBC channel definition

Value	Description
0_2	TpBC (top back centre) channel data do not exist
1_2	TpBC (top back centre) channel data exist

The BtFC channel shows whether BtFC (bottom front centre) channel data exist or not, as shown in Table 139.

Table 139 – BtFC channel definition

Value	Description
0_2	BtFC (bottom front centre) channel data do not exist
1_2	BtFC (bottom front centre) channel data exist

The BtFL channel shows whether BtFL (bottom front left) channel data exist or not, as shown in Table 140.

Table 140 – BtFL channel definition

Value	Description
0_2	BtFL (bottom front left) channel data do not exist
1_2	BtFL (bottom front left) channel data exist

The BtFR channel shows whether BtFR (bottom front right) channel data exist or not, as shown in Table 141.

Table 141 – BtFR channel definition

Value	Description
0_2	BtFR (bottom front right) channel data do not exist
1_2	BtFR (bottom front right) channel data exist

The LSd channel shows whether LSd (left surround direct) channel data exist or not, as shown in Table 142.

Table 142 – LSd channel definition

Value	Description
0_2	LSd (left surround direct) channel data do not exist
1_2	LSd (left surround direct) channel data exist

The RSd channel shows whether RSd (right surround direct) channel data exist or not, as shown in Table 143.

Table 143 – RSd channel definition

Value	Description
0_2	RSd (right surround direct) channel data do not exist
1_2	RSd (right surround direct) channel data exist

The TpLS channel shows whether TpLS (top left surround) channel data exist or not, as shown in Table 144.

Table 144 – TpLS channel definition

Value	Description
0_2	TpLS (top left surround) channel data do not exist
1_2	TpLS (top left surround) channel data exist

The TpRS channel shows whether TpRS (top right surround) channel data exist or not, as shown in Table 145.

Table 145 – TpRS channel definition

Value	Description
0_2	TpRS (top right surround) channel data do not exist
1_2	TpRS (top right surround) channel data exist

12.5.14 Data for CCI

Figure 82 and Table 146 provide a definition of ancillary data for CCI.

SUB LABEL $C0_{16}$ is for CCI.

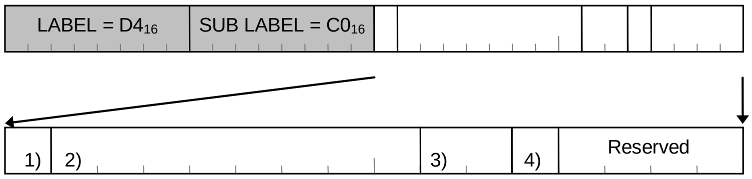

Figure 82 – Ancillary data for CCI

Table 146 – Data transmitted at every data block

Data	Bits
1) CP-bit	1
2) Category code	8
6) CGMS-A	2
5) CGMS-A validity	1

NOTE 1 Ancillary data for CCI have the same meaning as specified in IEC 60958-3.

NOTE 2 Each value is based on the following condition in IEC 60958-3:

- consumer use of channel status block;
- audio sample word represents linear PCM samples;
- channel status mode is Mode 0.

These data shall be transmitted at least once during a 100 ms period.

12.5.15 Example of MBLA stream for the fixed channels' structure

Figure 83 shows one-channel examples.

$D4_{16}$	01_{16}	Ancillary Data
$D4_{16}$	$C0_{16}$	Ancillary Data
42_{16}	Mono	
42_{16}	Mono	
42_{16}	Set to 000000_{16}	
42_{16}	Set to 000000_{16}	
42_{16}	Set to 000000_{16}	
42_{16}	Set to 000000_{16}	
42_{16}	Set to 000000_{16}	
42_{16}	Set to 000000_{16}	

a) Example 1

$D4_{16}$	01_{16}	Ancillary Data
$D4_{16}$	$C0_{16}$	Ancillary Data
42_{16}	Set to 000000_{16}	
42_{16}	Set to 000000_{16}	
42_{16}	Set to 000000_{16}	
42_{16}	Mono	
42_{16}	Set to 000000_{16}	
42_{16}	Set to 000000_{16}	
42_{16}	Set to 000000_{16}	
42_{16}	Set to 000000_{16}	

b) Example 2

$D4_{16}$	01_{16}	Ancillary Data
$D4_{16}$	$C0_{16}$	Ancillary Data
42_{16}	Mono	
42_{16}	Mono	

c) Example 3

Figure 83 – Examples of MBLA stream for the fixed channels' structure of one channel

The channel structure shown in example 2 of Figure 83 appears when only FL and FR are transmitted.

