IEC-PAS 61883-6

Edition 1.0
1998-05

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

PUBLICLY AVAILABLE SPECIFICATION

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

1394 TRADE ASSOCIATION
THE MULTIMEDIA CONNECTION

Reference number
IEC/PAS 61883-6

Audio and Music Data Transmission Protocol

Version 1.0
May 1997

Sponsored by:
Audio/Video Working Group of the 1394 Trade Association

Approved for Release by:
1394 Trade Association Steering Committee

Abstract: This specification defines a protocol for the transmission of audio and music data over IEEE Std. 1394-1995. Currently this includes the transport of IEC 60958 digital format, raw audio samples, and MIDI data.

1394 Trade Association
3925 W. Braker Lane, Austin, TX 78759 USA
http://www.1394TA.org

INTERNATIONAL ELECTROTECHNICAL COMMISSION

CONSUMER AUDIO/VIDEO EQUIPMENT — DIGITAL INTERFACE —

Part 6: Audio and music data transmission protocol

FOREWORD

A PAS is a technical specification not fulfilling the requirements for a standard, but made available to the public and established in an organization operating under given procedures.

IEC-PAS 61883-6 was submitted by the 1394 Trade Association and has been processed by subcommittee 100C: Audio, video and multimedia subsystems and equipment, of IEC technical committee 100: Audio, video and multimedia systems and equipment.

The text of this PAS is based on the following document:	This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document:
Draft PAS	**Report on voting**
100C/209/PAS	100C/222/RVD

Following publication of this PAS, the technical committee or subcommittee concerned will investigate the possibility of transforming the PAS into an International Standard.

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of the IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.
3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical reports or guides and they are accepted by the National Committees in that sense.
4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.
5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.
6) Attention is drawn to the possibility that some of the elements of this PAS may be the subject of patent rights. The IEC shall not be held responsible for identifying any or all such patent rights.

COPYRIGHT/USER NOTICE

Editor, 1394 Trade Association
1394 Trade Association
221 West Sixth Street
Suite 1520
Austin, TX 78701, USA

Or contact the Editor via TAAdmin@1394ta.org

1394 Trade Association Specifications are developed within Working Groups of the 1394 Trade Association, a non-profit industry association devoted to the promotion of and growth of the market for IEEE 1394-compliant products. Participants in working groups serve voluntarily and without compensation from the Trade Association. Most participants represent member organizations of the 1394 Trade Association. The specifications developed within the working groups represent a consensus of the expertise represented by the participants.

Use of a 1394 Trade Association Specification is wholly voluntary. The existence of a 1394 Trade Association Specification is not meant to imply that there are not other ways to produce, test, measure, purchase, market or provide other goods and services related to the scope of the 1394 Trade Association Specification. Furthermore, the viewpoint expressed at the time a specification is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the specification. Users are cautioned to check to determine that they have the latest revision of any 1394 Trade Association Specification.

Comments for revision of 1394 Trade Association Specifications are welcome from any interested party, regardless of membership affiliation with the 1394 Trade Association. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments.

Interpretations: Occasionally, questions may arise about the meaning of specifications in relationship to specific applications. When the need for interpretations is brought to the attention of the 1394 Trade Association, the Association will initiate action to prepare appropriate responses.

Comments on specifications and requests for interpretations should be addressed to:

Editor, 1394 Trade Association
3925 W. Braker Lane
Austin, TX 78759
USA

Table of Contents

Introduction

Scope of the Audio and Music Data Transmission Protocol

This document defines the audio and music data transmission protocol as an instance of a real-time data transmission protocol standardized in IEC 61883-1. The audio and music data transmission protocol (hereafter referred to as the A/M protocol) can be applied to all modules or devices which have any kind of audio and/or music data processing, generation and conversion function blocks.

This specification 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 specification according to each application area.

All modules or devices which implement this A/M protocol should have the capability of "arbitrated short bus reset" defined in IEEE P1394a in order to prevent the interruption of audio and music data transmission when a bus reset occurs.

