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First edition
2003-11

Transmission of audio and/or video and related signals using infrared radiation –

Part 8-1: Digital audio and related signals

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

TRANSMISSION OF AUDIO AND/OR VIDEO AND RELATED SIGNALS USING INFRARED RADIATION –

Part 8-1: Digital audio and related signals

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International Standard IEC 61603-8-1 has been prepared by technical area 3, Infrared systems and applications, of IEC technical committee 100: Audio, video and multimedia systems and equipment.

This part of IEC 61603 replaces 6.8.3 of IEC 61603-2.

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

FDIS	Report on voting
100/628/FDIS	100/706/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.

The committee has decided that the contents of this publication will remain unchanged until 2005. At this date, the publication will be

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- withdrawn;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

TRANSMISSION OF AUDIO AND/OR VIDEO RELATED SIGNALS USING INFRARED RADIATION –

Part 8-1: Digital audio and related signals

1 Scope

This part of IEC 61603 specifies the characteristics and measuring methods for digital audio signal transmission systems using infrared radiation with sub-carrier of the frequency ranges 3 MHz to 6 MHz. It describes systems with different economic uses of the available bandwidth in order to obtain minimum interference and maximum compatibility.

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 60958-1, *Digital Audio Interface – Part 1: General*

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

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

IEC 61603-1:1997, *Transmission of audio and/or video and related signals using infrared radiation – Part 1: General*

IEC 61603-2:1997, *Transmission of audio and/or video and related signals using infrared radiation – Part 2: Transmission systems for audio wide band and related signals*

IEC 61937:2000, *Digital audio – Interface for non-linear PCM encoded audio bitstreams applying IEC 60958*

IEC 61938, *Audio and audiovisual systems – Interconnections and matching values – Preferred matching values of analogue signals*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this part of IEC 61603, the definitions given in Part 1 together with the following apply.

3.1.1
source stream
source_block stream with a corresponding source_info stream and transmission_info stream

3.1.2
block_structure
structure of data and parties for transmission

3.1.3
Tr_section

interleaved stream from the block_structure

3.2 Abbreviations

For the purposes of this part of IEC 61603, the following abbreviations apply.

IR	infrared (see IEC 61603-1)
PD	photo diode
O/E	optical/ electrical
Tx	transmitter/ radiator
Rx	receiver
QPSK	quadrature phase shift keying
DQPSK	differential encoded QPSK
Transmission_info	transmission information
CRC	cyclic redundancy check
source_info	source information
Sync Gen.	sync pattern generator
Header Gen.	header generator
GF	galois field
RS	Reed-Solomon code
ECC	error correction code

4 System description

4.1 General

This part of 61603 defines an application using digital audio signals based on the digital audio interface, IEC 60958, for professional and consumer applications. This includes an ability to transmit non-linear PCM data formatted according to IEC 61937.

The digital audio bitstream transmission systems that are the subject of this document are characterized by the following features:

– used for interface with infrared radiation,
– harmonized with IEC 60958;
– harmonized with IEC 61937;
– used for multi-channel transmission in future;
– signal block structure;
– error correction;
– frequency range: 3 MHz to 6 MHz;
– channel coding;
– low spurious (band-pass filter).

This standard gives the detailed specifications of the digital audio signal transmission. Infrared digital audio signal transmission is used in a frequency range of 3 MHz to 6 MHz as specified in IEC 61603-2. It shares this range with analogue audio applications, so that care should be taken to avoid interference with any such applications being used simultaneously.

This system supports a full-band mode that carries all the data on the IEC 60958 interface at sample rates of 48 kHz and below. It also supports a half-band mode carrying two streams each of two 16-bit audio channels without the capacity for all the associated validity data, user data, or channel status data defined in IEC 60958. Some of those data are carried elsewhere in the system.

Depending on the applicable bit rate, two different channel bandwidths are possible. One is called the full-band mode, which carries 2 channels, 32-slot bit stream with the bandwidth of 3 MHz wide, the other is called the half-band mode, which carries 2 channels, 16-slot bit stream with the bandwidth of 1,5 MHz wide.

Both the full-band mode and half-band mode are based on IEC 60958-1, IEC 60958-3, IEC 60958-4 and IEC 61937.

The system concept is shown in Figure 1.

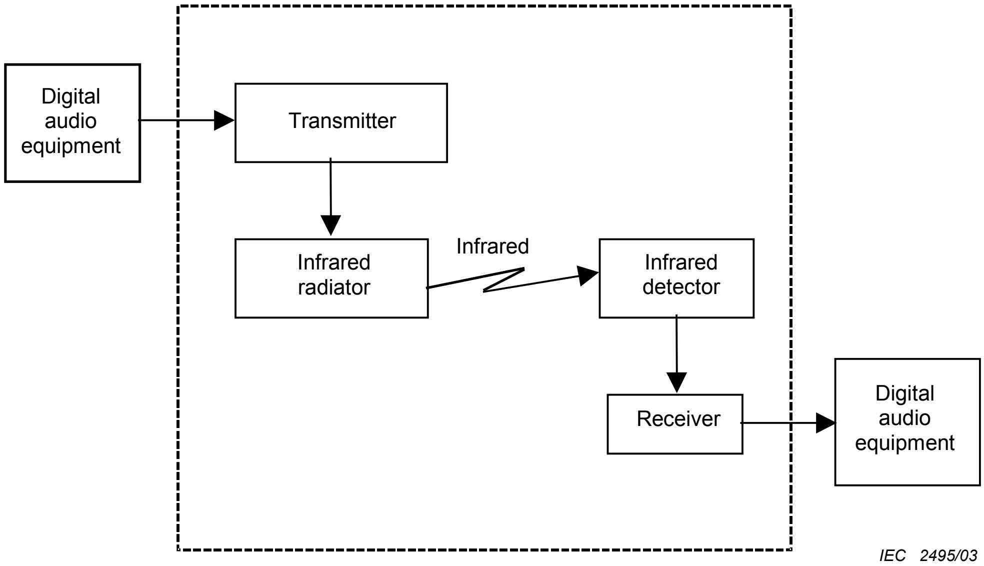


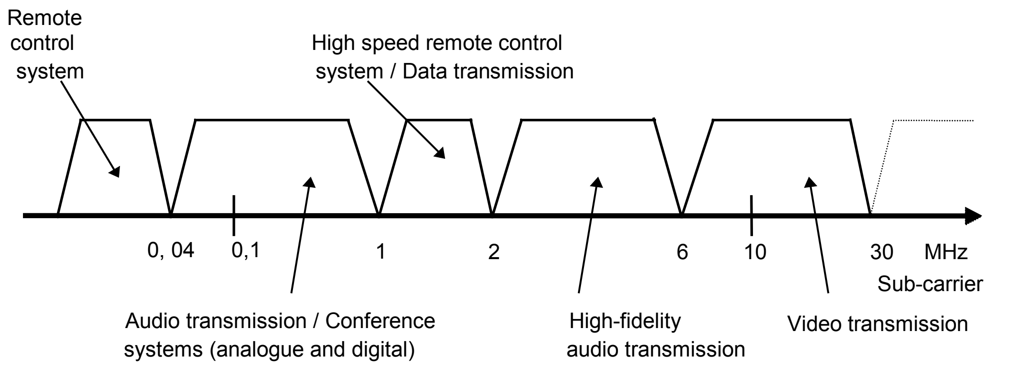
Figure 1 – System concept

4.2 Area of application

This digital audio signal transmission system using infrared radiation is mainly used for transmitting digital audio signals from a CD player, DAT player or MD player, etc. to headphones, speakers and infrared receivers, etc.

4.3 Band allocation

In IEC 61603-2, the band allocation for high quality audio transmission ranges from 2 MHz to 6 MHz is as shown in Figure 2.



IEC 2496/03

Figure 2 – IEC 61603 band allocation

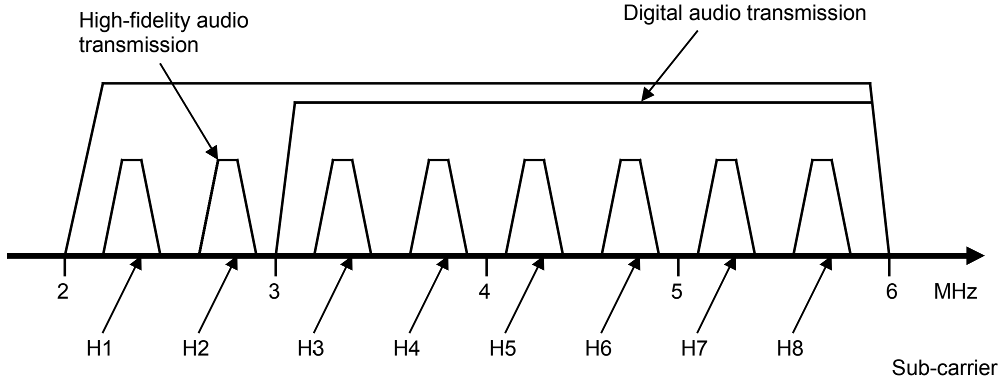
There are 8 channels in this band, named H1 through H8, for analogue audio signals, as defined in Table 1.

In general, wireless loudspeaker or wireless headphone systems use H1 and H2 for left and right channels, so this format for digital audio uses channel allocation from H3 to H8.

Table 1 – Analogue audio channel allocation

Name	Sub-carrier
H1	2,3 MHz
H2	2,8 MHz
H3	3,2 MHz
H4	3,7 MHz
H5	4,3 MHz
H6	4,8 MHz
H7	5,2 MHz
H8	5,7 MHz

Figure 3 shows the channel allocation for this digital audio format together with analogue channel allocation.



IEC 2497/03

Figure 3 – Band allocation

5 General characteristics

5.1 Environment conditions for operation

The environmental conditions for the equipment are mainly defined in relevant standards for individual units. However, unless otherwise specified, the equipment shall be capable of operating at least within the temperature and relative humidity ranges:

5 °C to 40 °C, and 25 % RH to 75 % RH

Systems and apparatus in accordance with this standard are primarily used indoors, with the advantage of operating more than one system interference-free in adjacent rooms.

5.2 Partition of functions between elements of the systems

Due to the different applications for different room sizes, equipment is designed in various combinations of functional blocks. For home applications it is desirable to have only a few blocks of small size and low installation cost.

6 Specific requirements

6.1 Block diagram

Figure 4 shows a block diagram of the transmitter described in Figure 1. Figure 5 shows a block diagram of the channel-coding block. The signal from sync gen., header gen. and Tr_section are multiplexed into the transmission stream.

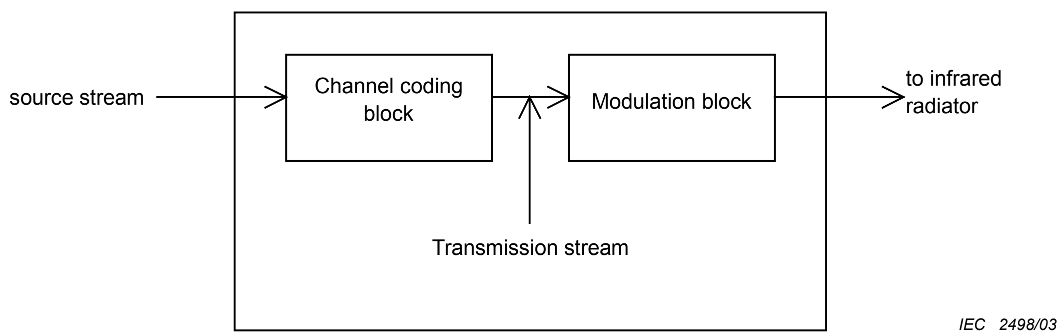


Figure 4 – Transmitter

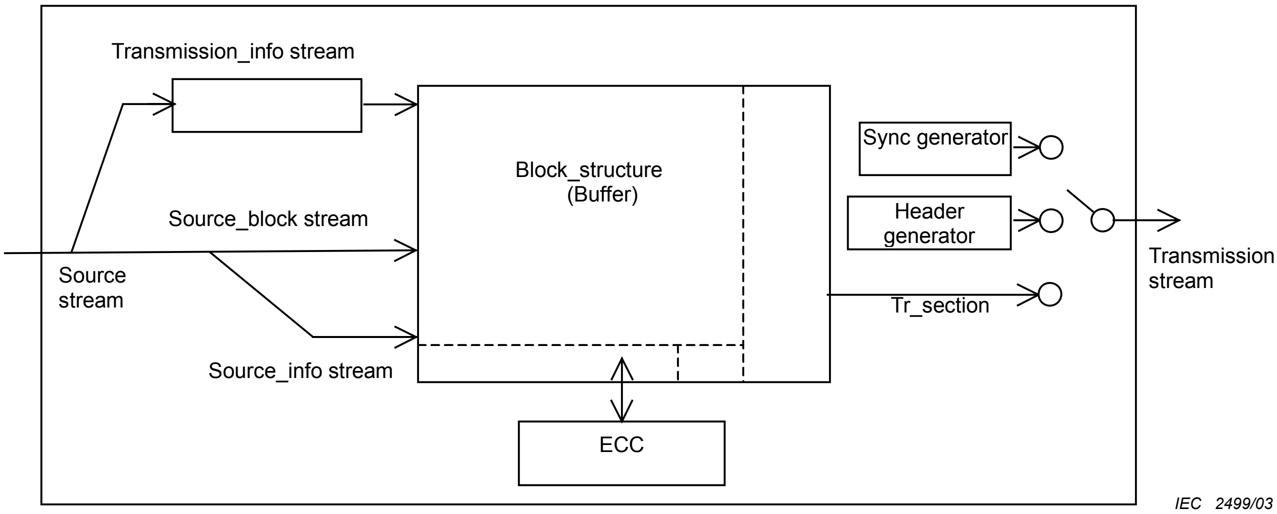


Figure 5 – Channel-coding block

6.2 Input and output

The digital audio signals at input and output shall be in accordance with IEC 61938.

