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Digital audio interface –

Part 1: General

International Electrotechnical Commission, 3, rue de Varembé, PO Box 131, CH-1211 Geneva 20, Switzerland
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: inmail@iec.ch Web: www.iec.ch

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DIGITAL AUDIO INTERFACE –

Part 1: General

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IEC 60958-1, edition 2 has been prepared by Technical Area 4, Digital system interfaces, of IEC technical committee 100: Audio, video and multimedia systems and equipment.

This second edition of IEC 60958-1 cancels and replaces the first edition published in 1999 and constitutes a technical revision.

All changes introduced in this second edition of IEC 60958-1 intend to clarify the structure and the relationship between all of IEC 60958 series families.

A brief list of changes include:

- Annex B has been added to explain the definition given in 5.3 with relation of the families of the IEC 60958 series. Clause 5.3 is also added to this description.
- Annex C has been added to explain the relationship of the IEC 60958 series families.
- Annex D has been added as an explanation for a data transmission other than linear PCM.
- Subclause 5.4 has been added to define category code appliance.
- A Bibliography has been added.

CONTENTS

DIGITAL AUDIO INTERFACE –

Part 1: General

1 Scope

This part of IEC 60958 describes a serial, uni-directional, self-clocking interface for the interconnection of digital audio equipment for consumer and professional applications.

It specifies the basic structure of the interface. Separate documents define items specific to particular applications.

The interface is primarily intended to carry monophonic or stereophonic programmes, encoded using linear PCM and with a resolution of up to 24 bits per sample.

When used for other purposes, the interface is able to carry audio data coded other than as linear PCM coded audio samples. Provision is also made to allow the interface to carry data related to computer software or signals coded using non-linear PCM. The format specification for these applications is not part of this standard.

The interface is intended for operation at audio sampling frequencies of 32 kHz and above. Auxiliary information is transmitted along with the programme.

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.

IEC 60958-3, *Digital audio Interface – Part 3: Consumer applications*

IEC 60958-4, *Digital audio Interface – Part 4: Professional applications*

3 Terms and definitions

For the purpose of all parts of the IEC 60958 series, the following terms and definitions apply.

3.1
sampling frequency
frequency of the samples representing an audio signal

NOTE When more than one signal is transmitted through the same interface, the sampling frequencies are identical.

3.2
audio sample word
value of a digital audio sample. Representation is linear in 2s complement binary form

NOTE Positive numbers correspond to positive analogue voltages at the input of the Analogue-to-Digital Converter (ADC).

3.3
auxiliary sample bit
one of the four least significant bits (LSBs) that can be assigned as auxiliary sample bits and used for auxiliary information when the number of audio sample bits in the main data field is less than or equal to 20

3.4
validity bit
bit indicating whether the main data field bits in the sub-frame (time slots 4 to 27 or 8 to 27, depending on the audio word length as described in 4.1.1) are reliable or not

3.5
channel status
carrier, in a fixed format, of information associated with each main data field channel which is decodable by any interface user

NOTE Examples of information to be carried in the channel status are: length of audio sample words, pre-emphasis, sampling frequency, time codes, alphanumeric source and destination codes.

3.6
user data
data channel provided to carry any other information

3.7
parity bit
bit provided to permit the detection of an odd number of errors resulting from malfunctions in the interface

3.8
preamble
specific patterns used for synchronization

NOTE There are three different preambles (see 4.3).

3.9
sub-frame
fixed structure used to carry information (see 4.1.1 and 4.1.2)

3.10
frame
sequence of two successive and associated sub-frames

3.11
block
group of 192 consecutive frames

NOTE The start of a block is designated by a special sub-frame preamble (see 4.3).

3.12
channel coding
coding method by which the binary digits are represented for transmission through the interface

3.13
unit interval
UI
shortest nominal time interval in the coding scheme

NOTE There are 128 UI in a sample frame.

3.14
interface jitter
deviation in the timing of interface data transitions (zero crossings) when compared with an ideal clock

3.15
intrinsic jitter
output interface jitter of a device that is either free-running or is synchronized to a jitter-free reference

3.16
jitter gain
ratio of the amplitude of jitter components at the output, to their amplitude at the synchronization input to the device under test

4 Interface format

4.1 Structure of format

4.1.1 Sub-frame format

Each sub-frame is divided into 32 time slots, numbered from 0 to 31 (see Figure 1).