References

This document assumes that the reader is familiar with the content of the reference material noted here; it does not attempt to provide introductory or background information which can be found elsewhere. For a complete understanding of the Audio and Music Data Transmission Protocol, the following documents will be helpful:

IEEE 1394 — 1995, Standard for a High Performance Serial Bus

ISO/IEC 13213 — 1994, Control and Status Register (CSR) Architecture for Microcomputer Buses

IEC 61883-1 Digital Interface for consumer electronics audio/video equipment - Part 1: General

IEC 60958 Digital audio interface

MIDI 1.0 Detailed Specification, Version 4.1 January 1989

IEEE 754 — 1985, Standard for Binary Floating-Point Arithmetic

Definitions and Abbreviations

Abbreviations and Acronyms

A/M Protocol Audio and Music Data Transmission Protocol

MIDI Musical Instrument Digital Interface - a standard for the interconnection of digital music processing devices (e.g. keyboards, signal processors) and computers together.

Technical glossary

stream Uni-directional data transmission.

time stamp Quantized timing in which an event occurs based on a reference clock. The reference clock is CYCLE_TIME unless specified in this document.

music data Data generally used for controlling a tone generator. The data defined in the MIDI specification, which may be called MIDI data, is an example of music data.

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

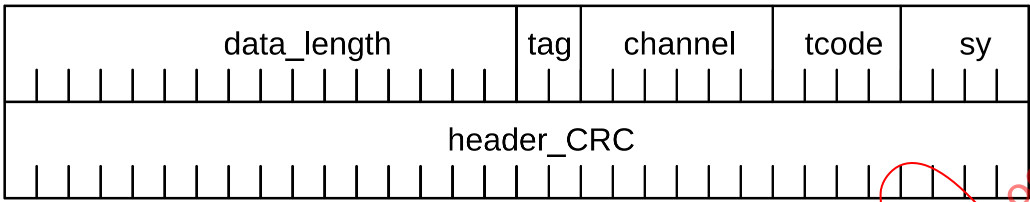
Bit, Byte and Quadlet Ordering

This document defines the ordering of bits, bytes and quadlets for bus packets according to the IEEE 1394-1995 standard.

Packet Header for Audio and Music Data

Isochronous Packet Header Format

The header for an isochronous packet which conforms to the Audio and Music Data transmission protocol shall have the following format:



The following table defines the fields with unique values that are specified by this protocol:

field	value	comments
tag	01 b	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	0_{16}	This field is reserved. The transmitter shall set this field to 0_{16}.

CIP Header Format

The CIP header format for an isochronous packet which conforms to the Audio and Music Data transmission protocol shall be as follows:

The following table defines the fields with unique values that are specified by this protocol:

field	value	comments
FMT	10_{16}	This value indicates that the format is for Audio and Music Data.
FN	0_{16}	
QPC	0_{16}	
SPH	0_{16}	
SYT	xx	This field shall contain the time when the specified event is to be presented at a receiver.
FDF	see note*	see note*

NOTE: * There are currently no special bit or bit field definitions for the FDF field. This was done intentionally to leave room for new subformats to be defined in the future.

When defined, each subformat must allocate a range of FDF space and define its usage. In addition, it must specify the packetization attributes of EVENT TYPE and DBS, which are described in the section titled Event Type which begins on page 11.

Note: Other optional attributes may be defined in each subformat.

Packetization

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 behavior 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:

1) In order to minimize TRANSFER_DELAY, the condition of a non-empty CIP being ready for transmission is defined to be true if more than one event has arrived within a *nominal isochronous cycle*. This transmission method is called **Non-Blocking** transmission, and is described in detail in the section titled Transmission Control on page 8.

2) The condition of "non-empty CIP ready" can also be defined as true when a fixed number of events has arrived. This transmission method is called **Blocking** transmission, and is described in Appendix A.

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 events, it is necessary to specify which event of the CIP corresponds to the time stamp.

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

mod(data block count, SYT_INTERVAL) = 0

Where SYT_INTERVAL denotes the number of events between two successive valid SYTs, which includes one of the events with a valid SYT. For example, if there are three events between two valid SYT's, 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:

index = mod((SYT_INTERVAL - mod(DBC, SYT_INTERVAL)), SYT_INTERVAL)

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

Time Stamp Processing

The transmitter must specify the presentation time of the event at the receiver. A receiver for professional use must 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, then the SYT of the outgoing CIP shall be the sum of the incoming SYT and the processing delay.