6.3 Carrier

The carrier shall use infrared wavelengths between 800 nm and 900 nm.

6.4 Sub-carrier

The sub-carrier modulates the carrier of infrared. In this format, the sub-carrier band ranges from 3 MHz to 6 MHz.

6.5 Channel allocation

6.5.1 General

Figure 6 shows the channel allocation of digital audio signal transmission using infrared radiation, with the frequencies of each sub-carrier. The signal has a dual modulation. The infrared signal is intensity-modulated by the sub-carrier, which is DQPSK-modulated with the digital audio signals.

6.5.2 Sub-carrier frequency

Table 2 shows the values of sub-carrier frequency.

Table 2 – Sub-carrier frequency

divcode	Number of channels	$f_{sub\text{-}carrier}$ MHz
0	1	4,5
1	2	3,75 5,25

Figure 6 shows two kinds of transmission channel allocation.

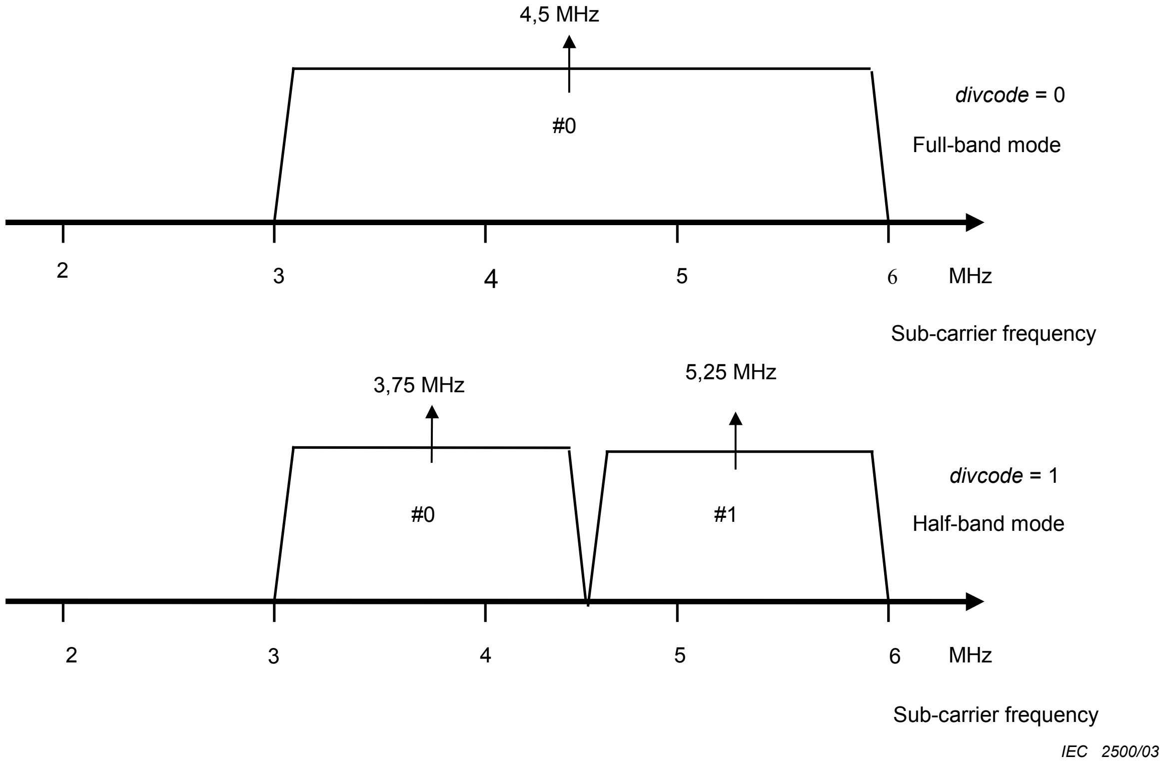


Figure 6 – Channel allocation

6.5.3 Bit rate

The maximum source stream bit rate is shown in Table 3.

Table 3 – Maximum source stream bit rate

divcode	Rate	Number of channels
0	3,072 Mbps	1
1	1,536 Mbps	2

For reference, Table 4 shows bit rate of digital audio.

Table 4 – Bit rate of digital audio

Bit rate	Digital audio signal
3,072 Mbps	48 kHz, 32 bit, 2 ch
1,536 Mbps	48 kHz, 16 bit, 2 ch
2,8224 Mbps	44,1 kHz, 32 bit, 2 ch
1,4112 Mbps	44,1 kHz, 16 bit, 2 ch
2,048 Mbps	32 kHz, 32 bit, 2 ch
1,024 Mbps	32 kHz, 16 bit, 2 ch

6.6 Block structure

“Source stream” to “Tr_section” conversion is based on the block structure in Figure 7. Each symbol in this structure has a size of 1 byte.

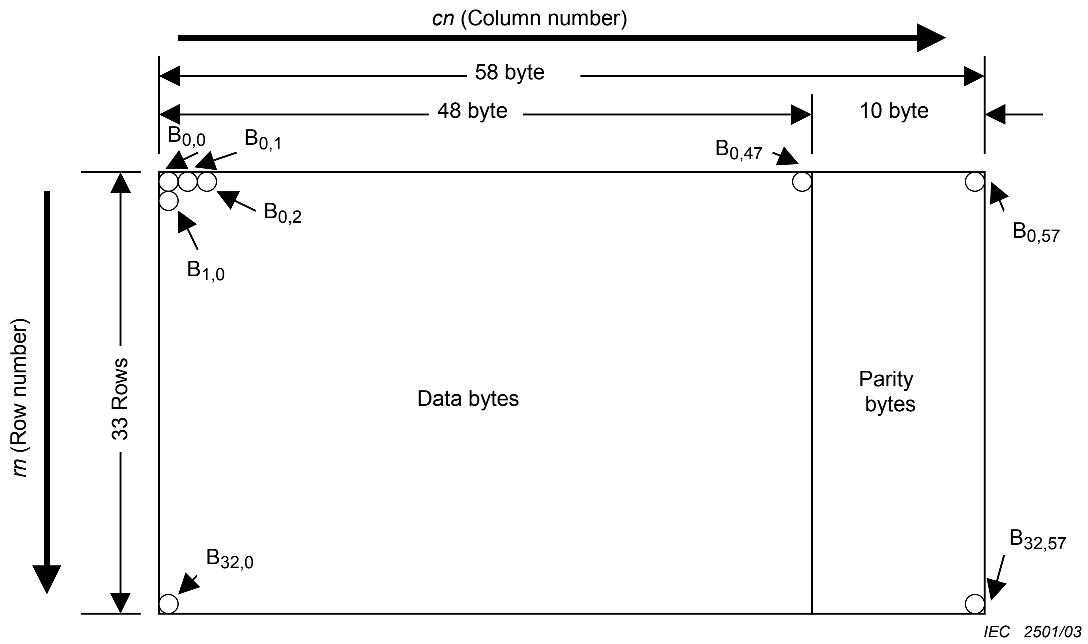


Figure 7 – Block structure

A byte in Figure 7 is defined as:

$$B_{\mathrm{rn,cn}}$$

where

rn is the row number

cn is the column number

In Figure 7, left-upper corner is byte $B_{0,0}$ and right-lower corner is byte $B_{32,57}$.

6.7 Source stream

6.7.1 General

“Source stream” consists of a “source_block stream” with a corresponding “source_info stream” and a “transmission_info stream.”

As shown in Figure 8, the “source_block stream”, “source_info stream” and “transmission_info stream” are simultaneous.

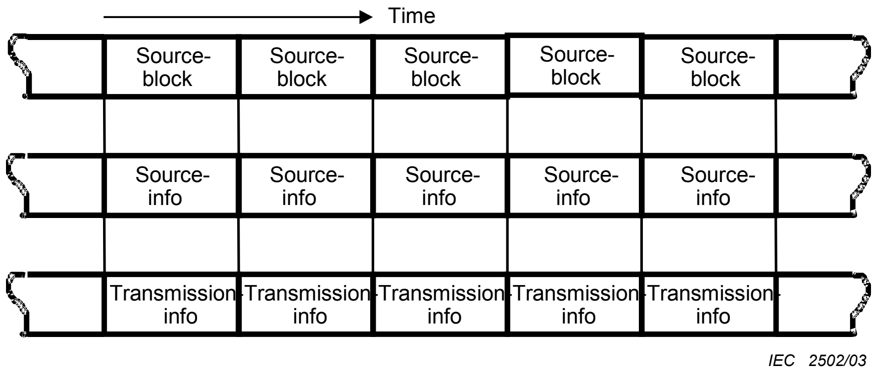


Figure 8 – Source stream

6.7.2 Source_block stream

The data clock frequency of the "source_block stream" should be a multiple of one of

48 kHz

44,1 kHz

32 kHz

For example, the clock is 44,1 kHz × 32, when transmitting CD audio.

The "source_block stream" is composed of a series of continuous "source_blocks", each of which consists of 1 536 bytes .

The format of the "source_block" is defined in Annexes A and B.

Figure 9 shows this format.

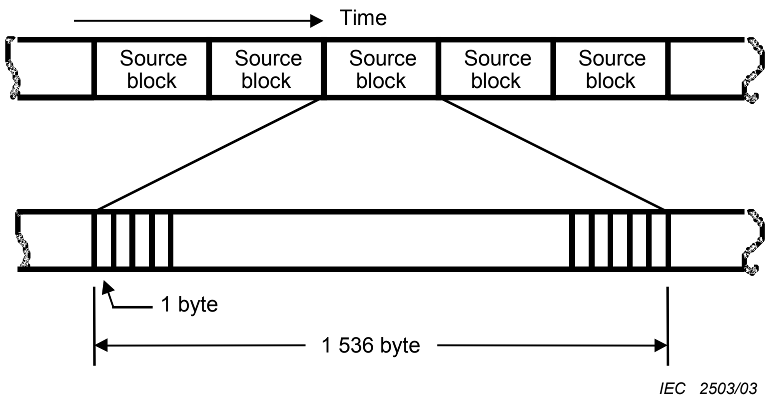


Figure 9 – Source_block stream

The order of each byte in the "source_block" is shown as follows:

$$B_{0,0} \quad B_{0,1} \quad B_{0,2} \quad \ldots\ B_{0,47} \quad B_{1,0} \quad B_{1,1} \quad \ldots \quad B_{31,47}$$

6.7.3 Source_info stream

The "source_info stream" is composed of a continuous source_info made up from 40 bytes.

The format of "source_info" is defined in Annexes A and B.

Figure 10 shows the format of the "source_info stream."

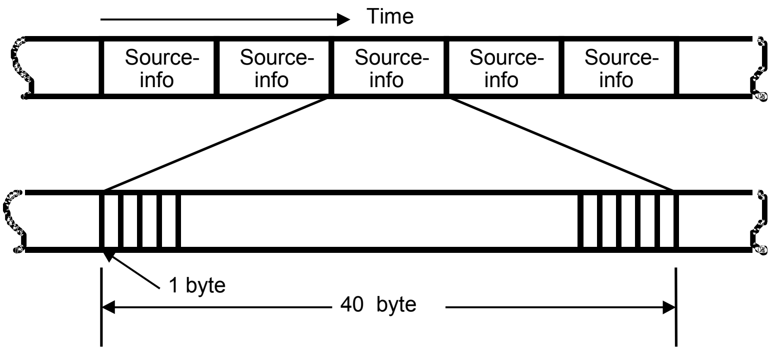


Figure 10 – Source_info stream

The order of each byte in the "source_info" is shown as follows:

$$B_{32,0} \quad B_{32,1} \quad B_{32,2} \quad \ldots \; B_{32,38} \quad B_{32,39}$$

6.7.4 Transmission_info stream

"Transmission_info stream" is composed of a continuous "transmission_info" made up from 8 bytes.

Each byte of "transmission_info" is defined in Table 5.

Table 5 – Byte values in a transmission_info

B32.cn	Default value	Meaning
40	0	Reserved
41	0	Reserved
42	0	Reserved
43	0	Reserved
44	0	Reserved
45	0	Reserved
46-47	–	SectionID

SectionID is a serial number, modulo 0x10 000 (65 536), incremented at each "source_block" to show the serial number of the "source_block."

6.7.5 Block alignment

Figure 11 shows alignment of the "source_block", "source_info", and "transmission_info" in the "block-structure."

