

STANDARDS AND INFORMATION DOCUMENTS

AES50-2011
(stabilized 2017)



AES standard for digital audio engineering — High-resolution multi-channel audio interconnection (HRMAI)

Users of this standard are encouraged to determine if they are using the latest printing incorporating all current amendments and editorial corrections. Information on the latest status, edition, and printing of a standard can be found at:
<http://www.aes.org/standards>

AUDIO ENGINEERING SOCIETY, INC.
551 Fifth Avenue, New York, NY 10176, US. www.aes.org/standards



The AES Standards Committee is the organization responsible for the standards program of the Audio Engineering Society. It publishes technical standards, information documents and technical reports. Working groups and task groups with a fully international membership are engaged in writing standards covering fields that include topics of specific relevance to professional audio. Membership of any AES standards working group is open to all individuals who are materially and directly affected by the documents that may be issued under the scope of that working group. Complete information, including working group scopes and project status is available at <http://www.aes.org/standards>. Enquiries may be addressed to standards@aes.org

A standards document may be considered for "stabilized" status if it has continuing value but there is no requirement or available expertise to revise it. Any person may, at any time, propose a revision of any stabilized standard, subject to the same criteria and procedures as for new project initiations. If accepted, the project shall be assigned to the appropriate subcommittee and working group for development in the same way as for any other project. See AESSC Rules, clause 17.

The AES Standards Committee is supported in part by those listed below who, as Standards Sustainers, make significant financial contribution to its operation.



audio-technica



This list is current as of 2017/7/25

AES standard for digital audio engineering - High-resolution multi-channel audio interconnection (HRMAI)

Published by
Audio Engineering Society, Inc.
Copyright ©2011 by the Audio Engineering Society

Abstract

HRMAI provides a professional multi-channel audio interconnection with a number of distinctive characteristics:

- Support for a wide range of commonly-used digital audio coding formats
- Low and deterministic latency
- Use of ubiquitous “Category-5” data cable
- Interconnect span up to 100 m
- High-quality full-duplex clocks transmitted in parallel with audio data
- Full-duplex audio interconnection
- 5 Mbit/sec full-duplex auxiliary data connection, compatible with Ethernet networks.

HRMAI is a high-performance point-to-point audio interconnection rather than a network, although the auxiliary data may operate as a true network, independently of the audio.

An AES standard implies a consensus of those directly and materially affected by its scope and provisions and is intended as a guide to aid the manufacturer, the consumer, and the general public. The existence of an AES standard does not in any respect preclude anyone, whether or not he or she has approved the document, from manufacturing, marketing, purchasing, or using products, processes, or procedures not in agreement with the standard. Prior to approval, all parties were provided opportunities to comment or object to any provision. Attention is drawn to the possibility that some of the elements of this AES standard or information document may be the subject of patent rights. AES shall not be held responsible for identifying any or all such patents. Approval does not assume any liability to any patent owner, nor does it assume any obligation whatever to parties adopting the standards document. This document is subject to periodic review and users are cautioned to obtain the latest edition. Recipients of this document are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

Contents

Contents	2
Introduction	5
0 Preamble	6
0.1 Patents	6
0.2 Documentation conventions	6
1 Scope	6
2 Normative references	6
3 Definitions and abbreviations	8
4 Physical Interface	10
4.1 Physical medium	10
4.2 Medium dependent interface (MDI)	10
4.3 Visible link status indicators	10
4.4 Audio data physical layer	11
4.5 Synchronization signal physical layer	11
4.6 Synchronisation signal automatic crossover configuration	13
5 Audio data frame format	15
5.1 Overview	15
5.2 Frame structure (MAC compatibility)	16
5.3 Frame structure (protocol identification headers)	16
5.4 User octet	16
5.5 Frame format identifier header	17
5.6 Frame format identifier error control	18
5.7 Receiver behaviour on processing frame format identifier	18
5.8 Frame data payload	19
6 Frame payload format	19
6.1 Overview	19
6.2 Logical channels	20
6.3 PCM sample subframe formatting	21
6.4 Audio channel multiplexing	22
6.5 LC sub-segment packing	23
6.6 Forward error correction (FEC) encoding	23
6.7 Encoded block interleaving	25
7 Frame payload: receiver behaviour	25
7.1 General	25
7.2 Forward error correction (FEC) decoding	25
7.3 Receiver error records	26
7.4 Receiver behaviour on detection of corrected error	26
7.5 Receiver behaviour on detection of uncorrected error	26
8 Auxiliary data system	27
8.1 Auxiliary data bit-stream	27
8.2 Auxiliary data packets	27
8.3 Auxiliary data packet scrambling	27
8.4 Auxiliary data packet structure example	28