Figure 84 shows two-channel examples.

$D4_{16}$	01_{16}	Ancillary Data
$D4_{16}$	$C0_{16}$	Ancillary Data
42_{16}	Front Left	
42_{16}	Front Right	
42_{16}	Set to 000000_{16}	
42_{16}	Set to 000000_{16}	
42_{16}	Set to 000000_{16}	
42_{16}	Set to 000000_{16}	
42_{16}	Set to 000000_{16}	
42_{16}	Set to 000000_{16}	

a) Example 1

$D4_{16}$	01_{16}	Ancillary Data
$D4_{16}$	$C0_{16}$	Ancillary Data
42_{16}	Front Left	
42_{16}	Front Right	

b) Example 2

Figure 84 – Examples of MBLA stream for the fixed channels' structure of two channels

Figure 85 shows a three-channel example.

$D4_{16}$	01_{16}	Ancillary Data
$D4_{16}$	$C0_{16}$	Ancillary Data
42_{16}	Front Left	
42_{16}	Front Right	
42_{16}	Set to 000000_{16}	
42_{16}	Front Centre	
42_{16}	Set to 000000_{16}	
42_{16}	Set to 000000_{16}	
42_{16}	Set to 000000_{16}	
42_{16}	Set to 000000_{16}	

Figure 85 – Example of MBLA stream for the fixed channels' structure of three channels (3/0)

Figure 86 shows a four-channel example.

$D4_{16}$	01_{16}	Ancillary Data
$D4_{16}$	$C0_{16}$	Ancillary Data
42_{16}	Front Left	
42_{16}	Front Right	
42_{16}	Set to 000000_{16}	
42_{16}	Set to 000000_{16}	
42_{16}	Left Surround	
42_{16}	Right Surround	
42_{16}	Set to 000000_{16}	
42_{16}	Set to 000000_{16}	

Figure 86 – Example of MBLA stream for the fixed channels' structure of four channels (2/2)

12.5.16 Example of MBLA stream for the variable channels' structure

Figure 87 shows one-channel examples.

$D4_{16}$	05_{16}	Ancillary Data
$D4_{16}$	$C0_{16}$	Ancillary Data
42_{16}	Mono	
42_{16}	Mono	

a) **Example 1**

$D4_{16}$	05_{16}	Ancillary Data
$D4_{16}$	$C0_{16}$	Ancillary Data
42_{16}	Mono	
CF_{16}	CF_{16}	

b) **Example 2**

Figure 87 – Examples of MBLA stream for the variable channels' structure of one channel

Figure 88 shows a two-channel example.

$D4_{16}$	05_{16}	Ancillary Data
$D4_{16}$	$C0_{16}$	Ancillary Data
42_{16}	Front Left	
42_{16}	Front Right	

Figure 88 – Example of MBLA stream for the variable channels' structure two channels

Figure 89 shows a three-channel example.

$D4_{16}$	05_{16}	Ancillary Data
$D4_{16}$	$C0_{16}$	Ancillary Data
42_{16}	Front Left	
42_{16}	Front Right	
42_{16}	Front Centre	
CF_{16}	CF_{16}	

Figure 89 – Example of MBLA stream for the variable channels' structure of three channels (3/0)

Figure 90 shows a four-channel example.

$D4_{16}$	05_{16}	Ancillary Data
$D4_{16}$	$C0_{16}$	Ancillary Data
42_{16}	Front Left	
42_{16}	Front Right	
42_{16}	Left Surround	
42_{16}	Right Surround	

Figure 90 – Example of MBLA stream for the variable channels' structure of four channels (2/2)

Figure 91 shows a seven-channel example.

$D4_{16}$	01_{16}	Ancillary Data
$D4_{16}$	$C0_{16}$	Ancillary Data
42_{16}	Front Left	
42_{16}	Front Right	
42_{16}	Front Centre	
42_{16}	Left Surround	
42_{16}	Right Surround	
42_{16}	Front Left wide	
42_{16}	Front Right wide	
CF_{16}	CF_{16}	

Figure 91 – Example of MBLA stream for the fixed channels' structure of seven channels

Annex A
(informative)

Synchronization issues

A.1 General

The following synchronization issues have been identified:

a) rate matching between the transmitter and receiver;

b) adjusting the presentation time at a receiver;

c) adjusting the location at a transmitter.