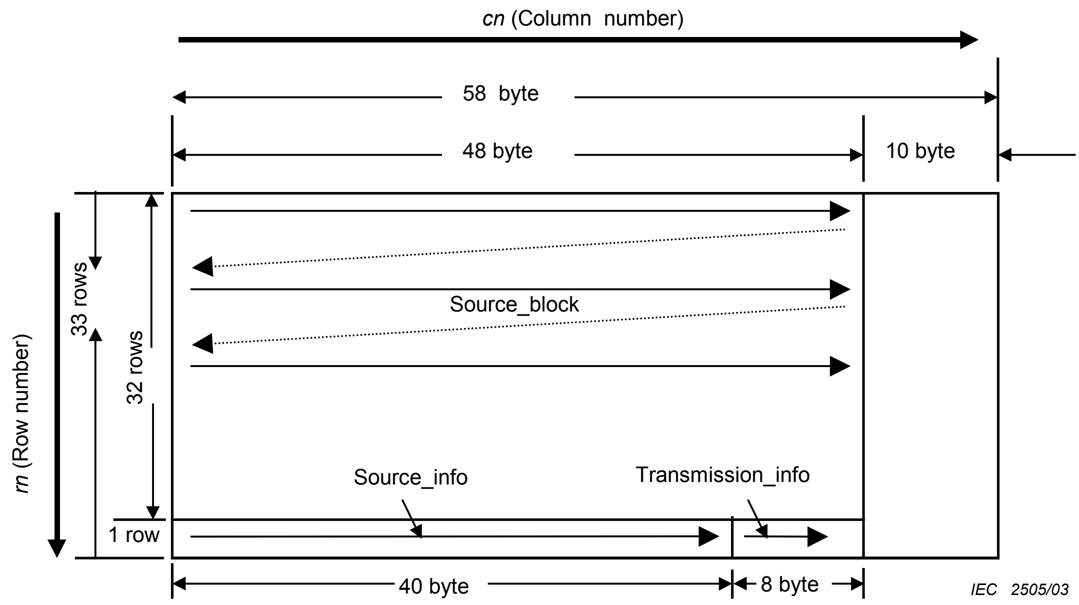


Figure 11 – Block alignment

6.7.6 Forward error correction code

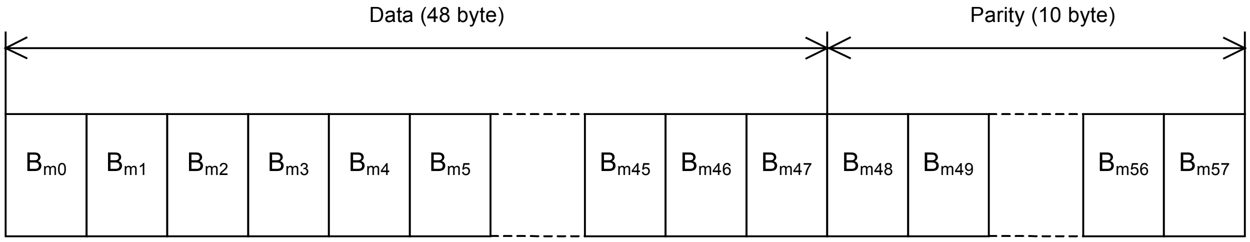
A forward error correction policy is chosen in this format for error correction, because there is no feedback information.

The chosen error correction code is Reed-Solomon code on *GF* (2^8).

Table 6 – Reed-Solomon code parameter

Primitive polynomial	$p(x) = x^8 + x^4 + x^3 + x^2 + 1$
Generator polynomial	$g(x) = \prod_{i=0}^{9} (x - \alpha^i)$
Primitive element	MSB LSB [00000010]
Code length	58
Parity length	10

Parity check matrix (Hp) used in “block_structure” is shown in Figure 12.



$$
Hp = \begin{bmatrix}
1 & 1 & 1 & 1 & \cdots & \cdots & 1 & 1 & 1 & 1 \\
\alpha^{57} & \alpha^{56} & \alpha^{55} & \alpha^{54} & \cdots & \cdots & \alpha^{3} & \alpha^{2} & \alpha & 1 \\
\alpha^{114} & \alpha^{112} & \alpha^{110} & \alpha^{108} & \cdots & \cdots & \alpha^{6} & \alpha^{4} & \alpha^{2} & 1 \\
\alpha^{171} & \alpha^{168} & \alpha^{165} & \alpha^{162} & \cdots & \cdots & \alpha^{9} & \alpha^{6} & \alpha^{3} & 1 \\
. & . & . & . & . & . & . & . & . & . \\
. & . & . & . & . & . & . & . & . & . \\
\alpha^{513} & \alpha^{504} & \alpha^{495} & \alpha^{486} & \cdots & \cdots & \alpha^{27} & \alpha^{18} & \alpha^{9} & 1
\end{bmatrix}
$$

$$
Vp = \begin{bmatrix}
B_{rn,0} \\ B_{rn,1} \\ B_{rn,2} \\ B_{rn,3} \\ . \\ . \\ B_{rn,45} \\ B_{rn,46} \\ B_{rn,47} \\ . \\ . \\ B_{rn,56} \\ B_{rn,57}
\end{bmatrix}
$$

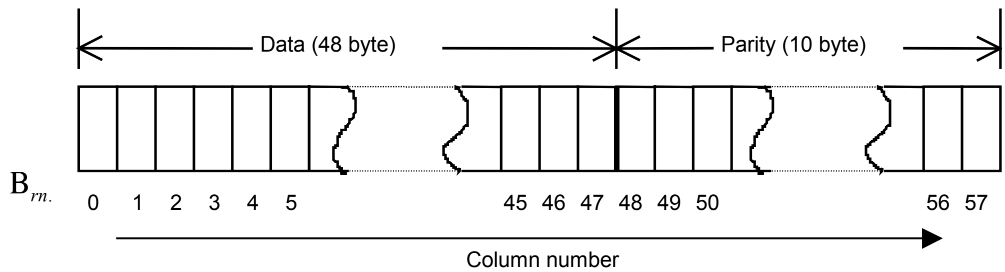
IEC 2506/03

where

$Hp \times Vp$ = [0]

Figure 12 – Parity check matrix

The alignment of error correction code blocks in “block_structure” is shown in Figure 13.



IEC 2507/03

Figure 13 – Error correction code block

6.8 Transmission stream

6.8.1 Ratio of transmission stream data to source_block stream data

The ratio R of "transmission stream" data to "source_block stream" data is as follows:

$$R = \frac{B\_ts}{B\_sb} = \frac{1\,920}{1\,536} = 1{,}25$$

where:

R is the ratio of transmission stream data to source_block stream data;

B_ts is the number of bytes contained in a block structure of transmission stream;

B_sb is the number of bytes contained in a block structure of source_block stream.

6.8.2 Transmission stream format

6.8.2.1 General

The transmission stream format is specified in Figure 14.

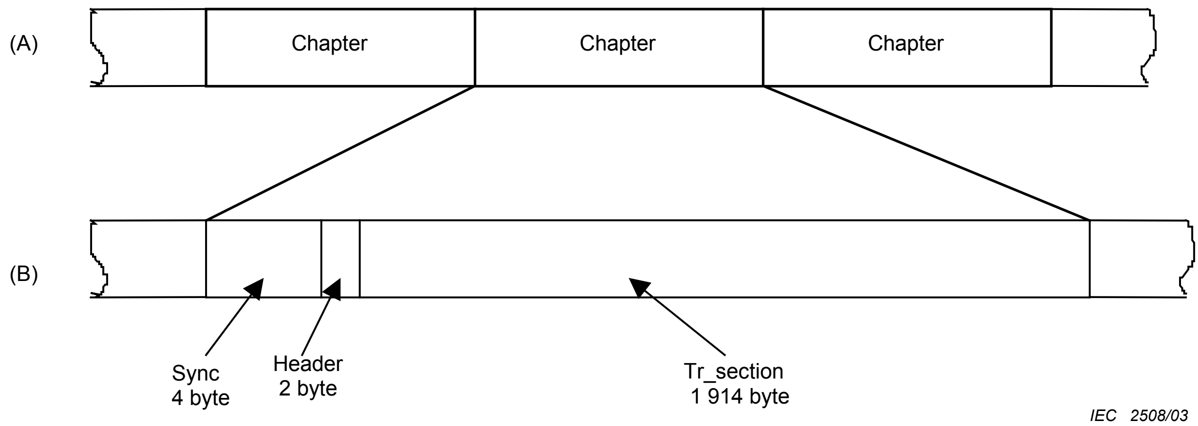


Figure 14 – Transmission stream

bit stream:	continuous chapters
Chapter:	Sync + Header + Tr_section
Sync:	bit pattern ("01111011 01111011 01111011 01111011")
Header:	bit field parameter (16 bit)
Tr_Section:	1 914 byte (= 15 312 bit)

The "'header" is not protected by error correction code.

6.8.2.2 Sync

"Sync" is a 32 bit (4 byte) long pattern. Sync is the beginning of the chapter.

6.8.2.3 Header

The header bit field parameter is defined in Table 7.

Table 7 – Header bit field

Contents	Bit-width	Default bit pattern	Meaning
reserved	7	0000000	-
divcode	1	-	division code : 0-1
reserved	7	0000000	-
chnum	1	-	channel number

“Divcode” and “chnum” are used for defining respectively the division code and channel number of the sub-carrier for frequency-division multiplex transmission.

When “divcode” = 0, the transmission mode is called the "full-band mode", and when “divcode” = 1, the mode is called the "half-band mode". These modes are described in 6.5.2.

6.8.2.4 Tr_section

“Tr_section (transmission_section)” is made up from 1 914 byte, and forms a block structure.

The order of bytes in “Tr_section” is shown as follows:

B0,0 B1,0 B2,0 **...** *B32,0 B0,1 B1,1 B2,1* **...** *B30,57 B31,57 B32,57*

Figure 15 shows the order of bytes in Tr_section.

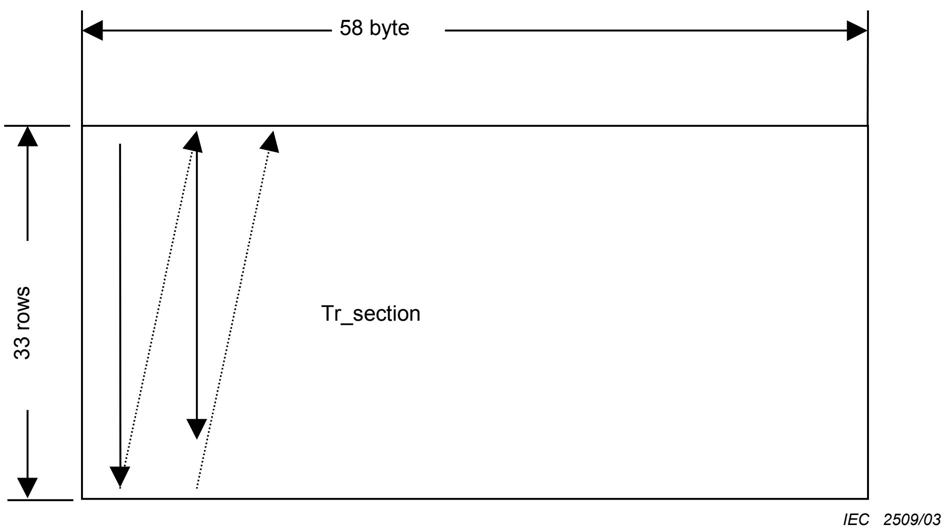


Figure 15 – The order bytes in Tr_section

6.9 Modulation

6.9.1 Modulation block

6.9.1.1 General

The modulation block is illustrated in Figure 16.

The modulation block has the function of byte to symbol conversion, scrambler, differential encoder and QPSK modulator. The QPSK modulator consists of signal mapping and baseband filters.

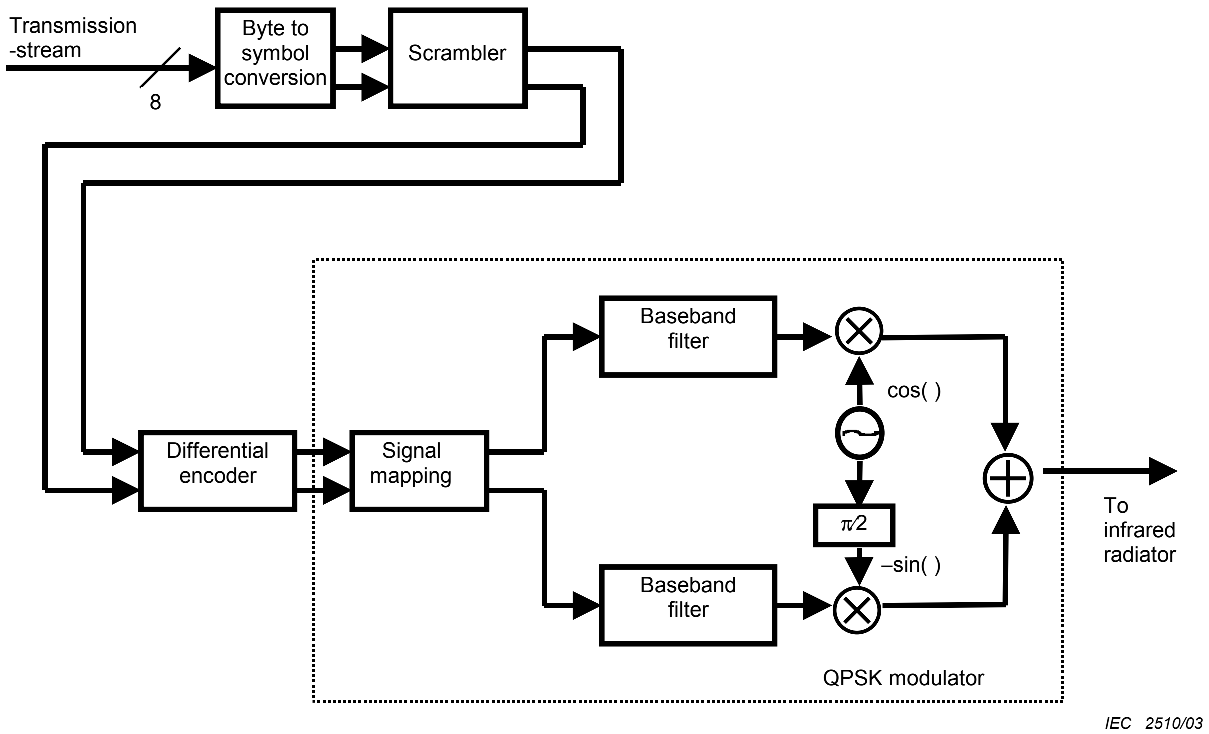


Figure 16 – Modulation block

6.9.1.2 Byte to symbol conversion

A transmission stream is composed of bytes, and should thus be converted to 2-bit pairs (a symbol) for feeding DQPSK modulator. Figure 17 shows how to convert a transmission stream byte to a 2-bit symbol.