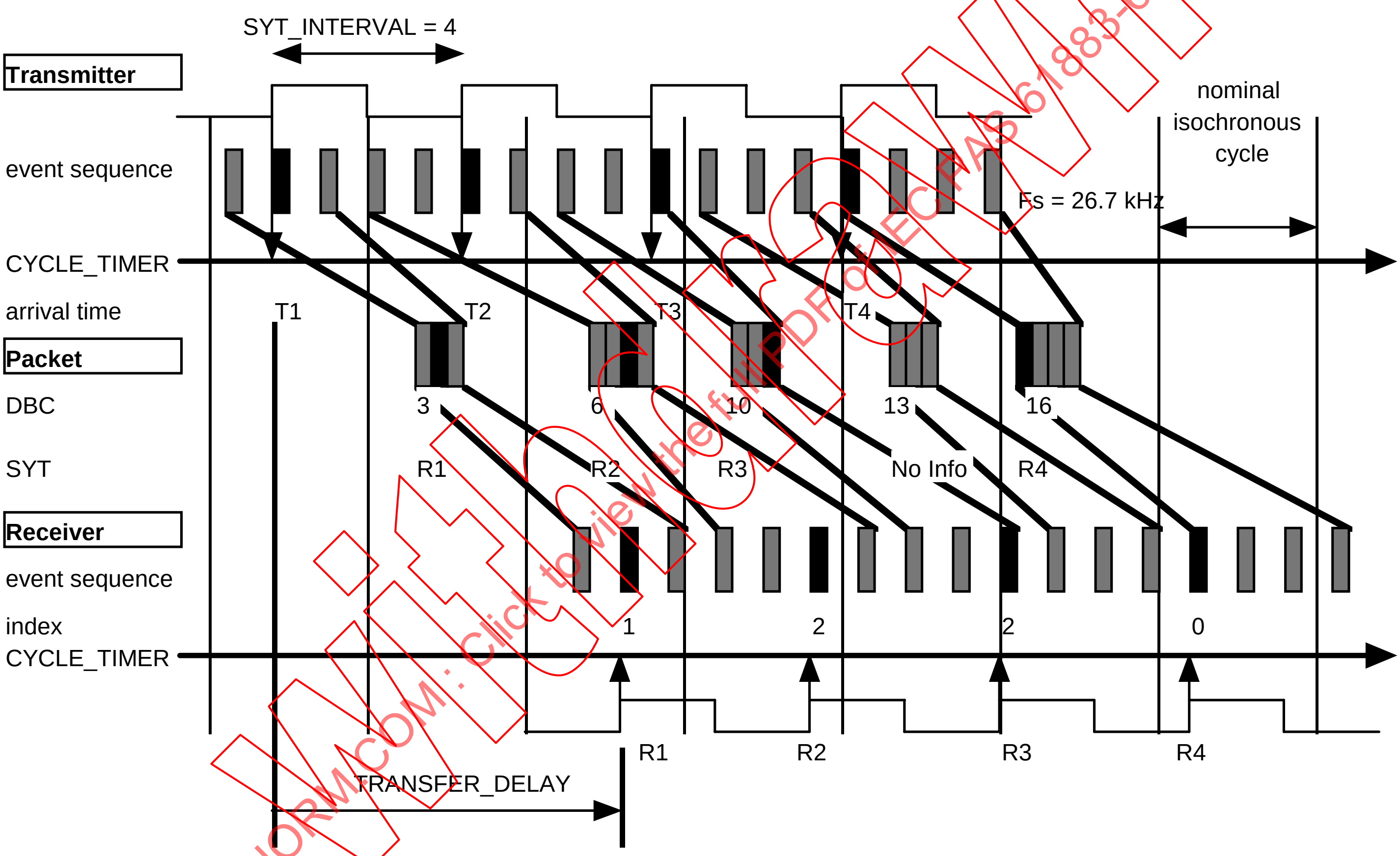
The transmitter shall add TRANSFER_DELAY to the quantized timing of an event to construct the SYT. The TRANSER_DELAY value is initialized with the DEFAULT_TRANSFER_DELAY value. For professional use, TRANSFER_DELAY may be changed to achieve a shorter TRANSFER_DELAY value, according to the bus configuration.

Products for consumer use are not required to support the modification of TRANSFER_DELAY.

The DEFAULT_TRANSFER_DELAY value is 352 µs, which is the maximum latency time of CIP transmission caused by an arbitrated short bus reset and the insertion of a packet from another isochronous channel transmission.