Time slots 0 to 3 (preambles) carry one of the three permitted preambles (see 4.1.2 and 4.3; see also Figure 2).

Time slots 4 to 27 (main data field) carry the audio sample word in linear 2's complement representation. The most significant bit (MSB) is carried by time slot 27.

When a 24-bit coding range is used, the LSB is in time slot 4 (see Figure 1).

When a 20-bit coding range is used, time slots 8 to 27 carry the audio sample word with the LSB in time slot 8. Time slots 4 to 7 may be used for other applications. Under these circumstances, the bits in the time slots 4 to 7 are designated auxiliary sample bits (see Figure 1).

If the source provides fewer bits than the interface allows (either 20 or 24), the unused LSBs are set to a logical "0".

For a non-linear PCM audio application or a data application, the main data field may carry any other information.

Time slot 28 (validity bit) carries the validity bit associated with the main data field (see 4.4).

Time slot 29 (user data bit) carries 1 bit of the user data channel associated with the main data field channel transmitted in the same sub-frame.

NOTE 1 For the applications, refer to the other parts of the IEC 60958 series.

Time slot 30 (channel status bit) carries 1 bit of the channel status information associated with the main data field channel transmitted in the same sub-frame.

NOTE 2 For details refer to the other parts of the IEC 60958 series.

Time slot 31 (parity bit) carries a parity bit such that time slots 4 to 31 inclusive carry an even number of ones and an even number of zeros (even parity).

NOTE 3 The preambles have even parity as an explicit property.

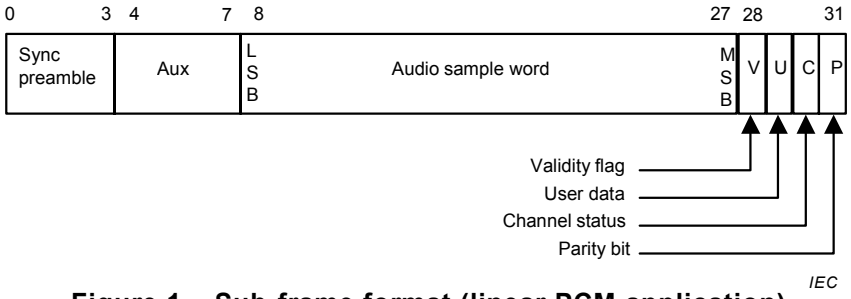

Figure 1 – Sub-frame format (linear PCM application)

4.1.2 Frame format

A frame is uniquely composed of two sub-frames (see Figure 2). For linear coded audio applications, the rate of transmission of frames normally corresponds exactly to the source sampling frequency.

In 2-channel operation mode, the samples taken from both channels are transmitted by time multiplexing in consecutive sub-frames. The first sub-frame (left or "A" channel in stereophonic operation and primary channel in monophonic operation) normally starts with preamble "M". However, the preamble changes to preamble "B" once every 192 frames to identify the start of the block structure used to organize the channel status information. The second sub-frame (right or "B" channel in stereophonic operation and secondary channel in monophonic operation) always starts with preamble "W".

In single channel operation mode in a professional application, the frame format is the same as in the 2-channel mode. Data is carried in the first sub-frame and may be duplicated in the second sub-frame. If the second sub-frame is not carrying duplicate data, time slot 28 (validity flag) shall be set to logical "1".

NOTE For historical reasons, preambles "B", "M" and "W" are, for use in professional applications, referred to as "Z", "X" and "Y", respectively.

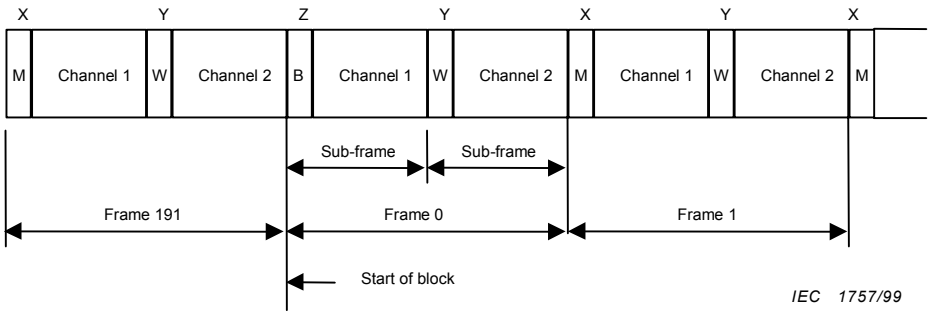

Figure 2 – Frame format

4.2 Channel coding

To minimize the direct current (DC) component on the transmission line, to facilitate clock recovery from the data stream and to make the interface insensitive to the polarity of connections, time slots 4 to 31 are encoded in biphase-mark.