9 Synchronisation, link initialization and latency control 29

9.1 Synchronisation signal phase indicators.....29

9.2 Clock synchronisation – system behaviour 30

9.3 f_s initialization mode.....31

9.4 $2048 \cdot f_s$ initialization mode 32

Annex A (Normative) Frame format identifier: Field definitions 33

Annex B (Informative) AES3-mode metadata: M-bit encoding 35

B1 Examples 35

B2 Validity bit sub-sampling implications 35

Annex C (Normative) Audio channel multiplexing definitions.....36

Annex D (Normative) Link latency.....39

Annex E (Informative) Informative references.....40

Annex F (Normative) AES EtherType and protocol identifier 41

Foreword

This foreword is not part of AES50, *AES standard for digital audio engineering - High-resolution multi-channel audio interconnection (HRMAI)*.

This document was developed under project AES-X140: High-resolution multi-channel audio interconnection (HRMAI). It was developed by task group SC-02-02-H from an initial draft by M Page.

The members of the task group were: P. Eastty, C. Gaunt, J. Grant, S. Harris, J. McTigue, M. Page, S. Scott, T. Thompson, and M. Yonge.

J Grant
Chair, SC-02-02 Working Group on Digital Input/Output Interfacing
2005-03

Foreword to the second edition, 2011

This new edition revises AES50-2005 and contains amendments resulting from a real-world implementation of the standard.

J Grant
Chair, SC-02-02 Working Group on Digital Input/Output Interfacing
2011-05-04

Note on normative language

In AES standards documents, sentences containing the word “shall” are requirements for compliance with the document. Sentences containing the verb “should” are strong suggestions (recommendations). Sentences giving permission use the verb “may”. Sentences expressing a possibility use the verb “can”.

AES standard for digital audio engineering - High-resolution multi-channel audio interconnection (HRMAI)

Introduction

HRMAI provides a professional multi-channel audio interconnection with a number of distinctive characteristics:

- Support for a wide range of commonly-used digital audio coding formats, including “high-resolution” formats such as high sample-rate linear PCM, and one-bit delta-sigma modulated formats.
- Low and deterministic latency ($< 100 \mu\text{s}$)
- Use of ubiquitous “Category-5” data cable
- Interconnect span up to 100 m
- High-quality full-duplex clocks transmitted in parallel with audio data
- Full-duplex audio interconnection
- 5 Mbit/sec full-duplex auxiliary data connection, compatible with Ethernet networks.

HRMAI is a high-performance point-to-point audio interconnection, rather than a network (although the auxiliary data may operate as a true network, independently of the audio). It is thus an alternative to AES10 (MADI). AES10 lacks many of the features listed above, which are enabled by developments in underlying technology in the thirteen years since AES10 was introduced. However, for applications which do not need these additional facilities, AES10 will continue to be appropriate.

It is recommended that this standard be read in conjunction with the accompanying AESSC Technical Report, AES-R6, *Guidelines for AES standard for digital audio engineering - High-resolution multi-channel audio interconnection (HRMAI), AES50*. This provides additional background, rationale and implementation advice. In particular, the first section of AES-R6 is an overview of the technology, providing context which may aid understanding of the normative clauses of this standard.

0 Preamble

0.1 Patents

The Audio Engineering Society draws attention to the fact that it is claimed that compliance with this AES standard or information document may involve the use of patents owned by Midas Klark Teknik Ltd..

The AES holds no position concerning the evidence, validity and scope of these patent rights.

The holder of these patent rights has assured the AES that it is willing to negotiate licenses under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holder of this patent right is archived with the AES.

Information may be obtained from:

MUSIC Group IP, Ltd.
Trident Chambers Wickhams Cay
PO. Box 146
Road Town
Tortola
British Virgin Islands

Attention is drawn to the possibility that some of the elements of this AES standard or information document may be the subject of patent rights other than those identified above. AES shall not be held responsible for identifying any or all such patent rights.

0.2 Documentation conventions

Following ISO convention, decimal points are conventionally shown as commas (,).

Non-decimal numbers are shown by a subscript suffix indicating the number base. For example, 10_{16} is a hexadecimal number.