The rate matching between the transmitter and receiver can be done by one of two methods:

1) clock-based rate control;

2) command-based rate control (see 10.4).

Clock-based rate control may use sampling clock delivery in an isochronous stream or another clock delivery system such as a dedicated clock.

The presentation time adjustment of the application sequence at a receiver can be done since the time stamp of a CIP is defined in such a way that it reflects the time when the corresponding audio sample goes out of a buffer for depacketization. If an application requires precise adjustment of the presentation time, the application should take into account the extra delay caused by signal processing or A/D and D/A conversion.

A.2 Delivery of sampling clock of arbitrary frequency

This clause focuses on rate matching in terms of sampling clock delivery, which is very familiar to audio engineers. It only applies to real time transfer, which occurs when the sample transmission frequency is used to define the sampling frequency.

Since a CIP without a source packet header (SPH) has only one time stamp in the SYT field, the maximum synchronization clock frequency shall be limited to the isochronous cycle of 8 kHz.

Assume that a transmitter carries an audio stream with sampling frequency STF and that STF > 8 kHz.

The transmitter derives a synchronization clock with frequency F_{sync} according to Equation (A.1):

$$F_{\text{sync}} = STF \text{ / SYT\_INTERVAL} < 8\,000 \qquad \text{(A.1)}$$

where

F_{sync} is the synchronization clock frequency (in Hz);

STF is the sampling transmission frequency (in Hz);

SYT_INTERVAL denotes the number of events between two successive valid SYTs, which includes one of the events with a valid SYT.

The transmitter quantizes the timing of the synchronization clock, for instance, the rising edge of the clock, by referring to its own CYCLE_TIME. It transmits the sum of the timing and TRANSFER_DELAY by using the SYT field of the CIP. The resolution of the time stamp is 1/(24,576 MHz), or approximately 40 ns, and CYCLE_TIME may have 40 ns of jitter due to this quantization. If the timing information is not available for a CIP, the SYT shall indicate the no information code.

A receiver can reproduce the synchronization clock in terms of the pulse generated when the SYT equals its own CYCLE_TIME.

The sampling clock can be reproduced by multiplying the synchronization clock by the SYT_INTERVAL, which shall be determined before receiving begins.

This sampling clock delivery does not require synchronization of the sampling clock and the isochronous cycle.

The reproduced synchronization clock will have jitter. This jitter can degrade audio quality unless adequate jitter attenuation is used.

The local CYCLE_TIME registers at the transmitter and the receiver nodes will have jitter from various sources. This CYCLE_TIME register jitter has a minimum peak-peak amplitude equivalent to the approximately 40 ns resolution of CYCLE_TIME. If one of the nodes is the cycle master this jitter only applies to CYCLE_TIME at the other node. If neither of the nodes is the cycle master then it will apply to CYCLE_TIME at both the transmit and received nodes. There is also a source of CYCLE_TIME jitter from the quantization of the correction for variable delay to the cycle start packets from the cycle master.

The jitter added to the synchronization clock by delivery in this manner is the sum of the CYCLE_TIME jitter and the jitter due to the quantization of the time stamp.

Annex B
(informative)

Catching up in non-blocking transmission method

Equation (3) in 7.4.1 stipulates that in normal operation, each transmitter shall construct a packet containing between 0 and SYT_INTERVAL events. Table 20 specifies SYT_Interval for each sample transmission frequency such that: provide

Event_arrival_time[SYT_INTERVAL-1] – Event_arrival_time[0] > Min_period (B.1)

and

125 µs <= Min_Period

where

Event_arrival_time[M]	is the time (measured in µs) of the arrival at the transmitter of event at index M. The event with index = 0 is the event which has Presentation Time = SYT.
Min_Period	is the time (measured in µs) of SYT_INTERVAL events.

The Min_Period ensures that at most only a single SYT will be required for each packet.

