INTERNATIONAL STANDARD

IEC 61603-7

First edition
2003-05

Transmission systems of audio and/or video and related signals using infra-red radiation –

Part 7: Digital audio signals for conference and similar applications

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TRANSMISSION SYSTEMS OF AUDIO AND/OR VIDEO AND RELATED SIGNALS USING INFRA-RED RADIATION –

Part 7: Digital audio signals for conference and similar applications

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International Standard IEC 61603-7 has been prepared by Technical Area 3, Infrared systems and applications, of IEC technical committee 100: Audio, video and multimedia systems and equipment.

This first edition cancels and replaces 2.6.2 of IEC 61603-3 (1997).

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

FDIS	Report on voting
100/649/FDIS	100/676/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- withdrawn;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 SYSTEMS OF AUDIO AND/OR VIDEO AND RELATED SIGNALS USING INFRA-RED RADIATION –

Part 7: Digital audio signals for conference and similar applications

1 Scope

This part of IEC 61603 describes the characteristics of a digital multiple channel, multiple carrier audio transmission system as an extension to conference interpretation or similar systems using the frequency ranges 45 kHz to 1 MHz and 2 MHz to 6 MHz.

NOTE These frequency ranges are also covered by analogue pulse systems used for the same applications. Interference is not expected because both transmission systems are normally not applied at the same time in the same room.

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

IEC 61603-3:1997, *Transmission of audio and/or video and related signals using infrared radiation – Part 3: Transmission systems for audio signals for conference and similar systems*

IEC 61920, *Infrared transmission systems – Free air applications*[1]

ISO/IEC 7498-1:1994, *Information technology – Open Systems Interconnection – Basic Reference Model: The Basic Model*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61603-1 apply.

4 Abbreviations

APCM	Adaptive pulse code modulation
AQM	Audio quality mode
CAT	Channel allocation table
CM	Configuration message
CRC	Cyclic redundancy check
DCI	Display changed identifier
DM	Display message
DM-CRC	Data message CRC

[1] To be published. For the purposes of the reference in C.1, IEC 61920:1998 is equally valid.

DMI	Data message identifier
DML	Data message length
DQPSK	Differential quadrature phase shift keying
HQ	High quality
MAXCN	Maximum channel number
MHQ	Mono high quality
MMQ	Mono medium quality
MQ	Medium quality
OSI	Open systems interconnection
PCM	Pulse code modulation
PRBS	Pseudo-random binary sequence
SCI	Source coding identifier
SEI	Setting changed identifier
SF	Scale factor
SHQ	Stereo high quality
SMQ	Stereo medium quality
SRRC	Square root raised cosine
XOR	Exclusive OR

5 Explanation of terms and general information

For the purposes of this part of IEC 61603, the explanation and information given in IEC 61603-3, Clause 2, apply.

6 System considerations

For the purposes of this part of IEC 61603, the considerations given in IEC 61603-3, Clause 3, apply.

NOTE With regard to the primary band, the special caution advised in IEC 61603-3, 3.3 should be observed, especially for inductive lighting and future developments.

7 Basic system concept

The basic system concept is shown in Figure 1.

The system consists of a number (N) of audio sources, either analogue or digital, which are connected to a transmitter. The transmitter processes the audio signals (in accordance with the protocol described in Clause 8) into an electrical output to feed the infrared radiator. The infrared signal is received by the infrared receiver that processes the signal and outputs an audio signal and/or associated data.