To identify the bits within an octet, 0 = LSB, 7 = MSB

1 Scope

This document specifies a means to carry multiple channels of digital audio in AES3 or bit-stream formats, plus system synchronisation information, over a structured data cable using the IEEE Std 802.3 physical layer. It includes a means to convey arbitrary packet-based data over the link, in addition to the specified audio interconnection.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

AES3-2009 *AES recommended practice for digital audio engineering – Serial transmission format for two-channel linearly represented digital audio data, Parts 1 to 4.* Audio Engineering Society, New York, NY., US.

ISO/IEC 8802-3: 2000 *Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications.* International Organisation for Standardisation, Geneva, Switzerland.

Note: adopted by ISO/IEC from: IEEE Std 802.3, 2000 edition, *Carrier sense multiple access with collision detection (CSMA/CD) access method and physical layer specifications*. New York, NY, US: Institution of Electrical and Electronics Engineers. At time of writing, the most recent version of this specification (if more than six months old) is available for free download from the IEEE website under their "Get IEEE802" programme: <http://standards.ieee.org/getieee802/>

ANSI X3.263-1995 *Fibre Distributed Data Interface (FDDI) – Token Ring Twisted Pair Physical Layer Medium Dependent (TP-PMD)* American National Standards Institute, New York, NY, US.

IEEE Std 802.1Q-2003 *IEEE Standards for Local and Metropolitan Area Networks: Virtual Bridged Local Area Networks*. Institution of Electrical and Electronics Engineers, New York, NY, US.

TIA/EIA-568-B.2 (2003) *Commercial building telecommunications cabling standards, Part 2: Balanced twisted-pair cabling components* Telecommunications Industry Association, Arlington, VA, US.

3 Definitions and abbreviations

3.1 AES3-mode audio stream

digital audio stream conveying AES3-compatible digital audio

3.2 audio base sample rate

f_s

either 44,1 kHz or 48 kHz sampling frequencies

3.3 audio channel

path that carries one monophonic digital audio signal

3.4 auxiliary data

arbitrary data conveyed across the HRMAI physical link, in addition to and independently of the specified audio interconnection

3.5 audio format

set of parameters uniquely identifying a particular method of digital audio sampling and encoding

3.6 audio stream synchronisation marker

marker associated with a specific audio sample, embedded in the audio stream dependent on a synchronisation signal phase indicator

3.7 auxiliary data packet

unit of data structured as a frame, but for transfer on auxiliary data channel, multiplexed within an audio frame

3.8 bit-stream-mode audio stream

digital audio stream conveying non-AES3-compatible digital audio

Note: example of bit-stream-mode audio stream is single-bit, oversampled, delta-sigma-modulated audio

3.9 encoded block

32-bit data unit comprising an LC slice plus six parity bits

3.10 EtherType

value defined in IEEE 802.3, “Length/Type” field, and registered with the IEEE Registration Authority

3.11 frame

unit of data structured to facilitate transfer via the IEEE802.3 100Base-X Physical Coding Sublayer (ISO/IEC 8802-3: 2000(E) clause 24)

3.12 frame format identifier

six-octet data set identifying the type and format of the payload section of a frame

3.13 frame payload

portion of an HRMAI frame containing multiplexed audio and auxiliary data

3.14 logical channel

LC

independent serial data path across the HRMAI link, of consistent bit-rate regardless of audio format, on which audio or auxiliary data may be conveyed.

3.15 LC frame segment

352-bit contiguous segment of an LC, conveyed entirely in a single frame

3.16 LC slice

26-bit data unit, comprising concurrent bits, one from each LC

3.17 LC sub-segment

27-bit segment of an LC frame segment, containing sample subframe data

3.18 M-bit

metadata bit contained in each sample subframe, encoded to represent synchronisation and validity information associated with that audio stream

3.19 media access controller**MAC**

data link protocol and associated frame structure according to IEEE802.3 (ISO/IEC 8802-3: 2000(E), clauses 2, 3, 4)

3.20 medium dependent interface**MDI**

The mechanical and electrical interface between the transmission medium and the HRMAI node.

3.21 media independent interface**MII**

Standard interface to IEEE802.3 physical layer device (ISO/IEC 8802-3: 2000(E) clause 22)

3.22 node

A single instance of an HRMAI transceiver, associated with a single active MDI instance.