Each bit to be transmitted is represented by a symbol comprising two consecutive binary states. The first state of a symbol is always different from the second state of the previous symbol. The second state of the symbol is identical to the first if the bit to be transmitted is logical "0". However, it is different if the bit is logical "1" (see Figure 3).

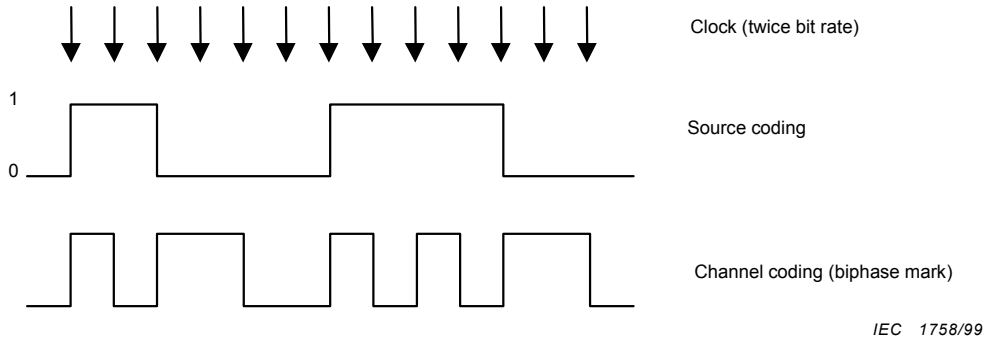

Figure 3 – Channel coding

4.3 Preambles

Preambles are specific patterns providing synchronization and identification of the sub-frames and blocks.

To achieve synchronization within one sampling period and to make this process completely reliable, these patterns violate the biphase-mark code rules, thereby avoiding the possibility of data imitating the preambles.

A set of three preambles is used. These preambles are transmitted in the time allocated to four time slots at the start of each sub-frame (time slots 0 to 3), and are represented by eight successive states. The first state of the preamble is always different from the second state of the previous symbol (representing the parity bit). Depending on this state, the preambles are as shown in Table 1.

Table 1 – Preamble coding

Preceding state	**0**	**1**	
Preamble code	**Channel coding**		
“B” or “Z” (see note to 4.1.2)	11101000	00010111	Sub-frame 1 and the start of the block
“M” or “X”	11100010	00011101	Sub-frame 1
“W” or “Y”	11100100	00011011	Sub-frame 2

Like biphase code, these preambles are d.c. free and provide clock recovery. They differ in at least two states from any valid biphase sequence.

Figure 4 represents preamble "M".

NOTE Owing to the even-parity bit in time slot 31, all preambles start with a transition in the same direction (see 4.1.1). Thus, only one of these sets of preambles is, in practice, transmitted through the interface. However, it is necessary for both sets to be decodable because either polarity is possible in a connection.

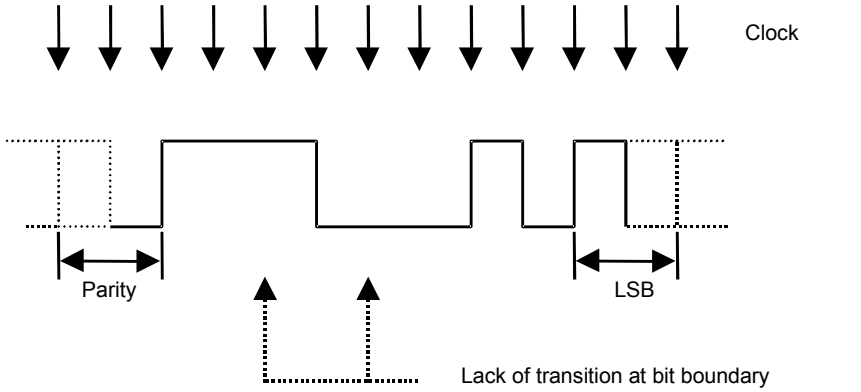

Figure 4 – Preamble M (shown as 11100010)

4.4 Validity bit

The validity bit is logical "0" if the information in the main data field is reliable, and it is logical "1" if it is not. There is no default state for the validity bit.