Transmission Control

The following diagram illustrates the Non-Blocking transmission method:



The transmitter shall construct a packet in every nominal isochronous cycle (125 µs) which consists of the events in the input buffer which meet the following conditions:

Condition 1:

if Event_arrival_time[N-1] - Event_arrival_time[0] <= 125 µs

then Event_arrival_time[I] - Event_arrival_time[0] < 125 µs

(0 <= I < N-1)

Condition 2:

if Event_arrival_time[N-1] - Event_arrival_time[0] > 125 µs

then Event_arrival_time[I] - Event_arrival_time[0] < Max_BW µs

(0 <= I < N-1)

where

Event_arrival_time[M] is the time (measured in µs) of the event at index M of the input buffer which contains N events. The first event of the input buffer has the index number 0.

Max_BW is the maximum bandwidth which can be used for event transmission, expressed in µs.

For example, if the event sequence to be transmitted has Fs (measured in kHz) of maximum sampling frequency, Max_BW (measured in µs) is given by:

125µs < Max_BW <= 1/Fs * 1000 * SYT_INTERVAL

Extra bandwidth, Max_BW - 125 µs, contributes to catching up on transmission delay caused by a cycle start packet drop after a bus reset. If the cycle master can keep transmitting cycle start packets, the extra bandwidth may be removed to get Max_BW = 125 µs.

The transmitter shall transmit a packet which meets the following conditions:

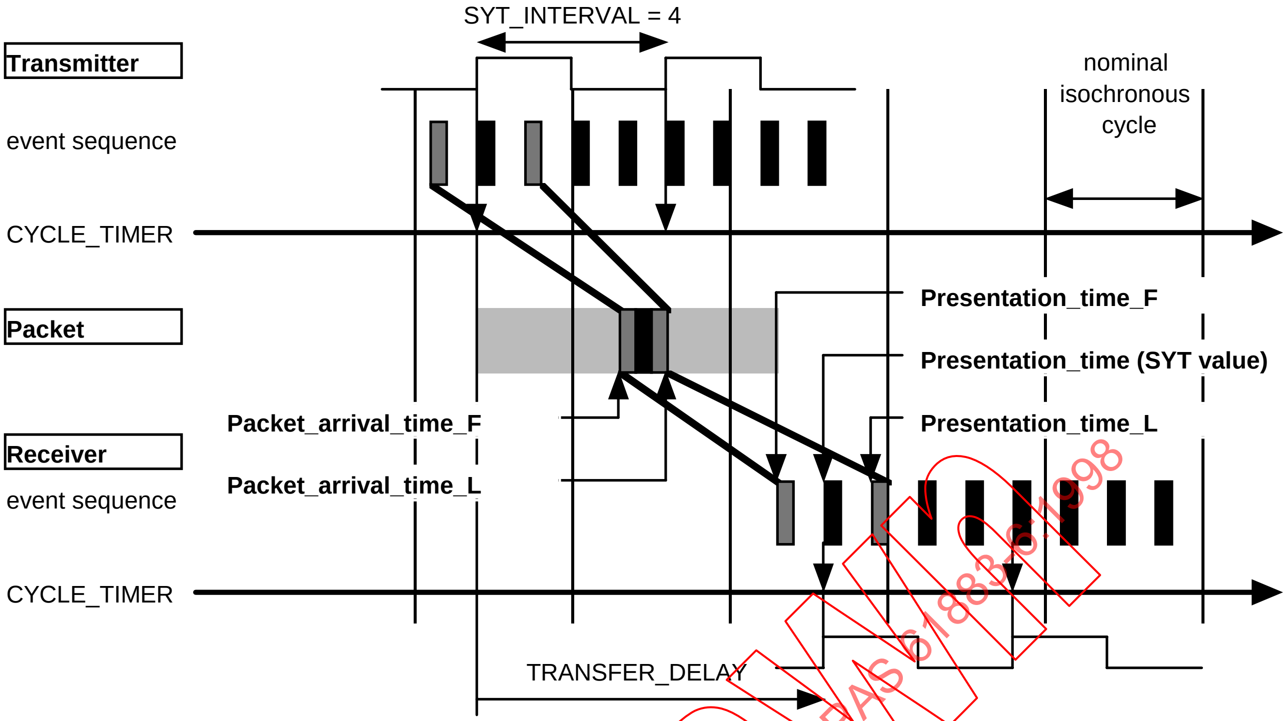
Packet_arrival_time_L <= Presentation_time_F