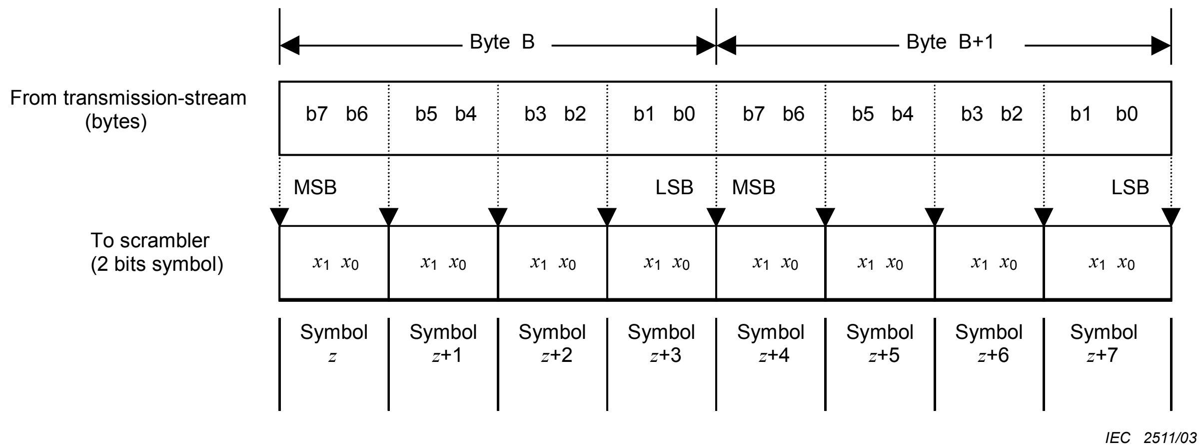


Figure 17 – Byte to symbol conversion

In Figure 17, b7 is the most significant bit (MSB) of a byte, and b0 is the least significant bit (LSB) of a byte. Therefore b7 of a byte is converted to x1 of a symbol.

6.9.1.3 Scramble

A scrambler is used for scrambling a symbol pattern for DQPSK to obtain spectrum shaping. DQPSK is adopted to ensure enough binary transitions for clock recovery.

A scrambler consists of XOR gates as shown in Figure 18 and the scramble pattern generator, which consists of a pseudo random binary sequence (PRBS) generator and a counter, as shown in Figure 19.

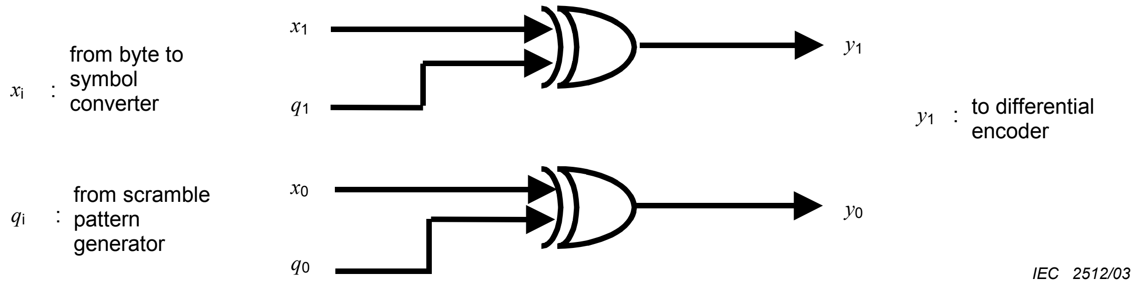


Figure 18 – XOR gates

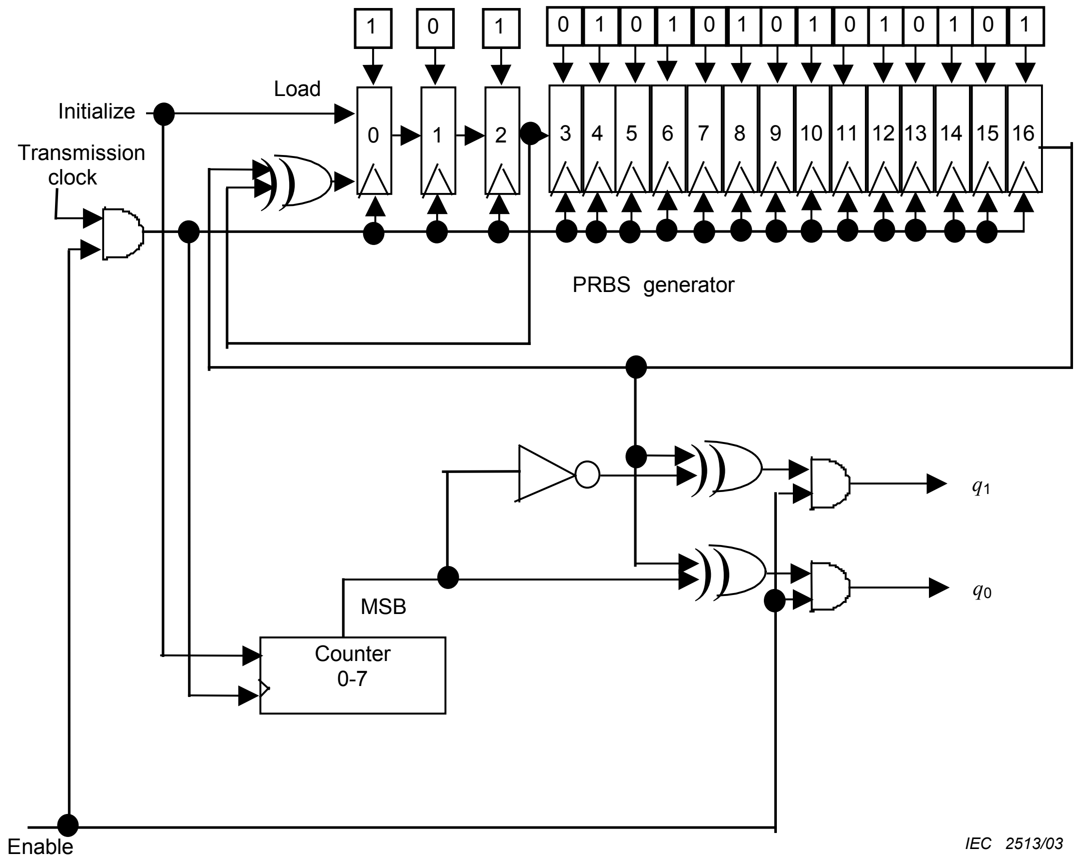


Figure 19 – Scramble pattern generator

The length of the PRBS is 17 bits and it is initialized at every chapter header. The polynomial for the PRBS generator is

$$1 + x^3 + x^{17}$$

and the initial pattern is

Initial pattern : "10101010101010101".

The counter is a 3 bit counter and is initialized to “0” at every chapter header.

Thus the first symbol output of the scramble pattern generator after initialization is “01”, and the next is “10”.

Scrambling is not applied to “sync” in order to prevent confusion of patterns.

6.9.1.4 Differential encoder

Differential encoding is used, to obtain a π/2 rotation-invariance QPSK constellation.

The encoding rule is defined as follows:

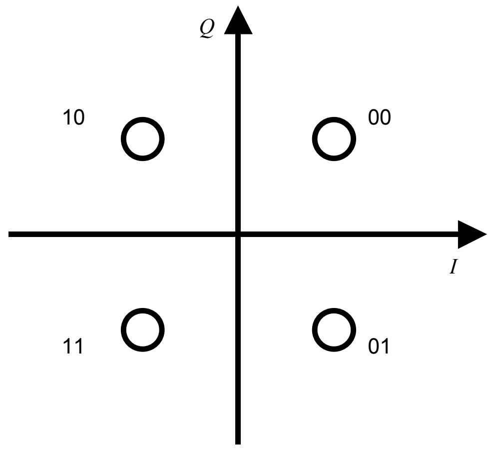
$$I(k) = \overline{(y_1(k) \oplus y_0(k))}(y_1(k) \oplus I(k-1)) + (y_1(k) \oplus y_0(k))(y_1(k) \oplus Q(k-1))$$
$$Q(k) = \overline{(y_1(k) \oplus y_0(k))}(y_0(k) \oplus Q(k-1) + (y_1(k) \oplus y_0(k))(y_0(k) \oplus I(k-1))$$

6.9.1.5 Signal mapping

The signal mapping of QPSK is defined as:

$$z(k) = \frac{1}{\sqrt{2}}\left[(1-2I(k)) + j(1-2Q(k))\right].$$

The signal mapping of QPSK is shown in Figure 20. “*I*” and “*Q*” axes are orthogonal.



IEC 2514/03

Figure 20 – QPSK mapping

6.9.1.6 Baseband filter

The baseband filter of the modulation block is illustrated in Figure 16.

The filter has a theoretical function defined as follows:

$$H(f) = 1, \qquad |f| < f_N \cdot (1-\alpha)$$

$$H(f) = \left\{ \frac{1}{2} + \frac{1}{2} \sin \frac{\pi}{2 f_N} \left[\frac{f_N - |f|}{\alpha} \right] \right\}^{\frac{1}{2}} \qquad , f_N \cdot (1-\alpha) \le |f| \le f_N \cdot (1+\alpha),$$

$$H(f) = 0, \qquad |f| > f_N \cdot (1+\alpha)$$

where

$H(f)$	is the signal amplitude;
f_N=1/(2T_s)	is the Nyquist frequency;
T_s	is the symbol interval;
(1/T_s)	= 0,625×bit rate;
α = 0,3	is the Roll off factor.

The amplitude characteristic of the baseband filter is shown in Figure 21.

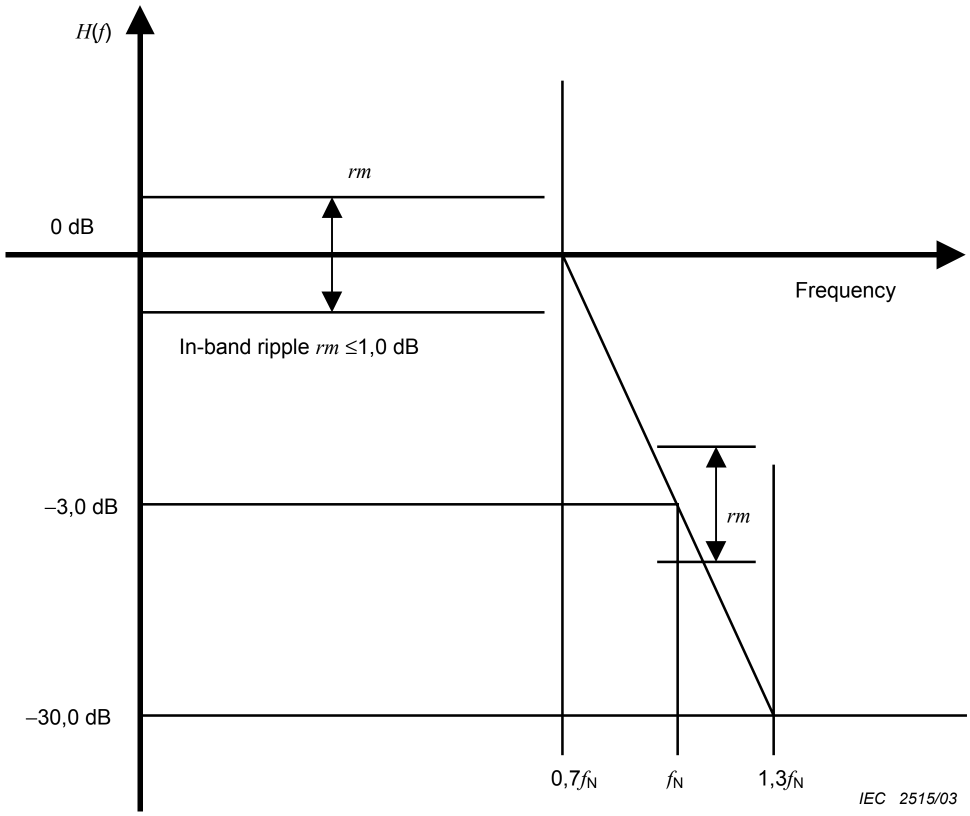


Figure 21 – Baseband filter characteristics

The filter should have a linear phase within the pass band ($f \le f_N$) and the group delay ripple should be less than 0,1T_s.