NOTE For transmissions not using a linear PCM coding, this bit may be set. This is intended to prevent accidental decoding of non-audio data to analogue before a complete channel status block is received. See Annex A.

5 Channel status

5.1 General

For every sub-frame, the channel status provides information related to the data carried in the main data field of that same sub-frame.

Channel status information is organized in a 192-bit block, subdivided into 24 bytes. The first bit of each block is carried in the frame with preamble "B". The channel status data format is defined in Table 2.

The specific organization depends on the application. In the descriptions, the suffix "0" designates the first byte or bit. Where channel status bits are combined to form non-binary values, the least significant bit should be transmitted first, unless otherwise indicated.

5.2 Applications

The primary application is indicated by the first channel status bit (bit 0) of a block as defined in 5.3.

For professional applications, refer to IEC 60958-4.

For consumer applications, refer to IEC 60958-3.

Secondary applications may be defined within the framework of these primary applications.

Application documents or specifications are listed in Annex B.

5.3 General assignment of the first and second channel status bits

The first and second channel status bits (bit 0 and bit 1) are specified as follows.

Byte 0

Bit 0 “0” Consumer use of channel status block.
“1” Professional use of channel status block.

Bit 1 “0” Main data field represents linear PCM samples.
“1” Main data field used for purposes other purposes.

5.4 Category code

Channel status including the category code is defined in IEC 60958-3 for consumer applications; these category codes are used for other variations of the IEC 60958 series for consumer use, such as the IEC 61937 series.

Channel status is also defined in IEC 60958-4 for professional applications, and these data are used for other variations of the IEC 60958 series for professional use, such as SMPTE 337M.

Table 2 – Channel status data format

Byte									
0		**a**	**b**						
	bit	0	1	2	3	4	5	6	7
1									
	bit	8	9	10	11	12	13	14	15
2									
	bit	16	17	18	19	20	21	22	23
3									
	bit	24	25	26	27	28	29	30	31
4									
	bit	32	33	34	35	36	37	38	39
5									
	bit	40	41	42	43	44	45	46	47
6									
	bit	48	49	50	51	52	53	54	55
7									
	bit	56	57	58	59	60	61	62	63
8									
	bit	64	65	66	67	68	69	70	71
9									
	bit	72	73	74	75	76	77	78	79
10									
	bit	80	81	82	83	84	85	86	87
11									
	bit	88	89	90	91	92	93	94	95
12									
	bit	96	97	98	99	100	101	102	103
13									
	bit	104	105	106	107	108	109	110	111
14									
	bit	112	113	114	115	116	117	118	119
15									
	bit	120	121	122	123	124	125	126	127
16									
	bit	128	129	130	131	132	133	134	135
17									
	bit	136	137	138	139	140	141	142	143
18									
	bit	144	145	146	147	148	149	150	151
19									
	bit	152	153	154	155	156	157	158	159
20									
	bit	160	161	162	163	164	165	166	167
21									
	bit	168	169	170	171	172	173	174	175
22									
	bit	176	177	178	179	180	181	182	183
23									
	bit	184	185	186	187	188	189	190	191
		a: use of channel status block. b: linear PCM identification.							

6 User data

6.1 General

The default value of the user bits is logical "0".

6.2 Applications

6.2.1 Professional use

User data may be used in any way required by the user. Application details are described in IEC 60958-4.

6.2.2 Consumer use

The application of the user data in digital audio equipment for consumer use is in accordance with IEC 60958-3.

7 Electrical requirements

The type of transmission line and timing accuracy of the transmitted signal waveform shall be as defined in other parts of IEC 60958-3 and IEC 60958-4, to meet the specifically required quality or purpose of use.

Annex A
(informative)

The use of the validity bit

The IEC 60958 series is based on two different industry standards: the AES/EBU digital audio interface standard (AES3 and EBU Tech. 3250-E) and the digital interface specification by Sony and Philips (SPDIF) introduced with the Compact Disc Digital Audio system.