Presentation_time_L - TRANSFER_DELAY <= Packet_arrival_time_F

where

Packet_arrival_time_F	The cycle time when the first bit of the packet arrived at the receiver
Packet_arrival_time_L	The cycle time when the last bit of the packet arrived at the receiver
Presentation_time_F	The cycle time when the first data block of the packet is presented at the receiver
Presentation_time_L	The cycle time when the last data block of the packet is presented at the receiver

The following diagram illustrates the transmission control rules as described in this section:



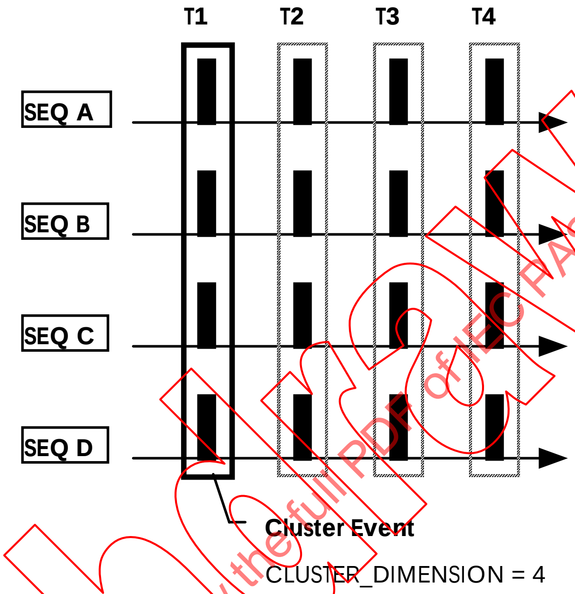
SYT_INTERVAL = 4
Transmitter
event sequence
CYCLE_TIMER
Packet
Receiver
event sequence
CYCLE_TIMER
nominal
isochronous
cycle
Presentation_time_F
Presentation_time (SYT value)
Presentation_time_L
Packet_arrival_time_F
Packet_arrival_time_L
TRANSFER_DELAY

Event Types

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

If multiple event sequences are synchronized, it is possible to convert the sequences into a single sequence which consists of an ordered collection of those events which occurred at the same time.

The ordered collection is called a *cluster*. The number of sequences clustered together is called the *dimension*, and is denoted by CLUSTER_DIMENSION. The following diagram illustrates these concepts:



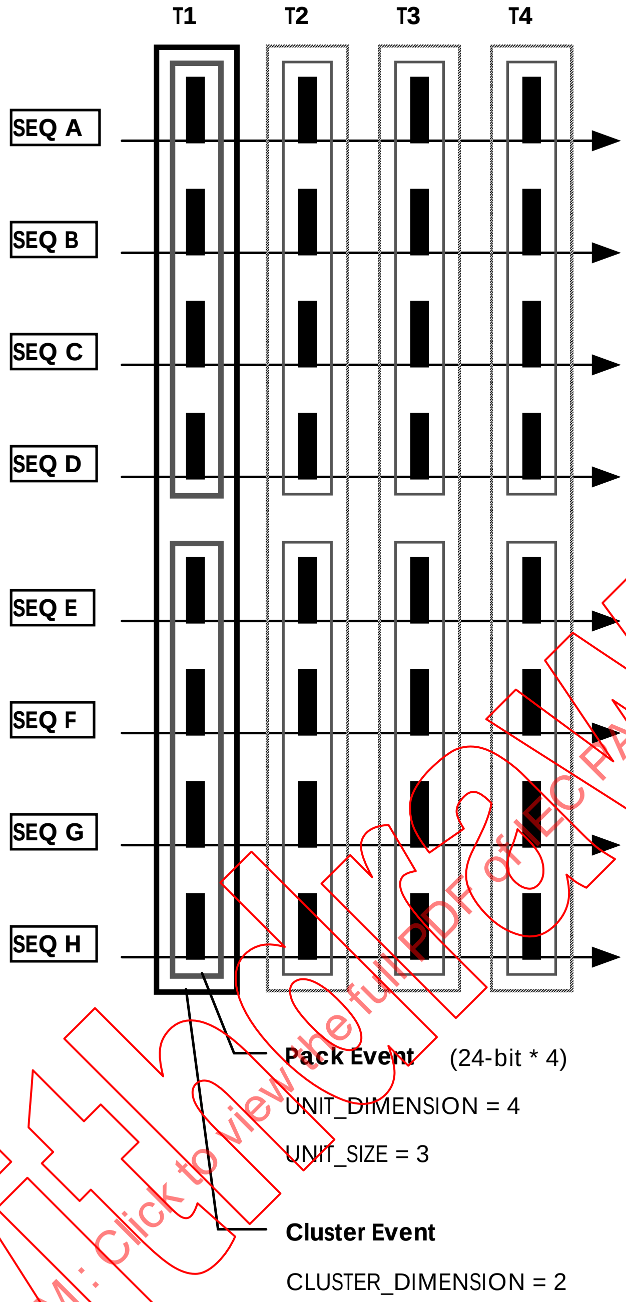
In order to efficiently cluster non-32-bit aligned events which occur at the same time, the *pack* event type is defined. For example, four events of 24-bit data can be collected into a pack of three quadlets.