6.9.2 Modulation method

The modulation method of this format is intensity modulation of the carrier by using QPSK.

6.9.2.1 Sub-carrier

The sub-carrier frequency of the full-band mode shall be 4,5 MHz and that of the half-band mode shall be 3,75 MHz or 5,25 MHz.

6.9.2.2 Frequency accuracy

The frequency accuracy of the sub-carrier shall be ± 0,1%.

6.9.2.3 Occupied bandwidth

The occupied bandwidth is determined as follows:

$$\textit{Bandwidth} \text{ (in Hz)} = 0{,}8125 \times \textit{bit rate} \text{ (in bps)}$$

Example:

32 bit slots specified in IEC 60958

$3{,}072 \times 0{,}8125 = 2{,}496$ MHz (in case of 48 kHz sampling frequency)

$2{,}8224 \times 0{,}8125 = 2{,}34195$ MHz (in case of 44,1 kHz sampling frequency)

$2{,}048 \times 0{,}8125 = 1{,}664$ MHz (in case of 32 kHz sampling frequency)

7 Characteristics and measurements

7.1 Test conditions

Temperature: 15 °C to 35 °C

Humidity: 45 % RH to 75 % RH

Brightness: 500 lx to 1 000 lx (on the surface of the receiver)

Normal (i.e. not operating at high frequency) fluorescent lamps shall be used.

7.2 Location

A sufficiently large room should be used for test, so the reflection of infrared from the walls, floor and ceiling is negligible. The location specified in Figure 23 may be used if a correction for reflection is made.

An absorbing optical filter (neutral density or ND filter) is applied to the transmitter or the receiver. The following precautions are essential:

– take into account the correlation between the absorption of the filter and the transmitting distance;
– when measuring directivity, adjust the filter to the direction of the transmitter;
– maintain the brightness: 500 lx to 1 000 lx (at the receiver).

7.3 Transmitting distance and directivity

7.3.1 Transmitting distance

7.3.1.1 General

Calculate the transmitting distance d_0 (in m)(see Figure 24) in the optical axis from the specified radiant intensity I (in mW/sr) and the irradiance value E (in mW/m^2) using the following equation:

$$d_0 = \sqrt{\frac{I}{E}} \cdots\cdots \qquad (1)$$

The transmitting distance d (in m) at an angle of half-optical radiant intensity such as $H1$, $H2$, $V1$, and $V2$ (see Figure 25) is then as follows:

$$d = \sqrt{\frac{I}{2E}} = d_0 \times \frac{1}{\sqrt{2}} \qquad (2)$$

Rated transmitting distance is not specified in this standard.

7.3.1.2 Characteristics of the transmitter to be specified

Radiant intensity I (in mW/sr) in the optical axis (see Figure 26) should be measured by use of measurement methods in accordance with IEC 61603-1.

7.3.1.3 Characteristics of the receiver to be specified

Minimum required irradiance E (in mW/m^2) for a bit error ratio less than or equal to 10^{-9} should be measured under the following conditions (see Figure 27).

Direction: optical axis (0°)

Signal: 1 kHz digital audio source, when reproducing a sinewave signal recorded at a level 12 dB below "full scale" recorded digital audio signal.

The definition of "full scale" is specified in IEC 61938, 6.2.

NOTE Besides the general characteristics given in IEC 61603-1, other characteristics may need to be specified if a receiver (link B-C in Figure 22) is combined with other functions, such as a television set.

7.3.2 Maximum transmitting distance

Calculate the maximum transmitting distance from the specified radiant intensity I (see 7.3.1.2) and the irradiance value E (see 7.3.1.3) using the equation (1) in 7.3.1.1.

In another method, the maximum transmitting distance for a bit error ratio less than or equal to 10^{-9} under the conditions of 7.3.3 can be measured by aligning the optical axes of the transmitter and receiver, without measurement of the radiant intensity of transmitter and the irradiance at the receiver. The distance increases until the condition is fulfilled.

7.3.3 Directivity

7.3.3.1 Characteristics of the transmitter to be specified

Use an optical power meter to measure radiant intensity on the optical axis "AB" (as illustrated in Figure 28). Measure the radiant intensity at different vertical and horizontal angles θ_{H1} and θ_{V1} according to.7.3.1.2. Then, find the directivity of the transmitter by scaling the radiant intensity I (mW/sr) at various angles θ_{H1} and θ_{V1} at the transmitter to the maximum values (see Figure 29).

Calculate the directivity characteristics of the transmitting distance from the above directivity characteristics and the irradiance E of the receiver (see 7.3.1.3), using the equation (1) in 7.3.1.1.

7.3.3.2 Directivity characteristics of the receiver to be specified

Use a transmitter giving a higher signal-to-noise ratio and place the receiver to be measured on the optical axis (0 degree) as below (see Figure 30).

Measure the minimum required irradiance E (in mW/m^2) for a bit error ratio less than or equal to10^{-9} under the conditions of 7.3.1.3 by changing the distance between the reference transmitter and the receiver. Find the minimum required irradiance E (in mW/m^2) in direction "AB" (as illustrated in Figure 30) by measuring the irradiance at vertical and horizontal angles θ_{H2} and θ_{V2} at the receiver. Find the directional characteristics for the minimum required irradiance E of the receiver by measuring at various angles θ_{H2} and θ_{V2} (see Figure 31).

Calculate the directivity characteristic at the transmitting distance from the above directivity characteristics and the radiant intensity I (in mW/sr) of the transmitter (see 7.3.1.2) using the equation (1) in 7.3.1.1.

If a transmitter and receiver are specified, the directivity characteristic at the transmitting distance can be calculated by equivalent method.

7.4 Spurious level

Due to the modulation procedure used, the outgoing signal may contain energy components outside of the used channel, and other systems may be disturbed.

It is recommended that, for frequencies from 10 kHz to 100 MHz, the carrier-frequency level of the digital audio signal with respect to the spurious signal (high harmonics and cross-modulation signal) level in other signal bands, should be 30 dB or more, when measured in accordance with following conditions.

The measuring conditions shall be:

– no modulation;

– measuring band range: 0 MHz to 100 MHz;

– measuring system: as specified in Figure 32.

7.5 Accuracy of transmission-check frequency

The accuracy of the transmission-clock frequency shall be ±0,1 % or less.

8 Marking and contents of specifications

8.1 Marking

The marking of data marked X in Table 8 is optional, but recommended.

8.2 Contents of specifications

The specifications of the product shall include all the data marked X in Table 8, and all the data marked X in Table 3 of IEC 61603-1. The provision of data marked R in either table is optional but recommended.

Table 8 – Marking and contents of specifications

Clause	Specifications	
7.3	Transmitting distance and directivity	R
7.4	Spurious level	R
6.2	Input and output	X
6.3	Wavelength of carrier	X
6.4	Sub-carrier frequency	X
6.7	Signal source	X
6.9	Modulation	R
X : mandatory R : recommended		