Using a normal non-blocking transmission method, fewer SYT_INTERVAL events will be transmitted in each packet. In the event of lost opportunities to transmit a packet (such as a cycle start packet drop after a bus reset) a transmitter can catch up by transmitting up to SYT_INTERVAL events in one or more of the subsequent packets. Events which are late according to Equation (4) are not transmitted.

Equation (9) in 9.2 can be used to determine the required isochronous bandwidth, but, in a normal non-blocking operation, not all of this bandwidth is used. Extra bandwidth is available for catching up. However, this extra bandwidth may not be sufficient to ensure that some events will not be late.

A method is provided below to allow a transmitter to add one extra event to each catch-up packet as long as the total number of events is not greater than the SYT_INTERVAL.

In Equation (9) in 9.2, the term (int(max(Fs)/8 000) + 1) can be changed to (int(max(Fs)/8 000) + 2). This increases the allocated bandwidth in such a way that one additional event can be sent per packet. While this bandwidth will be unused during normal operation, it will provide the extra bandwidth needed to catch up without violating the allocated bandwidth.

It is important to consider that in the case of lost isochronous cycles, more than one transmitter may be trying to catch up at the same time. Sufficient bandwidth should be allocated to allow for catch-up.

Annex C
(informative)

Transport characteristics

C.1 Sampling-clock jitter characteristics

Sampling-clock jitter can degrade the accuracy of conversion processes in sampling devices. This part of the annex describes the jitter mechanisms in the exchange of sample timing information and derives worst-case jitter levels to be used for stressing sampling devices when making performance measurements.

This issue applies to systems that require a sample clock to be transferred across the bus to a sampling device. For example, it does not apply for devices that use flow control with a single sampling device acting as destination and synchronization master, or where the destination device is a non-sampling device such as a recorder.

C.2 Sample clock transfer jitter mechanisms using A/M protocol

C.2.1 General

The A/M protocol and the serial bus use asynchronous clocks to define and exchange timing and synchronization information. The changing phase relationships and limited timing resolution of these clocks, and, in some circumstances, the changing phase relationship to an external sample clock, produce a variable error which introduces jitter into an embedded synchronization clock.

There are other sources of jitter including oscillator phase noise, variable gate delays and cable inter-symbol interference. These are normally small in comparison with the mechanisms considered here.

C.2.2 CYCLE_TIME register jitter

C.2.2.1 General

Embedded synchronization clock information is referenced to the CYCLE_TIME register value at the synchronization clock source. Jitter on this register value at the synchronization clock source and synchronization clock destination nodes contributes to embedded synchronization clock jitter.

C.2.2.2 Cycle start packet CYCLE_TIME resolution

The cycle start packet issued from the cycle master is used to align the CYCLE_TIME registers of any isochronous-capable nodes on a serial bus. It is transmitted at or after the cycle counter on the cycle master node and is incremented. It carries the value of the cycle master node CYCLE_TIME register at the time the cycle start is initiated.

Asynchronous activity on the bus at the time when the cycle starts an event causes a delay in transmitting the cycle start packet. At the other isochronous nodes, the CYCLE_TIME register is loaded with the value carried on the cycle start packet. That compensates for the cycle start delay but only up to the resolution of that register. This resolution is 1/24,576 MHz (which is approximated in this annex as 41 ns).

The cycle start packet carries a value from the CYCLE_TIME register. If the transmission of the packet is timed so that it always occurs at a fixed time after the moment that the CYCLE_TIME register is updated to that value, then the cycle start delays will be corrected without a significant error. This means that asynchronous activity at the time when the cycle starts an event will not generate jitter.

However, some IEEE 1394 compliant implementations might introduce a variable delay between the time the CYCLE_TIME register is updated and the cycle start packet transmission of that value. This will depend on the implementation, but this delay may be limited to less than the 41 ns CYCLE_TIME resolution, or it could possibly be even greater than this.

C.2.2.3 Variable transport delay to cycle start packets

As a cycle start packet is passed through intermediate nodes on the bus it is delayed by a variable amount of repeater data delay.

The normal mechanism for the variation in this delay is the re-timing of the packet by the local clock at each node. The repeater data delay varies as the relative timing of the incoming transitions and the local clock changes. This change is a result of the frequency difference between the local clock and the clock on the previous node the packet has passed through. Jitter produced in this way is in the form of a ramping variation with a step correction in the opposite direction. The frequency of this sawtooth is related to the frequency difference between the two node clocks.