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

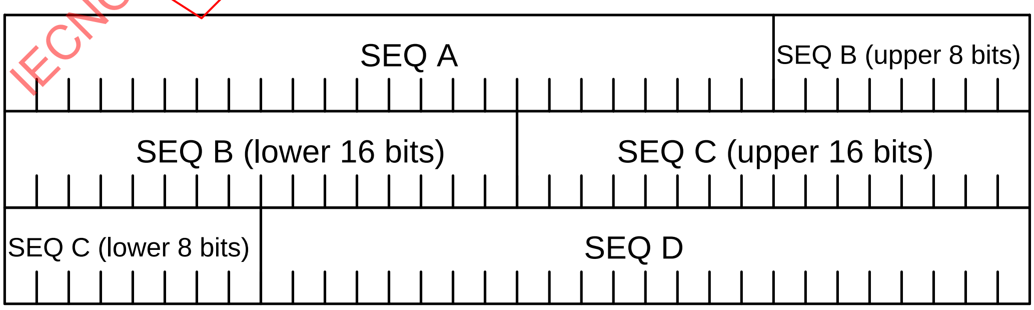
Only the pack and data types can be combined into units to make a cluster. All events in a cluster shall be of the same type.

These units must define UNIT_DIMENSION and UNIT_SIZE, which denotes the number of packed sequences and the number of quadlets, respectively. Obviously, the UNIT_DIMENSION of data is always 1.

The following diagram illustrates pack and cluster events:



The following diagram illustrates the structure of a pack which consists of four 24-bit event sequences (UNIT_DIMENSION = 4, UNIT_SIZE = 3):



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

DBS = CLUSTER_DIMENSION * UNIT_SIZE

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

number of sequences = DBS * UNIT_DIMENSION / UNIT_SIZE

For the pack illustrated above, 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:

NEVENTS_SUCCESSIVE = (data_length / 4 - CIPH_SIZE) / DBS

where

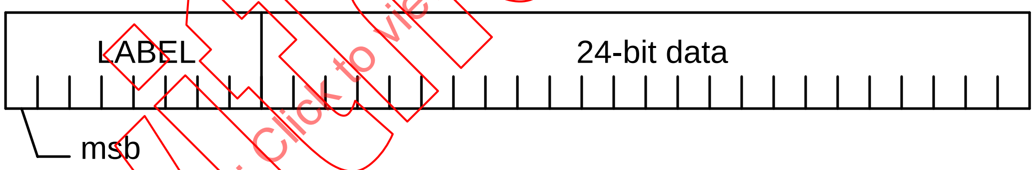
data_length	Size of the payload of an isochronous packet (in bytes)
CIPH_SIZE	Size of the CIP header (in quadlets)