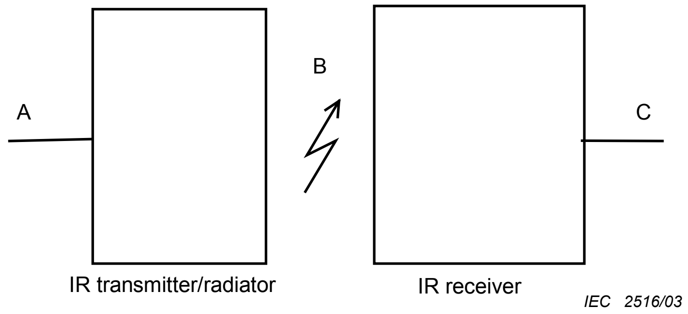


Figure 22 – Transmission chain

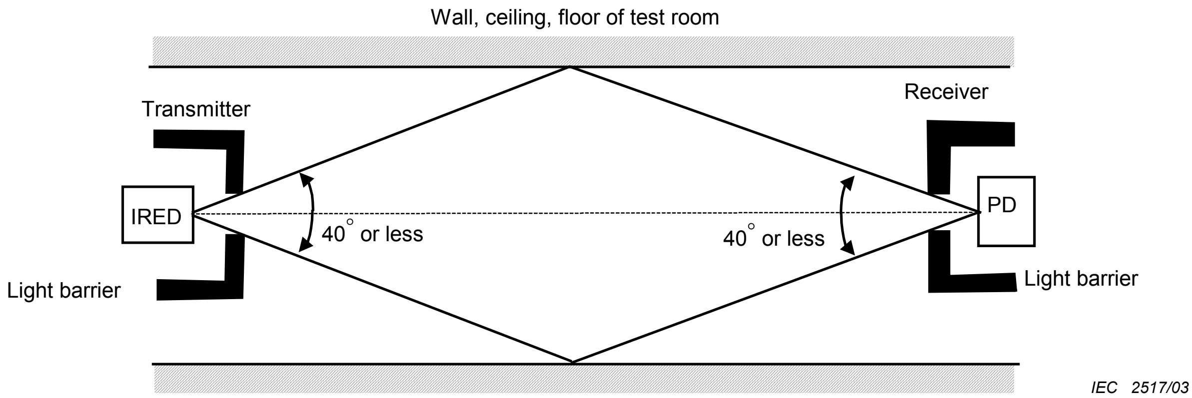


Figure 23 – Location for measurements

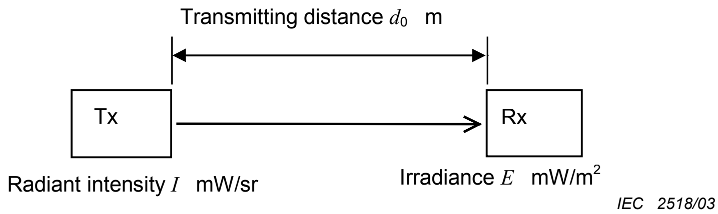


Figure 24 – Transmitting distance

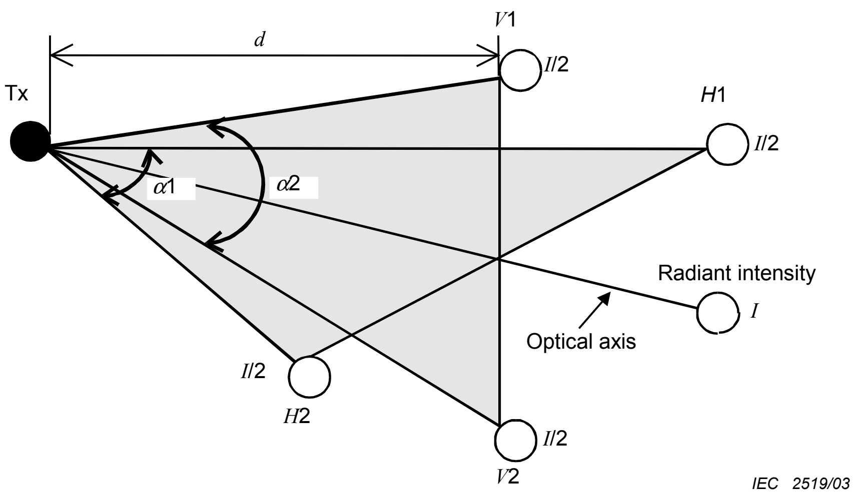


Figure 25 – Angle of half optical radiant intensity

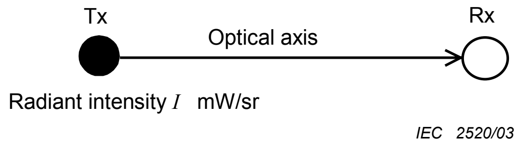


Figure 26 – Optical axis of the transmitter

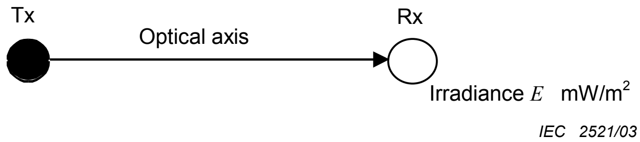


Figure 27 – Optical axis of the receiver

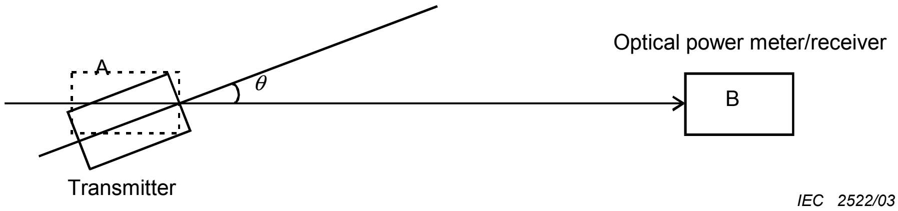


Figure 28 – Characteristics of the transmitter

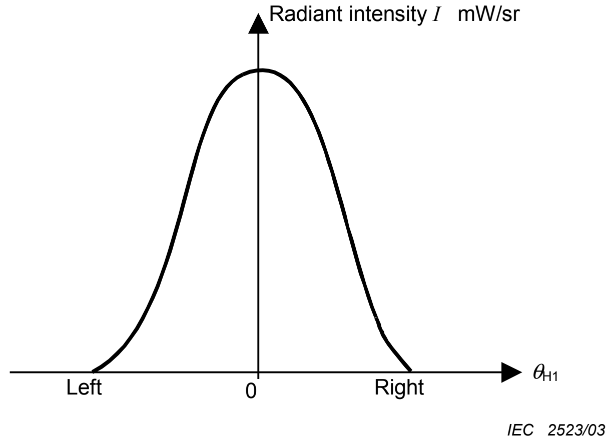


Figure 29a – Horizontal directivity

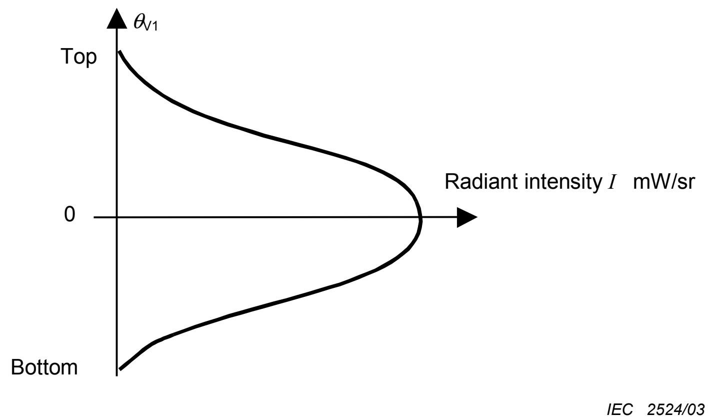


Figure 29b – Vertical directivity

Figure 29 – Directivity characteristics of the transmitter

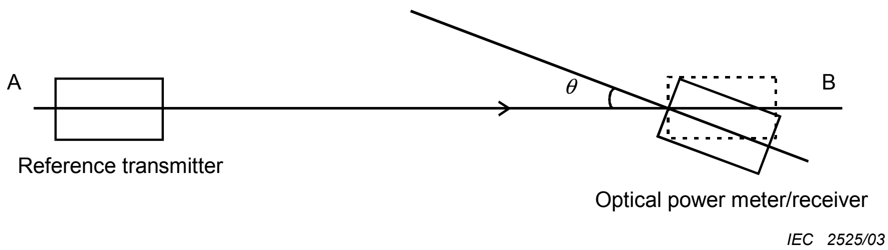


Figure 30 – Characteristics of the receiver

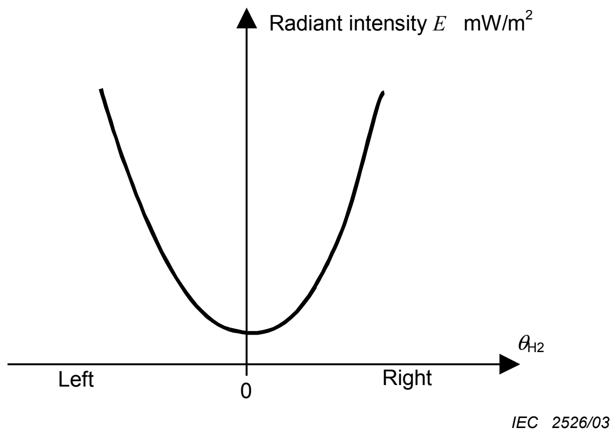


Figure 31a – Horizontal directivity

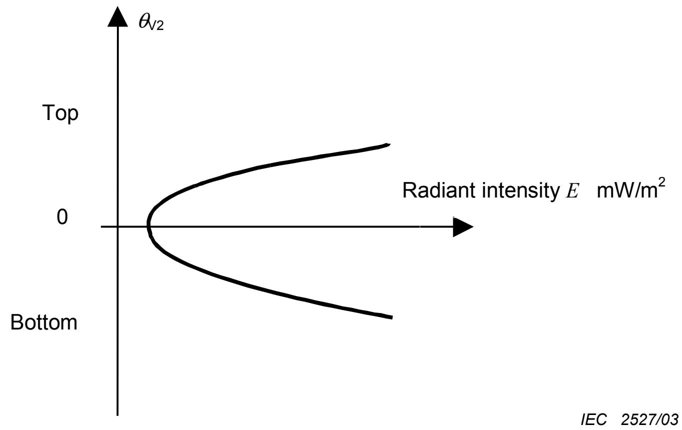


Figure 31b – Vertical directivity

Figure 31 – Directivity characteristics of the receiver

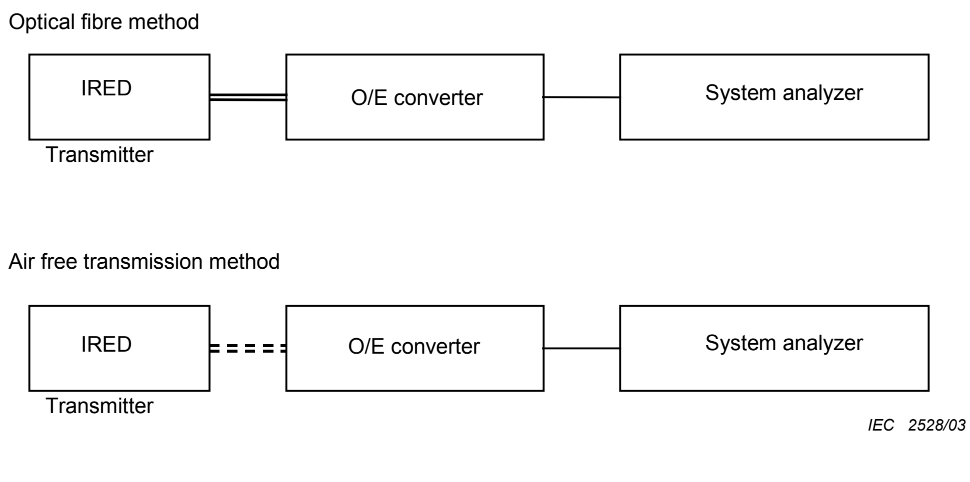


Figure 32 – Measuring system for spurious emission

Annex A
(normative)

Application of the transmission systems for digital audio and related signals using infrared radiation in the consumer audio mode

A.1 Full-band mode

A.1.1 Syntax of full-band mode

A.1.1.1 Source_info

Figure A.1 shows the structure of source_info.

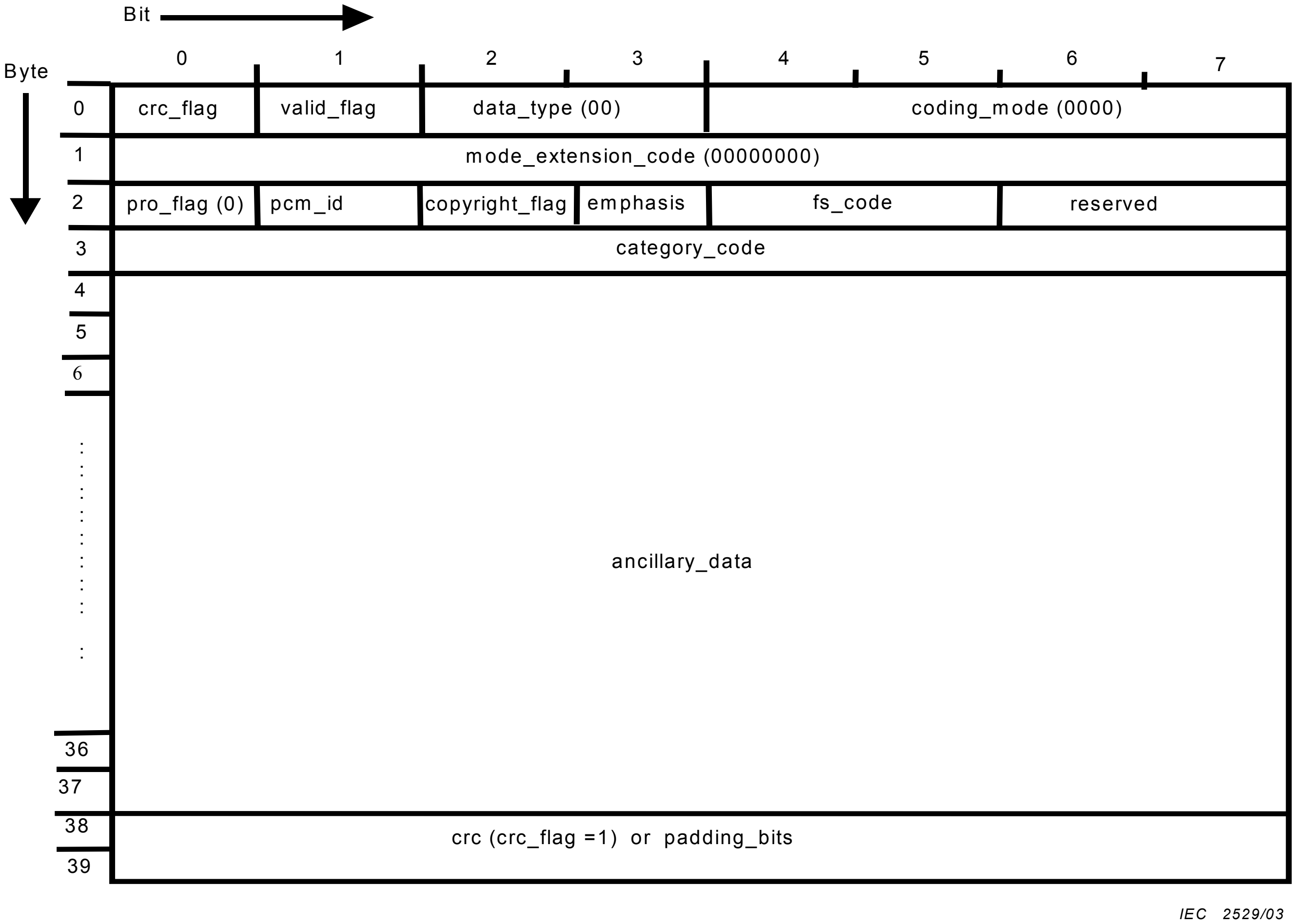


Figure A.1 – Source_info structure

The source_info function is as follows:

```
Source_info ( )
{
        crc_flag                                          1 bit
        valid_flag                                        1 bit
        data_type                                         2 bit
        coding_mode                                       4 bit
        mode_extension_code                               8 bit
        if ((data_type == 00) && (coding_mode == 0000)
            && (mode_extension_code == 0x00)) {
                pro_flag = 0                              1 bit
                pcm_id                                    1 bit
                        copyright_flag                    1 bit
                        emphasis                          1 bit
                        fs_code                           2 bit
                        reserved                          2 bit
                        category_code                     8 bit
                        ancillary_data ( )                34 byte
        }
        else {
                rsv_bits                                  36 byte
        }
        if (crc_flag) {
                crc                                       16 bit
        }
        else {
                padding_bits                              16 bit
        }
}
```

A.1.1.2 Source_block

If the “data_type” is equal to "00", the “coding_mode” is equal to "0000", and the “mode_extension_code” is equal to "0x00", the “source_block” is as follows:

```
Source_block ( )
{
        for (n = 0; n < 192; n++) {
                frame[ n ]                                 8 byte
        }
}
```

A.1.1.3 Frame and sub-frame

If the “data_type” is equal to "00", the “coding_mode” is equal to "0000", and the “mode_extension_code” is equal to "0x00", the frame and sub-frame are as follows:

```
frame [ n ]
{
        sub-frame [ 0 ]    /* L ch */                     4 byte
        sub-frame [ 1 ]    /* R ch */                     4 byte
}
```

```
sub-frame [ i ]     /* i = 0, 1 */
{
                free_field                                          4 bit
                24_bit_audio_sample_word_field  (LSB first)        24 bit
                V_field                                             1 bit
                U_field                                             1 bit
                C_field                                             1 bit
                P_field                                             1 bit
}
```

- L ch: left channel
- R ch: right channel

A.1.2 Semantics of full-band mode

A.1.2.1 Source_info

A.1.2.1.1 crc_flag

This 1-bit flag, shown in Table A.1, indicates whether CRC is added in the “source_block” and “source_info.” If this bit is equal to "0", no CRC is added. If this bit is equal to "1", CRC is added.

Table A.1 – crc_flag

crc_flag	CRC
0	off
1	on

A.1.2.1.2 Valid_flag

This flag, shown in Table A.2 is used to indicate whether the “source_block” contains errors. If the “source_block” is thought to be error free, the value of this flag should be set to "0". If the “source_block” contains some errors, this flag should be set to "1". The use of this flag by receivers is optional.

Table A.2 – Valid_flag

valid_flag	validity for source_block
0	error free
1	contains some errors

A.1.2.1.3 Data_type

This 2-bit code, shown in Table A.3, indicates the type of source data.

Table A.3 – Data_type

data_type	source data type
00	audio data
others	reserved

A.1.2.1.4 Coding_mode

This 4-bit code indicates the coding method. See Table A.4.

Table A.4

coding_mode	method
0000	linear PCM
others	reserved

A.1.2.1.5 Mode_extension_code

This 8-bit code indicates detail information of the “source_block.” See Table A.5.

Table A.5 – Mode_extension_code

data_type	coding_mode	mode_extension_code	mode
00	0000	0x00	IEC 60958 mode
others			reserved

A.1.2.1.6 pro_flag

If this flag, shown in Table A.6, is "0", the “source_info” is for consumer use. If “pro_flag” = 1, see Annex B.

Table A.6 – pro_flag

pro_flag	use of source_info
0	consumer use
1	professional use

A.1.2.1.7 pcm_id

If this bit is "0", the audio sample word represents the linear PCM sample. If this bit is "1", the audio sample word is used for other purposes.