IEEE 1394 does not define explicit limits for repeater delay jitter. The draft supplement, P1394a, specifies a PHY register field jitter that can indicate values from 1/49,152 MHz (which is approximated in this annex as 20 ns) to 7/49,152 MHz (approximately 163 ns).

IEEE 1394 PHY devices that resynchronize received data with a 49,152 MHz clock will have a repeater data delay jitter of approximately 20 ns peak-peak or 6 ns r.m.s.

The jitter due to a variable repeater delay jitter is cumulative. The total variable transport delay is the sum of the delay at each node. The total r.m.s. jitter to the cycle start packet transport delay is the root sum of squares (RSS) of the r.m.s. jitter at each intermediate repeater node.

C.2.2.4 Quantization of CYCLE_TIME register correction

The CYCLE_TIME registers at each isochronous node increment at a rate defined by the exact rate of the 24,576 MHz clock in the local node. These registers are time aligned with similar registers in other nodes by being loaded with the value carried in the cycle start packet transmitted by the cycle master. As the CYCLE_TIME register incrementing clock has a slightly different frequency at each node, there will be a gradually changing error between the updating of that register at the cycle master and the other nodes.

When there is a difference between the value on an incoming cycle start packet and the value in the local CYCLE_TIME register then a correction is made.

This correction is quantized to the CYCLE_TIME register resolution of 1/24,576 MHz. The contribution of this mechanism to the CYCLE_TIME register jitter is normally a gradually increasing delay or advance with corrective step in the opposite direction. This jitter has an amplitude equivalent to the CYCLE_TIME resolution of 41 ns peak-to-peak and 12 ns r.m.s.

C.2.3 Time-stamp quantization jitter

The time stamp (SYT) carrying the sampling timing information has a resolution of 1/24,576 MHz. The effect of quantization to this resolution is to add jitter to the embedded sample clock. This jitter has an amplitude equivalent to the SYT resolution of 41 ns peak-to-peak and 12 ns r.m.s. It will have frequency components related to the beat frequency between the time stamp rate (Fs/SYT_INTERVAL) and the 24,576 MHz clock incrementing the CYCLE_TIME register.

C.3 Embedded sample-clock jitter

C.3.1 Embedded sample-clock jitter spectrum

The error in the values and timing of the embedded synchronization clock can be considered as a time-varying signal. This can be examined in the frequency domain through spectrum analysis. This jitter spectrum will relate to the jitter spectrum in the sample clock transfer mechanism and the jitter transfer function.

There are discrete frequency components corresponding to the fundamental and harmonic frequencies associated with each of the applicable jitter sources described in the previous subclause. These frequencies depend on the frequency differences between the local PHY clocks on the nodes.

Any jitter source that produces a jitter signal similar to a sawtooth will have discrete jitter frequency components at the sawtooth frequency and multiples of that rate. Where the multiple is at a frequency above half the frequency that the timing information is updated, then that component will be aliased to below that rate and the signal will no longer appear as a sawtooth.

C.3.2 Embedded sample-clock jitter amplitude

C.3.2.1 General

The total amount of embedded sample-clock jitter is dependent on the following:

– the number of nodes between the cycle master and sample-clock source;
– the number of nodes between the cycle master and sample-clock destination;
– the implementation of each node;
– whether or not the sample-clock source is synchronized to the bus.

C.3.2.2 Example one: simple two-node bus

As an example, examine the simplest two-node system as shown in Figure C.1. This two-node bus has the cycle master as the sample clock source node (node 0), and the sample clock is locked to the sample clock source node PHY clock at a multiple of the cycle time rate. Asynchronous activity is low enough to ensure that the cycle start packet is never delayed.

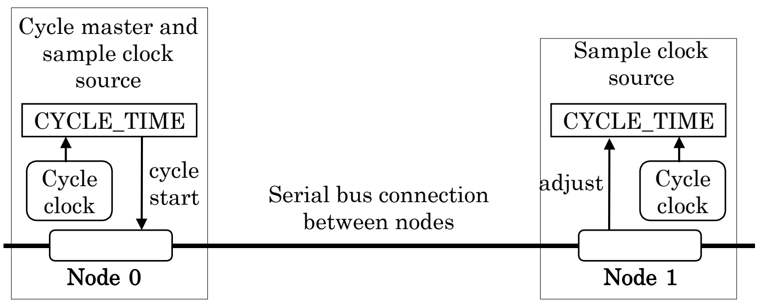

Figure C.1 – Two-node bus

The jitter analysis of this example is as follows.