AM824 Data

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

Generic Format

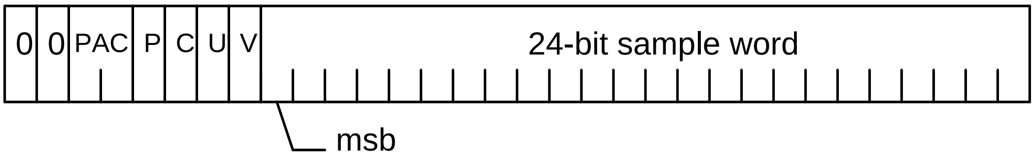
UNIT_SIZE = 1
UNIT_DIMENSION = 1



LABEL definition	
Value	Description
00_{16} - $3F_{16}$	IEC 60958 Conformant
40_{16} - 43_{16}	Raw Audio
44_{16} - $7F_{16}$	Reserved
80_{16} - 83_{16}	MIDI Conformant
84_{16} - FF_{16}	Reserved

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

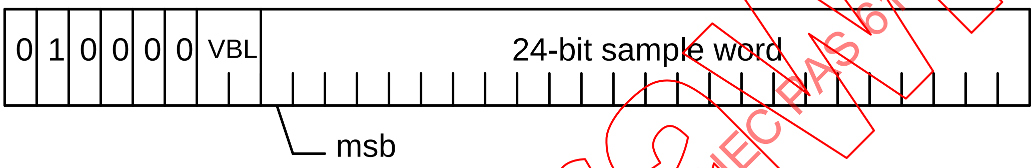
IEC 60958 Conformant Data



PAC (Preamble Code) definition	
Value (binary)	Description
11	'B'
01	'M'
00	'W'

All information defined in the IEC 60958 standard is mapped into this data format. Applications which use this data type shall follow the IEC 60958 standard.

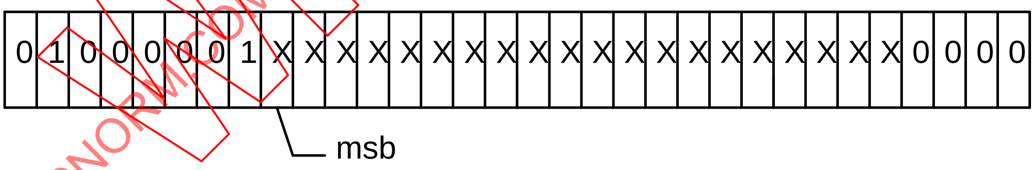
Raw Audio Data



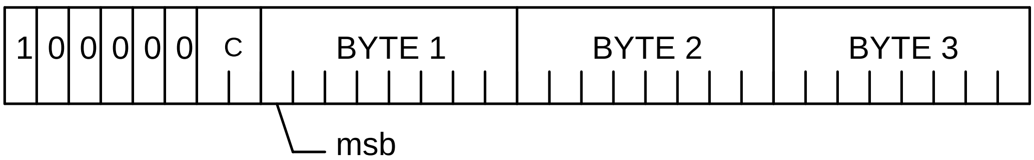
VBL (Valid Bit Length Code) definition	
Value (binary)	Description
00	24 bits
01	20 bits
10	16 bits
11	Reserved

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

For example, a 20-bit audio data shall be placed in a 24-bit field as follows (note the four zero pad bits at the end of the structure):



MIDI Conformant Data

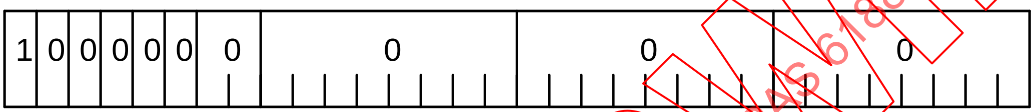


C (Counter) definition	
Value (decimal)	Description
0	BYTE1 = BYTE2 = BYTE3 = 0 Others No Data Reserved
1	Byte 1 is valid
2	Bytes 1 and 2 are valid
3	Bytes 1, 2 and 3 are valid

If the CIP carries only MIDI Conformant data or cluster, and there is no MIDI data to be packed into a CIP, then 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".

The following diagram illustrates the “No Data” structure:

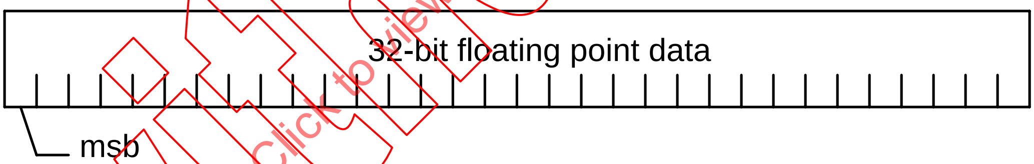


The receiver must check the continuity of DBC.