Table A.7 – pcm_id

pcm_id	contents
0	linear PCM
1	other purposes

A.1.2.1.8 Copyright_flag

This 1-bit flag, shown in Table A.8, indicates copyright information.

Table A.8 – Copyright_flag

copyright_flag	copyright
0	software for which copyright is asserted
1	software for which no copyright is asserted

A.1.2.1.9 Emphasis

This 1-bit flag, shown in Table A.9, indicates whether pre-emphasis is used or not.

Table A.9 – Emphasis

emphasis	emphasis specified
0	none
1	50/15 μs

A.1.2.1.10 fs_code

This 2-bit code, shown in Table A.10, indicates the sampling frequency.

Table A.10 – fs_code

fs_code	sampling frequency
00	44,1 kHz
01	48 kHz
10	reserved
11	32 kHz

A.1.2.1.11 Category_code

This "category_code", which indicates category code defined in IEC 60958-3, should be copied from the source.

A.1.2.1.12 Ancillary_data

The default value of ancillary_data is "0".

A.1.2.1.13 CRC

"CRC" is a 16 bit CRC word obtained from 1 574 byte data as shown in Figure A.2.

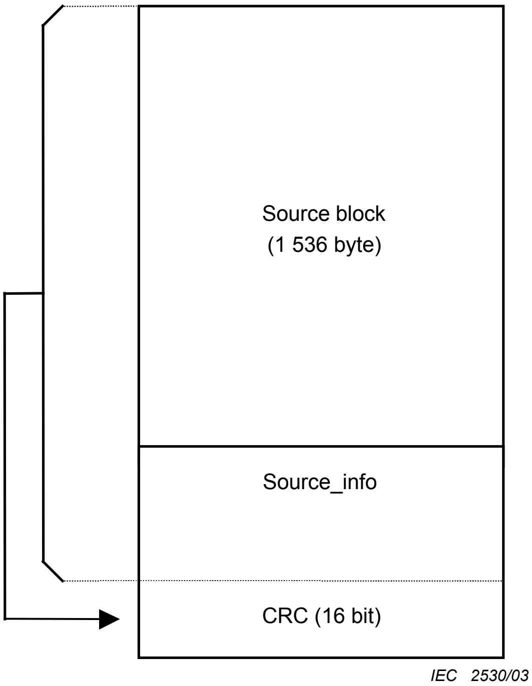


Figure A.2 – crc_area

Generator polynomial of CRC is shown as follows:

$$x^{16} + x^{15} + x^{2} + 1$$

with initial state of all zeros.

CRC can be implemented by linear feedback shift register. An example of this register circuit for the above generator polynomial is shown in Figure A.3.

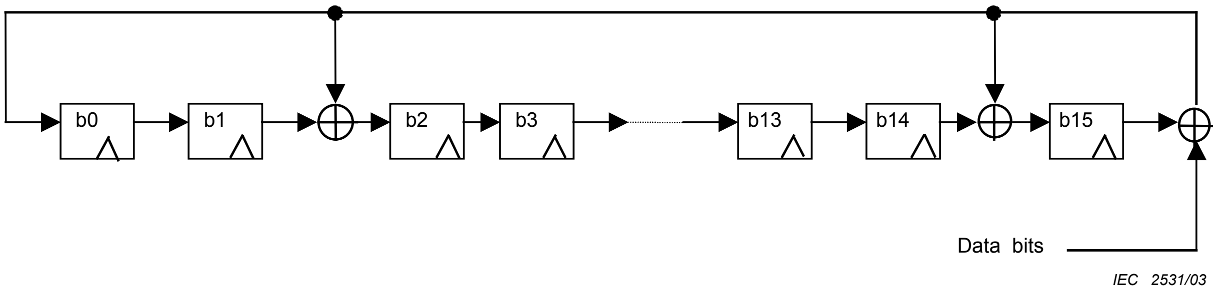


Figure A.3 – Linear feedback shift register circuit

A.1.2.1.14 Padding_bits

Each bit of padding_bits should be set to "0".

A.1.2.2 Source_block

“Source_block” corresponds to a block of IEC 60958.

Figure A.4 shows the sub-frame structure. This structure is similar to the IEC 60958 sub-frame.

Applications of free_field are not defined in this standard.

- The sub-frame consists of four bytes.
- The sub-frame[0] contains the audio sample word of left channel.
- The sub-frame[1] contains the audio sample word of right channel.
- 24-bit audio sample word, validity flag (V), user data (U), channel status (C), and parity bit (P) are copied from decoded IEC 60958 sub-frame, and located in 24_bit_audio_sample_word_field, V_field, U_field, C_field, and P_field, respectively.

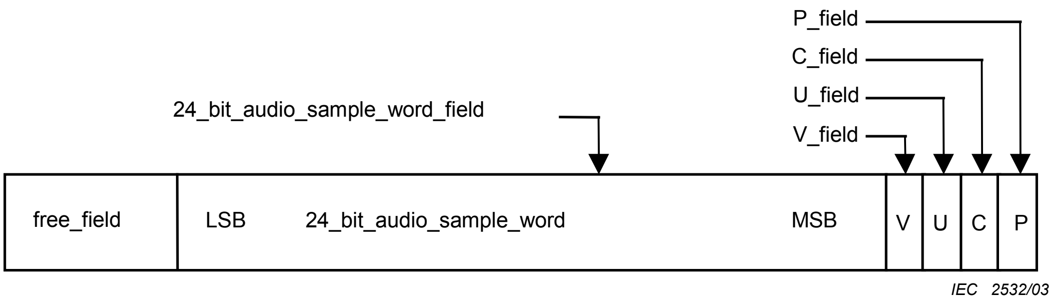


Figure A.4 – Sub-frame structure of full-band mode

A.2 Half-band mode

A.2.1 Syntax of half-band mode

A.2.1.1 Source_info

The structure of “source_info” of half-band mode is the same as that of the full-band mode. See Figure A.1.

The “source_info” function of half-band mode is the same as that of the full-band mode.

A.2.1.2 Source_block

If the “data_type” is equal to "00", the “coding_mode” is equal to "00", and the “mode_extension_code” is equal to "0x00", the “source_block” is as follows:

```
Source_block ( )
{
        for (n = 0; n < 384; n++) {
                frame[ n ]                              4 byte
        }
}
```

A.2.1.3 Frame and sub-frame

If the “data_type” is equal to "00", the “coding_mode” is equal to "00", and the “mode_extension_code” is equal to "0x00", the frame and sub-frame are as follows:

```
frame[ n ]
{
        sub-frame[ 0 ]  /* L ch */                  2 byte
        sub-frame[ 1 ]  /* R ch */                  2 byte
}

sub-frame[ i ]
{
        16_bit_audio_sample_word_field  (LSB first)  16 bit
}
```

A.2.2 Semantics of the half-band mode

A.2.2.1 Source_info

A.2.2.1.1 crc_flag

The “crc_flag” of the half-band mode is the same as that of the full-band mode. See Table A.1.

A.2.2.1.2 Valid_flag

The “valid_flag” of the half-band mode is the same as that of the full-band mode. See Table A.2.

A.2.2.1.3 Data_type

The “data_type” of the half-band mode is the same as that of the full-band mode. See Table A.3.

A.2.2.1.4 Coding_mode

The “coding_mode” of the half-band mode is the same as that of the full-band mode. See Table A.3.

A.2.2.1.5 Mode_extension_code

This 8-bit code indicates the detail information of the “source_block.” See Table A.4.

Table A.11 – Mode_extension_code

data_type	coding_mode	mode_extention_code	mode
00	0000	0x00	16 bit PCM mode
others			reserved

A.2.2.1.6 pro_flag

The “pro_flag” of the half-band mode is the same as that of the full-band mode. See Table A.6.

A.2.2.1.7 pcm_id

The “pcm_id” of the half-band mode is the same as that of the full-band mode. See Table A.7.

A.2.2.1.8 copyright_flag

The “copyright_flag” of the half-band mode is the same as that of the full-band mode. See Table A.8.

A.2.2.1.9 Emphasis

The emphasis of the half-band mode is the same as that of the full-band mode. See Table A.9.

A.2.2.1.10 fs_code

The “fs_code” of the half-band mode is the same as that of the full-band mode. See Table A.10.

A.2.2.1.11 Category_code

The “category_code” of the half-band mode is the same as that of the full-band mode. See Annex A.1.2.1.11.

A.2.2.1.12 Ancillary_data

The “ancillary_data” of the half-band mode is the same as that of the full-band mode. See Annex A.1.2.1.12.

A.2.2.1.13 CRC

The CRC of the half-band mode is the same as that of the full-band mode. See Annex A.1.2.1.13.

A.2.2.1.14 padding_bits

The “padding_bits” of the half-band mode is the same as that of the full-band mode. See Annex A.1.2.1.14.

A.2.2.1.15 Source_block

The “source_block” corresponds to 2 consecutive blocks of IEC 60958.

Figure A.5 shows the sub-frame structure.

- The sub-frame consists of two bytes.
- The sub-frame[0] contains audio sample word of left channel.
- The sub-frame[1] contains audio sample word of right channel.

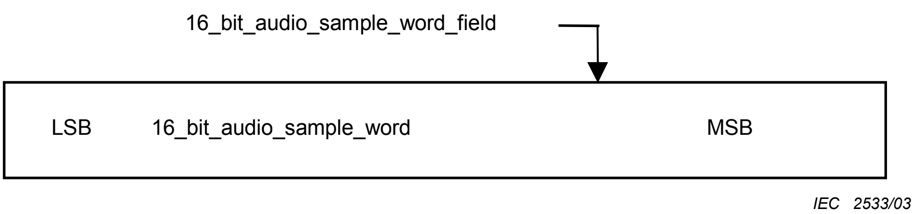


Figure A.5 – Sub-frame structure of half-band mode

Annex B
(normative)

Application of the transmission systems for digital audio and related signals using infrared radiation in the professional audio mode

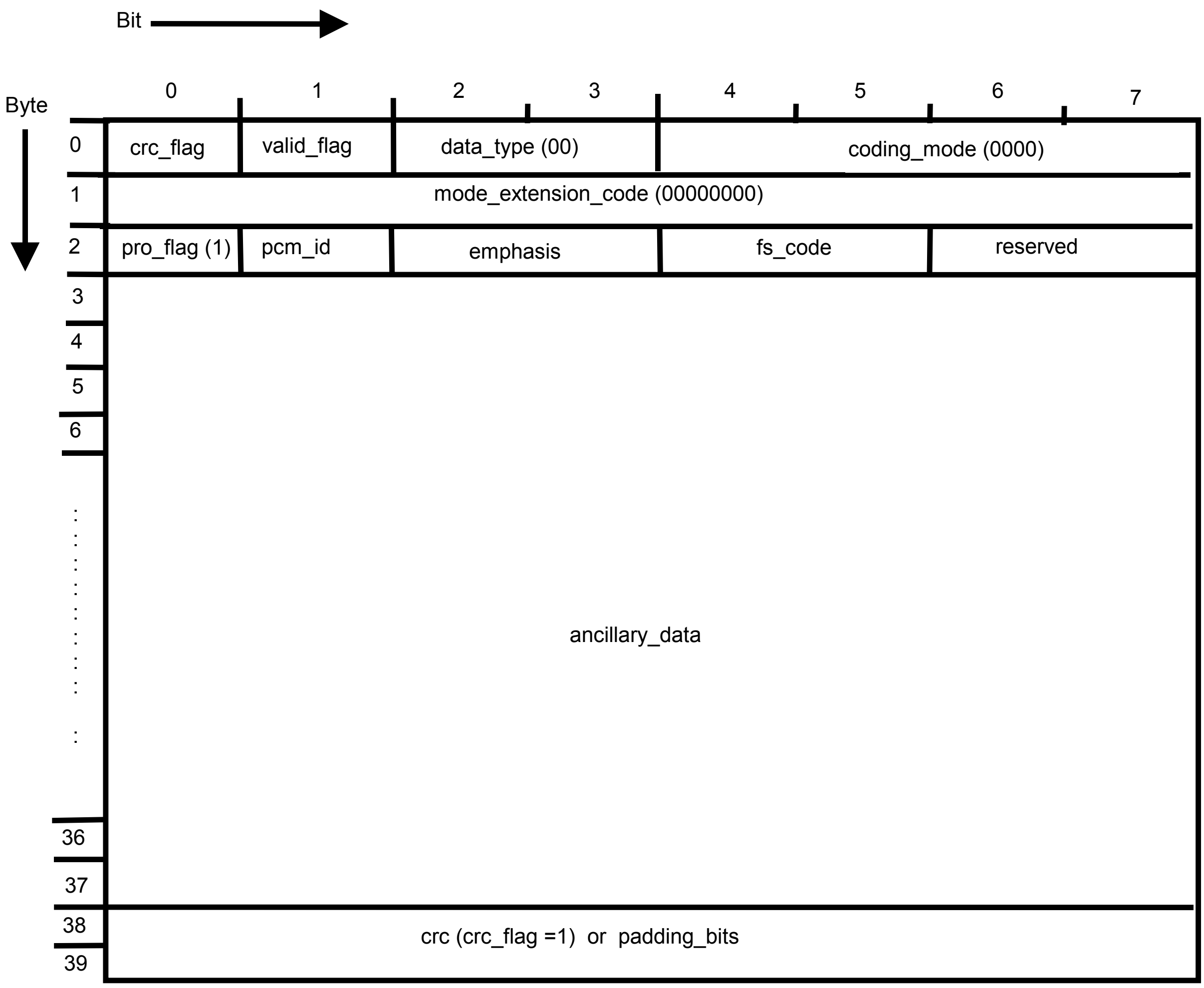
This annex applies to equipment in accordance with IEC 60958-4.