– There will not be any jitter due to cycle start packet CYCLE_TIME resolution as the cycle start packet is not delayed due to asynchronous activity.
– There is no variable transport delay to cycle start packets as there are no intermediate nodes on the bus.

– Quantization of CYCLE_TIME register correction in the sample clock destination node will be a source of jitter in this example. This will be in the form of one sawtooth at a frequency determined by the offset between the cycle start rate and the sample clock destination PHY clock. This will have an amplitude of approximately 12 ns r.m.s. (41 ns peak to peak).

– As the sample clock is frequency-locked to the cycle master PHY clock, there is no time-stamp quantization jitter.

Therefore, for the simple two-node system in this example, the recovered embedded sample clock will have just one systematic jitter source. This will have a jitter amplitude of approximately 12 ns r.m.s. (41 ns peak to peak) in the form of a sawtooth at a rate determined by the frequency offset between the two PHY node clocks.

C.3.2.3 Example two: three-node bus

In this example, there are three nodes which are: the cycle master node, the sample clock source node and the sample clock destination node, see Figure C.2.

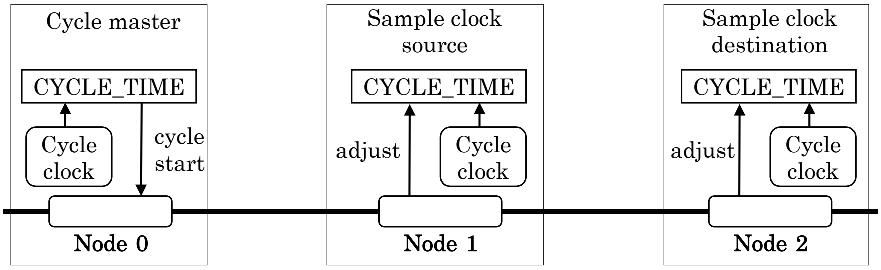

Figure C.2 – Three-node bus

The following analysis also assumes that the sample clock is not synchronous to any of the bus clocks.

– If the cycle start packet is sometimes delayed, there may be some jitter caused when the cycle start packet CYCLE_TIME value does not exactly correspond to the delay of the packet transmission. This will have a peak amplitude that is dependent on the implementation of the cycle master cycle start transmission mechanism. (The amplitude of this mechanism is not included in the analysis.)

– In the path from cycle master (node 0) to node 1 there are no intermediate nodes. In the path from cycle master (node 0) to node 2, there is one intermediate node that will have a variable transport delay to cycle start packets. This will contribute to the jitter in the CYCLE_TIME value at that node. This jitter will be in the form of a sawtooth related to the beating of node 0 and node 1 cycle clocks. The amplitude of this jitter mechanism depends on the implementation of the repeater function in this node. This analysis assumes that this repeater includes resynchronization with a 49,152 MHz clock. This will contribute jitter of approximately 6 ns r.m.s. (20 ns peak to peak).

– Quantization of CYCLE_TIME register correction in nodes 1 and 2 will be a source of jitter. In each of these nodes, this will be in the form of a sawtooth at a frequency determined by the offset between the cycle start rate and the node PHY clock. These two sources of jitter will each have an amplitude of approximately 12 ns r.m.s. (41 ns peak to peak).

– At node 1, the sample clock timing is encoded into the SYT with the resolution of the CYCLE_TIME register. The sample clock is asynchronous to the update of the CYCLE_TIME register. The error due to the variation in relative phase of the clocks is a sawtooth with a frequency determined by the difference between the node 1 cycle clock frequency and the time stamp rate. This source of jitter will have an amplitude of approximately 12 ns r.m.s. (41 ns peak to peak).

The list above illustrates that this system has four sources of periodic jitter (excluding the source of jitter related to asynchronous activity): three of 12 ns r.m.s. and one of 6 ns r.m.s. The sum total of the periodic jitter (excluding the component due to asynchronous activity) will be 21 ns r.m.s. (This would also have a peak-to-peak value of 132 ns. This value represents the infrequent coincidence of the peaks of all the contributing jitter components and would be an infrequent occurrence.)