Unfortunately, significant differences between the two standards exist, which can contribute in part to the different application areas: professional and consumer. The differences have contributed to many misunderstandings about the use and compatibility of the standards.

Originally, the definition of validity was, in both industry standards, that it indicated whether or not the associated audio sample was "secure and error free". Although, at first glance this may seem a clear definition, in practice it has led to important practical problems. It is unclear how the receiver should interpret this. When the sample is signalled not to be in error, it is not clear whether the transmitter has performed a successful concealment. If a sample is signalled in error, it is not clear whether the sample should be passed on unchanged, concealed or muted.

As a result, the AES has adopted in the 1992 revision of the AES3 standard a different wording: Validity indicates "whether the audio sample bits are suitable for conversion to an analogue audio signal".

Over the years, the application of the IEC 60958 series has gained popularity, resulting in a growing number of products conforming to its provisions. With these in use, applications other than strictly linear PCM audio transmission started to appear as well. The same basic frame structure is used, but the information transferred in the "audio sample word" is not encoded as linear PCM audio. As it is not always clearly indicated what kind of signal is carried, connection of such a transmitter to a linear PCM receiver may result in a very loud and noisy audio signal.

Therefore, it has been proposed in the revision of the IEC 60958 series to also adopt the wording of the AES3 standard for the validity bit definition. However, especially in consumer applications, the transmitter often has no active control of the validity bit. In many cases, this is generated by the error correction circuitry and automatically copied in the IEC 60958 series bitstream. A change of definition would, in theory, necessitate a redesign of circuits which have been in use for many years.

For this reason, the definition of the validity bit remains basically unchanged in the IEC 60958 series. However, it is noted that for applications not using a linear PCM coding, the bit may be set to "1", in which case it can prevent accidental decoding of non-audio data to analogue before a complete channel status block is received. For future applications of the IEC 60958 series with non-linear PCM data, such a provision is highly recommended.

Additionally, in IEC 60958-4, it is specified that the validity bit shall be used to indicate whether the audio sample is "suitable for conversion to an analogue audio signal using linear PCM coding". This retains, for professional applications, the intention of the wording in the AES3 standard.

Although not a perfect solution to problems relating to the use of the validity bit, the definitions as adopted in the IEC 60958 series seem to be the best achievable compromise to date.

The use described in this annex should be applied to all other IEC 60958 data conformant formats. This applies, for example, to the IEC 60958 series conformant mode of IEC 61883-6.

Annex B
(informative)

Application documents and specifications

Table B.1 indicates application documents and specification based on channel status bit 0 and bit 1, as defined in 5.3.

Table B.1 – Application documents and specifications

Byte0 of Channel status		Standards
Bit0	Bit1	
0	0	IEC 60958-3
1	0	IEC 60958-4
0	1	IEC 61937, IEC 62105 and others
1	1	SMPTE 337M and others

For that part of the channel status that is not implemented, the default is logical “0”.

Annex C
(informative)

A relationship of the IEC 60958 series families

A relationship between IEC specifications that are based on the IEC 60958 series is illustrated in Figure C.1.