32-bit Floating Point Data

UNIT_SIZE = 1
UNIT_DIMENSION = 1

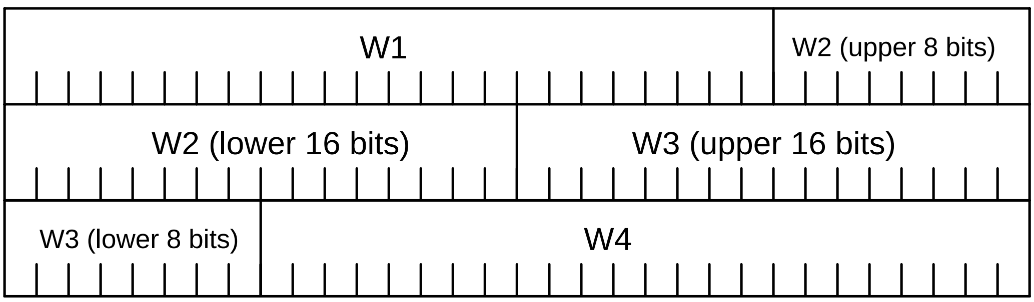
The following diagram illustrates the structure of 32-bit floating point data:



24-bit * 4 Audio Pack

UNIT_SIZE = 3
UNIT_DIMENSION = 4

The following diagram illustrates the structure of a 24-bit * 4 audio pack:



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

The audio data must be expressed in 24-bit 2's complement. In case of less than 24 bits, the correct number of zero bits must be padded below the least significant bit to make it a 24-bit data structure. For an example of this, please refer to the description of Raw Audio Data as defined above.

Subformat

The following table defines the subformat and FDF allocations:

FDF definition	
Value (binary)	Description
0000 0xxx	Basic format for AM824
0000 1xxx	Reserved
0001 0xxx	Basic format for 24-bit * 4 Audio Pack
0001 1xxx	Reserved
0010 0xxx	Basic format for 32-bit Floating-Point Data
0010 1xxx	Reserved
0011 0xxx	Reserved for basic format
0011 1xxx	Reserved
0100 0000	Reserved
...	...
1111 1110	Reserved
1111 1111	Packet for NO-DATA

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

Basic Format

DBS for AM824 Data and 32-bit Floating-Point Data	
Value (decimal)	Description
0	CLUSTER_DIMENSION = 256
1 - 255	CLUSTER_DIMENSION = DBS

DBS for 24-bit * 4 Audio Pack	
Value (decimal)	Description
3 - 255	CLUSTER_DIMENSION = DBS/3

The following diagram illustrates a generic FDF definition:

0	0	EVT	0	SFC

EVT (Event Type) code definition	
Value (decimal)	Description
0	AM824 Data
1	24-bit * 4 Audio Pack
2	32-bit Floating-Point Data
3	Reserved for 32-bit or 64-bit data

SFC (Nominal Sampling Frequency Code) definition	
Value (decimal)	Description
0	32kHz SYT_INTERVAL = 8
1	44.1kHz SYT_INTERVAL = 8
2	48kHz SYT_INTERVAL = 8
3	Reserved
4	96kHz SYT_INTERVAL = 16
5-7	Reserved

If a transmitter has variable sampling frequency capability, the nominal sampling frequency code indicates the center frequency.

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

The required isochronous bandwidth depends on whether the sampling clock is synchronous or asynchronous to the nominal isochronous cycle:

1) Sampling clock is asynchronous to the nominal isochronous cycle

BW[quadlet/sec] = (INT(Max(Fs[Hz]) / 8000[Hz]) + 1) * UNIT_SIZE * CLUSTER_DIMENSION * 8000[Hz]

2) Sampling clock is synchronous to the nominal isochronous cycle

BW[quadlet/sec] = Fs[Hz] * UNIT_SIZE * CLUSTER_DIMENSION

(Fs is an integer multiple of 8000)

Special Format

1	1	1	1	1	1	1	1

The transmitter must use this FDF code when a packet is a NO-DATA packet only for blocking transmission.

The transmitter must not use this FDF code for non-blocking transmission.

The receiver must ignore all the data in a CIP with this FDF code.