B.1 Full-band mode

B.1.1 Syntax of full-band mode

B.1.1.1 Source_info

Figure B.1 shows the structure of “source_info.”



IEC 2534/03

Figure B.1 – Source_info structure

The “source_info” function is as follows:

```
Source_info ( )
{
        crc_flag                                        1 bit
        valid_flag                                      1 bit
        data_type                                       2 bit
        coding_mode                                     4 bit
        mode_extension_code                             8 bit
        if ((data_type == 00) && (coding_mode == 0000)
            && (mode_extension_code == 0x00)) {
                pro_flag = 1                            1 bit
                pcm_id                                  1 bit
                        emphasis                        2 bit
                        fs_code                         2 bit
                        reserved                        2 bit
                        ancillary_data ( )              35 byte
        }
        else{
                rsv_bits                                36 byte
        }
        if (crc_flag) {
                crc                                     16 bit
        }
        else {
                padding_bits                            16 bit
        }
}
```

B.1.1.2 Source_block

If the “data_type” is equal to "00", the “coding_mode” is equal to "0000", and the “mode_extension_code” is equal to "0x00", the “source_block” is as follows:

```
Source_block ( )
{
        for (n = 0; n < 192; n++) {
                frame[ n ]                              8 byte
        }
}
```

B.1.1.3 Frame and sub-frame

If the “data_type” is equal to "00", the “coding_mode” is equal to "0000", and the “mode_code” is equal to "0x00", the frame and sub-frame are as follows:

```
frame [ n ]
{
        sub-frame [ 0 ]    /* L ch */                   4 byte
        sub-frame [ 1 ]    /* R ch */                   4 byte
}

sub-frame [ i ]    /* i = 0, 1 */
{
        free_field                                      4 bit
        24_bit_audio_sample_word_field  (LSB first)    24 bit
        V_field                                         1 bit
        U_field                                         1 bit
        C_field                                         1 bit
        P_field                                         1 bit
}
```

- L ch: left channel
- R ch: right channel

B.1.2 Semantics of full-band mode

B.1.2.1 Source_info

B.1.2.1.1 crc_flag

This 1-bit flag indicates whether CRC is added in the “source_block” and the “source_info.” If this bit is equal to "0", no CRC is added. If this bit is equal to "1", CRC is added.

Table B.1 – Crc_flag

crc_flag	CRC
0	off
1	on

B.1.2.1.2 Valid_flag

This flag, shown in Table B.2 is used for indicating whether the “source_block” contains errors. If the “source_block” is thought to be error free, the value of this flag should be set to "0". If the “source_block” contains some errors, this flag should be set to "1". The use of this flag by receivers is optional.

Table B.2 – Valid_flag

valid_flag	validity for source_block
0	error free
1	contains some errors

B.1.2.1.3 Data_type

This 2-bit code, shown in Table B.3, indicates type of source data.

Table B.3 – Data_type

data_type	source data type
00	audio data
others	reserved

B.1.2.1.4 Coding_mode

This 4-bit code indicates the coding method. See Table B.4.

Table B.4 – Coding_mode

coding_mode	method
0000	linear PCM
others	reserved

B.1.2.1.5 Mode_extension_code

This 8-bit code indicates detail information of the “source_block.” See Table B.5.

Table B.5 – Mode_extension_code

data_type	coding_mode	mode_extension_code	mode
00	0000	0x00	IEC60958 mode
others			reserved

B.1.2.1.6 pro_flag

If this flag is "1", the “source_info” is for professional use. If the “pro_flag” = 0, see Annex A.

Table B.6 – pro_flag

pro_flag	use of source_info
0	consumer use
1	professional use

B.1.2.1.7 pcm_id

This 1-bit code, shown in Table B.7, indicates pcm_id.

If this bit is "0", the audio sample word represents a linear PCM sample. If this bit is "1", the audio sample word is used for other purposes.

Table B.7 – pcm_id

pcm_id	contents
0	linear PCM
1	other purposes

B.1.2.1.8 Emphasis

This 2-bit flag, shown in Table B.8, indicates whether pre-emphasis is used or not.

Table B.8 – Emphasis

emphasis	emphasis specified
00	not indicated
01	no emphasis
10	50/15 µs
11	ITU-T J.17 emphasis

B.1.2.1.9 fs_code

This 2-bit code, shown in Table B.9, indicates sampling frequency.

Table B.9 – fs_code

fs_code	sampling frequency
00	not indicated
01	48 kHz
10	44,1 kHz
11	32 kHz

B.1.2.1.10 Ancillary_data

The default value of “ancillary_data” is "0".

B.1.2.1.11 CRC

"CRC" is a 16 bit CRC word obtained from 1 574 byte data as shown in Figure B.2.

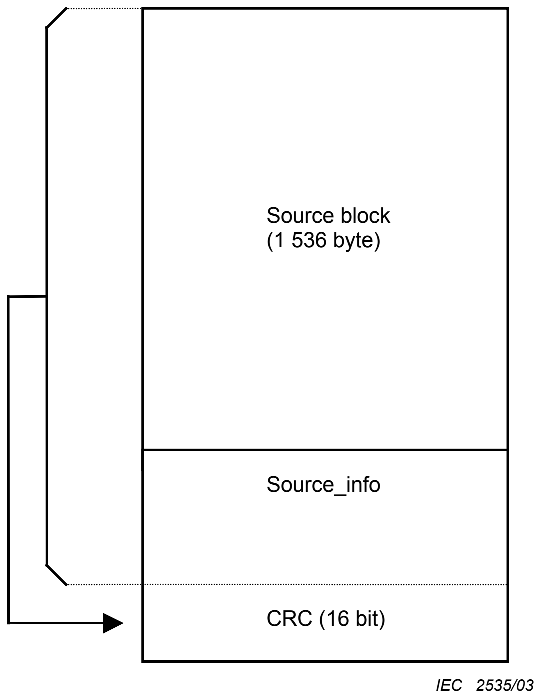


Figure B.2 – CRC area

Generator polynomial of CRC is shown as follows:

$$x^{16} + x^{15} + x^{2} + 1$$

with initial state of all zeros.

CRC can be implemented by linear feedback shift register. An example of this register circuit for the above generator polynomial is shown in Figure B.3.

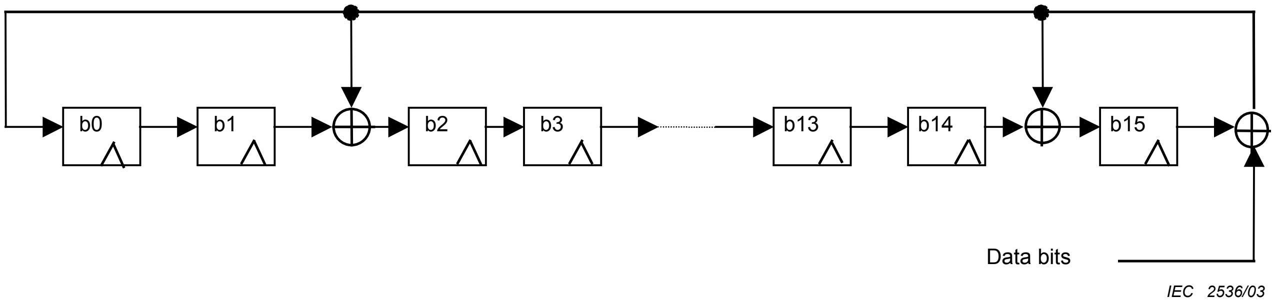


Figure B.3 – Linear feedback shift register circuit

B.1.2.1.12 Padding_bits

Each bit of “padding_bits” should be set to "0".

B.1.2.2 Source_block

The “source_block” corresponds to a block of IEC 60958.

Figure B.4 shows the sub-frame structure. This structure is similar to the IEC 60958 sub-frame.

Applications of “free_field” are not defined in this standard. This area is released for the user’s application.

– The sub-frame consists of four bytes.
– The sub-frame[0] contains audio sample word of left channel.
– The sub-frame[1] contains audio sample word of right channel.
– 24-bit audio sample word, validity flag (V), user data (U), channel status (C), and parity bit (P) are copied from decoded IEC 60958 sub-frame, and located in 24_bit_audio_sample_word_field, V_field, U_field, C_field, and P_field, respectively.

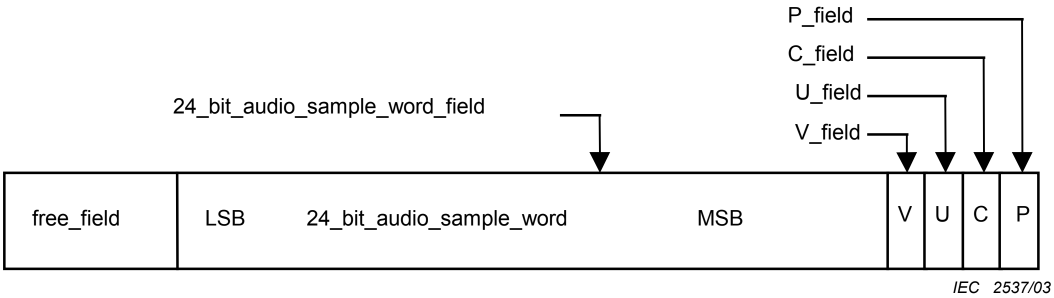


Figure B.4 – Sub-frame structure of full-band mode

B.2 Half-band mode

B.2.1.1 Syntax of half-band mode

The structure of the “source_info” of the half-band mode is the same as that of the full-band mode. See Figure B.1.

The “source_info” function of the half-band mode is the same as that of the full-band mode.

B.2.1.2 Source_block

If the “data_type” is equal to "00", the “coding_mode” is equal to "00", and the “mode_extension_code” is equal to "0x00", the “source_block” is as follows:

```
Source_block ( )
{
        for (n = 0; n < 384; n++) {
                frame[ n ]                                   4 byte
        }
}
```

B.2.1.2.1 Frame and sub-frame

If the “data_type” is equal to "00", the “coding_mode” is equal to "00", and the “mode_extension_code” is equal to "0x00", the frame and sub-frame are as follows:

```
frame[ n ]
{
        sub-frame[ 0 ]  /* L ch */                           2 byte
        sub-frame[ 1 ]  /* R ch */                           2 byte
}


sub-frame[ i ]
{
        16_bit_audio_sample_word_field  (LSB first)          16 bit
}
```

B.2.2 Semantics of half-band mode

B.2.2.1 Source_info

B.2.2.1.1 crc_flag

The “crc_flag” of the half-band mode is the same as that of the full-band mode. See Table B.1.

B.2.2.1.2 Valid_flag

The “valid_flag” of the half-band mode is the same as that of the full-band mode. See Table B.2.

B.2.2.1.3 Data_type

The “data_type” of the half-band mode is the same as that of the full-band mode. See Table B.3.

B.2.2.1.4 Coding_mode

The“coding_mode” of the half-band mode is the same as that of the full-band mode. See Table B.4.

B.2.2.1.5 Mode_extension_code

This 8-bit code indicates the detailed information of the "source_block." See Table B.10.

Table B.10 – Mode_extension_code

data_type	coding_mode	mode_extention_code	mode
00	0000	0x00	16 bit PCM mode
others			reserved

B.2.2.1.6 pro_flag

The "pro_flag" of the half-band mode is the same as that of the full-band mode. See Table B.6.

B.2.2.1.7 pcm_id

The "pcm_id" of the half-band mode is the same as that of the full-band mode. See Table B.7.

B.2.2.1.8 Emphasis

The emphasis of the half-band mode is the same as that of the full-band mode. See Table B.8.

B.2.2.1.9 fs_code

The "fs_code" of the half-band mode is the same as that of the full-band mode. See Table B.9.

B.2.2.1.10 Ancillary_data

The "ancillary_data" of the half-band mode is the same as that of the full-band mode. See Annex B.1.2.1.10.

B.2.2.1.11 CRC

The "CRC" of the half-band mode is the same as that of the full-band mode. See Annex B.1.2.1.11.

B.2.2.1.12 Padding_bits

The "Padding_bits" of the half-band mode is the same as that of the full-band mode. See Annex B.1.2.1.12.

B.2.2.1.13 Source_block

The "source_block" corresponds to 2 consecutive blocks of IEC 60958.

Figure B.5 shows the sub-frame structure.

- The sub-frame consists of two bytes.
- The sub-frame[0] contains audio sample word of left channel.
- The sub-frame[1] contains audio sample word of right channel.

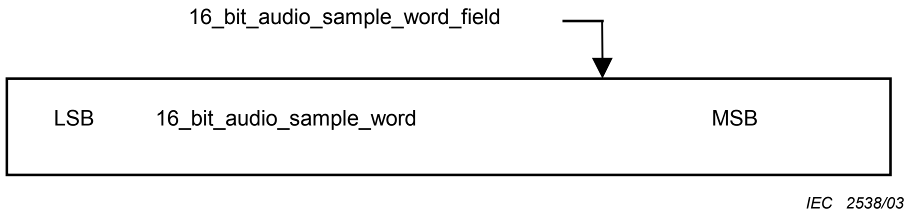


Figure B.5 – Sub-frame structure of half-band mode

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