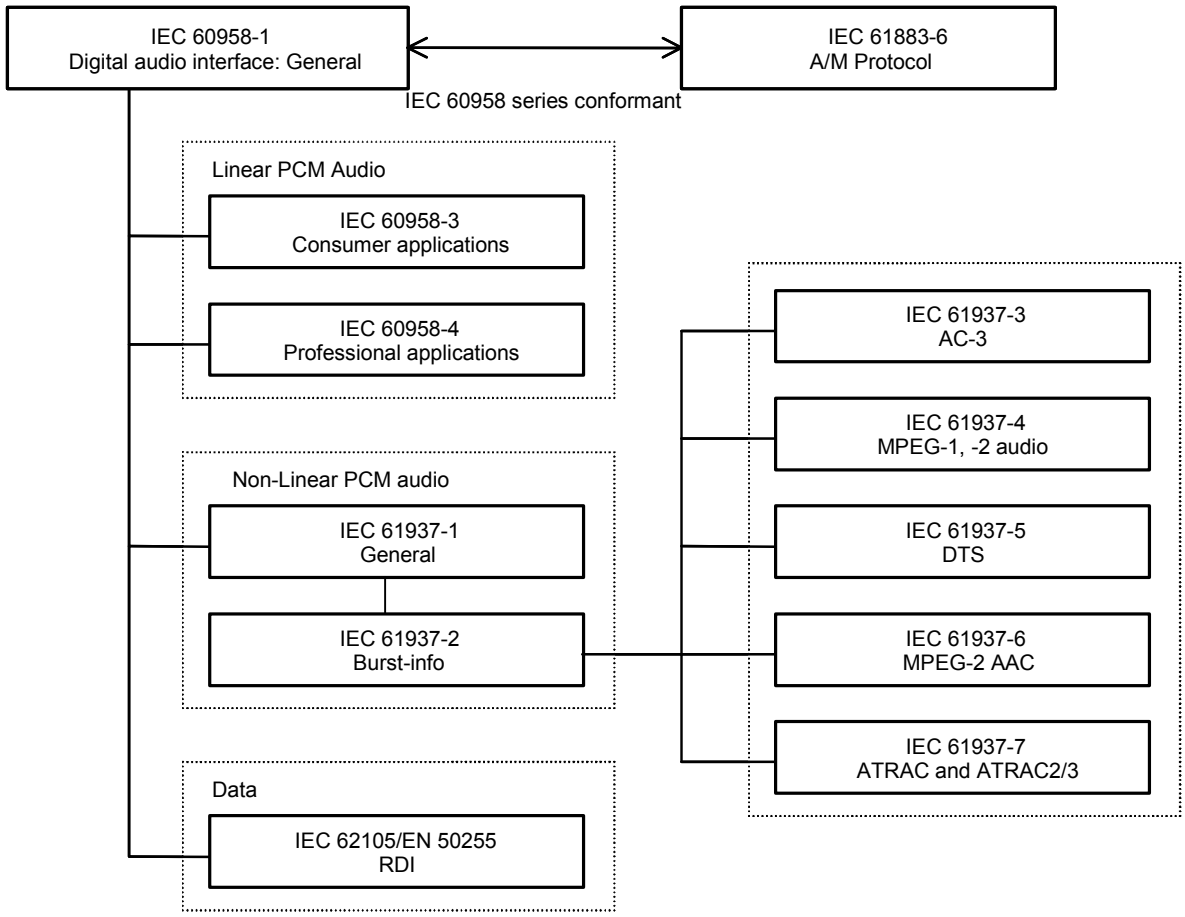

Figure C.1 – A relationship of the IEC 60958 series families

As illustrated, the IEC 60958 series consists of parts and also forms the basis for other applications. The IEC 61937 series and IEC 62105 are protocols that use the format of IEC 60958 as a transport, and the IEC 60958 series conformant mode in IEC 61883-6 is a variant where the data in an IEC 60958 stream is carried on the physical format of IEC 61883-6. This means that the IEC 60958 series – with data formats transported on the IEC 60958 series – can itself be carried on another interface format. As a result, the IEC 60958 series has relevance across various interface formats and systems.

Annex D
(informative)

Transmission of CD data other than linear PCM audio

This standard allows the interface to carry data related to computer software or signals coded using non-linear PCM and the format specification for these applications is not part of this standard. The channel status Bit 1 of Byte 0 indicates whether the data is linear PCM or not.

However, some CD applications currently set this Bit 1=”0” as meaning linear PCM data, while the actual data is not linear PCM but compressed audio data. Such applications do not conform to the IEC 60958 series.

Current data processing equipment such as computers and games machines have a CD-ROM drive and sometimes a IEC 60958 series interface, so there is a possibility of non-linear PCM data output that is dependent on the application software.

Therefore, all equipment and applications should respect the channel status definitions in this standard to prevent unexpected behaviour in the decoder.

Consideration is required for applications that, for historic reasons, do not behave in accordance with IEC 60958 with respect to channel status bit 1. This is in order to avoid a high level of noise being generated by the conversion of this signal as though is was linear PCM data. Such noise might damage hearing or equipment.

Bibliography

SMPTE 337M-2000, *Television – Format for Non-PCM Audio and Data in an AES3 Serial Digital Audio Interface*

IEC 61883-6:2002, *Consumer audio/video equipment – Digital interface – Part 6: Audio and music data transmission protocol*

IEC 61937 (all parts), *Digital audio – Interface for non-linear PCM encoded audio bitstreams applying IEC 60958*

IEC 62105:1999, *Digital audio broadcast system – Specification of the receiver data interface (RDI)*

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