C.3.2.4 Example: thirty-five-node system

This example illustrates a large bus configuration with 23 hops between the cycle master (node 0) and each sample clock source (node 23) and sample clock destination (node 34), see Figure C.3. (According to IEEE 1394A, this configuration represents a maximum within the constraints of a maximum PHY delay of 144 ns and maximum cable length of 4,5 m.)

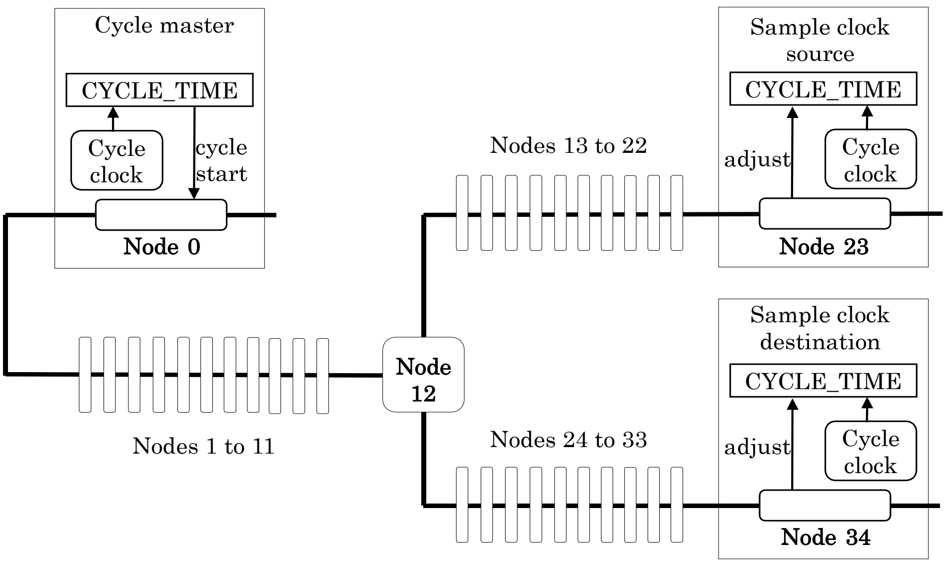

Figure C.3 – Thirty-five-node bus

The following analysis also makes similar assumptions for the 3-node example with respect to the sample clock.

– If there is asynchronous activity on the bus, then the jitter mechanism due to the cycle start packet delay is the same as for the three-node example. This is not included in the analysis.

– In the paths from the cycle master (node 0) to both the sample clock source (node 23) and sample clock destination (node 34) there are 22 intermediate nodes. Each of these will impose a variable transport delay on to cycle start packets in the same manner as the 3-node example. The peak jitter will scale in proportion to the number of hops (22) and the r.m.s. jitter will scale with the square root of that number, 4,7. If each repeater applies re-synchronization with a local 49,152 MHz clock, then they will add a total of 28 ns r.m.s. of jitter to the arrival time of the cycle start packet at the sample clock source (node 23) and at the sample clock destination (node 34).

– As with the 3-node example, quantization of CYCLE_TIME register correction at the sample clock source and destination will be a source of jitter of amplitude 12 ns r.m.s. each.

– As with the 3-node example, the time-stamp quantization jitter will add 12 ns r.m.s.

This illustrates how this system has three sources of periodic sawtooth jitter at 12 ns r.m.s. and two summed periodic components at 28 ns r.m.s. each. The sum total of the periodic jitter is 44 ns r.m.s.

This result does not represent a 'worst case'. The variable transport delay jitter at each intermediate node could be significantly greater than 20 ns while remaining compliant with IEEE 1394. The potential variable error in the CYCLE_TIME value in the cycle start packet (when the cycle start has been delayed by asynchronous activity) has also not been included.

C.4 Jitter attenuation

Jitter attenuation occurs with the filtering function of the sample-clock recovery device. This will have a low pass jitter attenuation characteristic. Sample-clock jitter causes modulation of the sampled signal. These modulation products may become audible. For high-quality applications, it is recommended that the jitter attenuation characteristic of the sample-clock recovery system satisfies the template shown in Figure C.4.