3.23 sample subframe

27-bit data unit containing multi-bit data for a single digital audio sample, plus associated metadata

3.24 synchronisation signal**sync signal**

clock signal transferred in parallel with the data link, typically on signal pairs in the interconnection cable not used for data transfer, for purposes of system synchronisation

3.25 synchronisation signal phase indicator

indicator embedded in the synchronisation signal every 2048 word clock periods, indicating word clock phase

3.26 syndrome

data element computed from received data, used as intermediate stage in error correction algorithm

3.27 word clock

audio clock signal of base sample frequency, in phase with local audio sample clock

4 Physical Interface

4.1 Physical medium

HRMAI uses a four-pair twisted pair data cable. The minimum specification shall be Category 5 as defined by TIA/EIA-568-B.2, although the use of more stringently-specified cable such as Category 6 is recommended.

The use of screened (shielded) twisted pair (STP) cable is recommended.

4.2 Medium dependent interface (MDI)

HRMAI connections shall be terminated with 8-pin connectors meeting the requirements of ISO/IEC 8802-3: 2000(E) clause 25, with the exception that table 25-2 in this reference shall be replaced with table 1 below.

Note: this reference in turn references ANSI X3.263: 1995 (TP-PMD), which in turn references ISO/IEC 8877: 1992.

Table 1: HRMAI connector contact assignments

Contact	MDI signal allocation	MDI-X (crossover) signal allocation
1	Audio data transmit +	Audio data receive +
2	Audio data transmit -	Audio data receive -
3	Audio data receive +	Audio data transmit +
4	Sync signal transmit +	Sync signal receive +
5	Sync signal transmit -	Sync signal receive -
6	Audio data receive -	Audio data transmit -
7	Sync signal receive +	Sync signal transmit +
8	Sync signal receive -	Sync signal transmit -

All connectors shall feature the same contact assignments. Switching between MDI and MDI-X modes shall be automatically negotiated, such that crossover cables are not required. MDI/MDI-X crossover negotiation for data and sync signal shall operate independently.

Connector sockets shall incorporate screen (shield) connections connected to the external chassis of the device, such that the screens (shields) of STP cables are connected to chassis ground at each end of the link.

4.3 Visible link status indicators

It is recommended that the media connection ports associated with an HRMAI transceiver feature adjacent light-emitting status indicators. If implemented, these indicators shall comprise one red (or yellow) and one green light emitter, or one bicolour red (or yellow) and green light emitter. They shall indicate link conditions as defined in table 2.

Table 2: Visible link status indicators

LED status	Condition
No light emitter on	No audio data physical layer connection detected
Red (or yellow) light emitter on	Audio data physical layer connection detected, but clock synchronisation failed or not present or not locked. Audio output inhibited
Green light emitter pulsating intensity at a frequency between 0.3 Hz and 1 Hz	Audio data physical layer connection detected, slave device has locked to master device clock, link is active, and received audio is being passed on by the device
Green light emitter on	Link is ready for fail-over operation, but is not the active audio source. (In the case of a pair of redundant links only).
Both light emitters on	Invalid indication

4.4 Audio data physical layer

The audio data physical layer shall be as specified by ISO/IEC 8802-3: 2000(E) clause 24: “Physical Coding Sublayer (PCS) and Physical Medium Attachment (PMA) sublayer, type 100BASE-X”, and clause 25: “Physical Medium Dependent (PMD) sublayer and baseband medium, type 100BASE-TX”.

The physical layer device shall be capable of automatically switching between crossover and non-crossover MDI connection.

Note: this capability is usually advertised in physical layer transceiver device specifications as “Auto-MDIX”.

4.5 Synchronization signal physical layer

4.5.1 Overview

The synchronisation signal electrical interface shall comprise two independent half-duplex signal paths. The two paths shall transmit data in opposite directions (that is, at a given node one sync signal path shall be an output, and the other an input). Control of which sync signal path is transmitting shall be achieved by automatic negotiation (see 4.6).

Each signal path shall use a pair of conductors. Differential signaling shall be used.

4.5.2 Electrical isolation requirement

The electrical isolation of the synchronisation signal interconnection shall be as specified by ANSI X3.263-1995, 8.4.1.

4.5.3 Test load

The test load for the synchronisation signal interface shall consist of a single 100-Ω resistor with a tolerance of $\pm 0,2$ % connected across those contacts of the MDI interface comprising the differential signal pair under test.