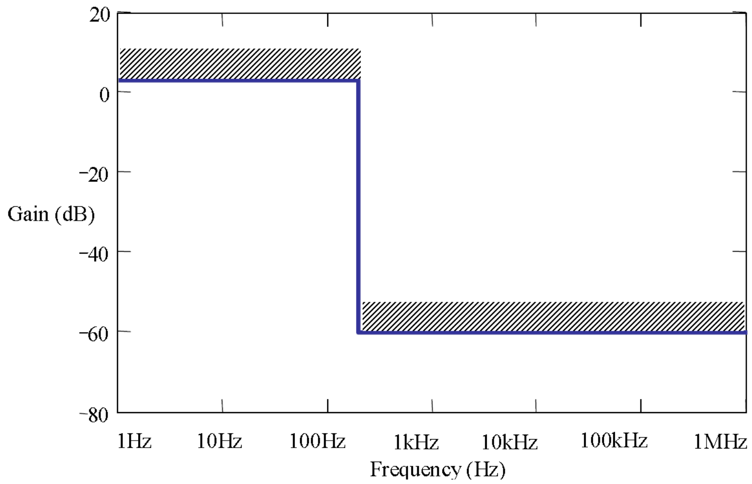

Figure C.4 – Sample-clock recovery jitter attenuation template

To satisfy this template, the jitter attenuation plotted against jitter frequency shall fall below the shaded subclauses of the graph. The attenuation shall exceed 60 dB at jitter frequencies above 200 Hz and up to half the recovered sample clock frequency. Below 200 Hz the gain shall not exceed 3 dB.

The jitter attenuation for received jitter at frequencies, f_r above half the SYT_MATCH clock rate, f_s is determined by the response to the images of the received jitter that may be present in the sampling clock. These will be present at image frequencies of:

$$f_i = N \times f_s \pm f_r$$

where N is an integer.

C.5 Jitter measurement

Jitter meters approximate the long-term average frequency and phase of a signal that they are measuring. This will result in a high-pass characteristic. As the sample clocks derived using the A/M protocol have a strong low-frequency jitter component, the low-frequency corner frequency of the jitter meter is important.

It is recommended that jitter measurements use the characteristics defined by the jitter measurement filter characteristic of Figure C.5.

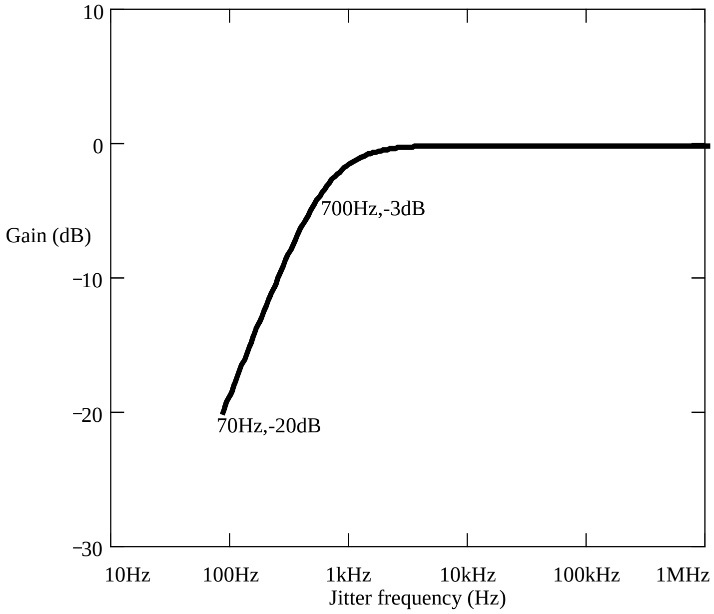

Figure C.5 – Sample clock jitter measurement filter characteristic

This is a minimum-phase high pass filter with a –3 dB frequency of 700 Hz, a first order roll-off to 70 Hz and with a pass-band gain of unity.

NOTE This is compatible with the intrinsic jitter measurement filter characteristic used in IEC 60958-3 and IEC 60958-4.

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

3, rue de Varembé
PO Box 131
CH-1211 Geneva 20
Switzerland

Tel: + 41 22 919 02 11
Fax: + 41 22 919 03 00
info@iec.ch
www.iec.ch