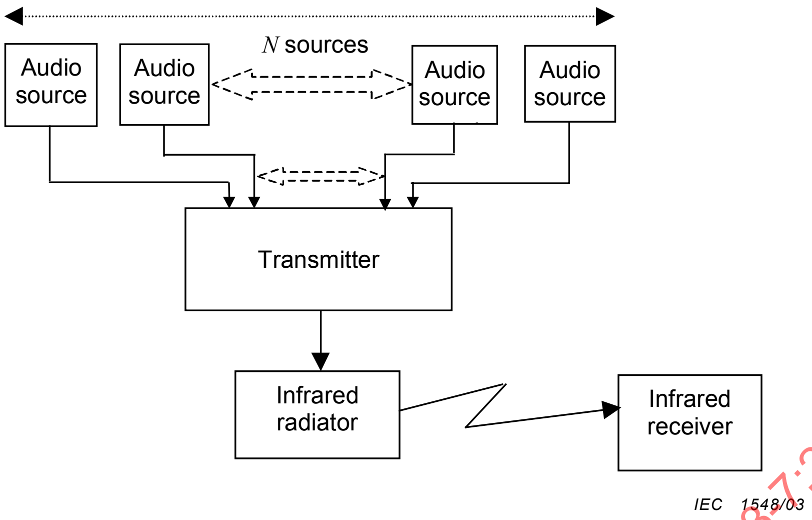


Figure 1 – System

8 Protocol

8.1 System context

In terms of the conceptual OSI reference model, the transmission protocol shall implement the following layers:

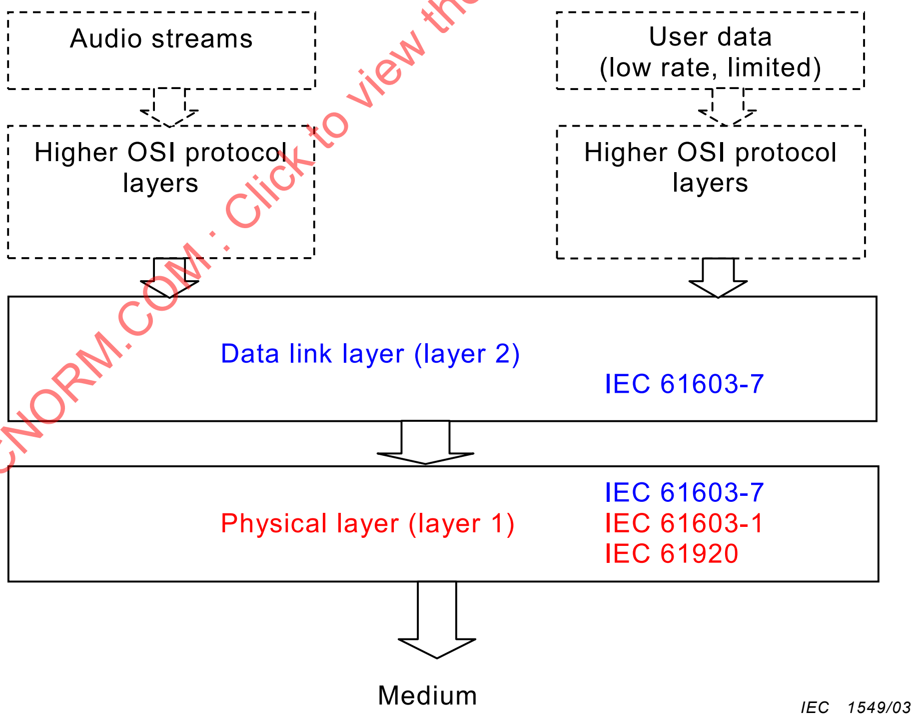


Figure 2 – Conceptual model

Figure 2 shows the system context using the OSI reference model. Layers 1 and 2 will be part of the transmission protocol defined in this standard.

8.2 Physical layer

8.2.1 General

OSI layer 1 (physical layer) shall use infrared radiation as the transfer medium between radiator and receiver as specified in IEC 61920 and IEC 61603-1.

8.2.2 Carrier

Optical wavelength at the optical peak intensity λ_P : 875 nm ± 25 nm

8.2.3 Sub-carriers

Primary frequency band (band IV): 2 MHz – 6 MHz

Secondary frequency band (band II): 45 kHz – 1 MHz.

NOTE The secondary frequency band, 45 kHz to 1 MHz, is under consideration.

Figure 3 shows the wideband allocation in the primary band, with the frequencies of each sub-carrier. A guard band between the transmission bands has been included. Table 1 shows the frequencies of each sub-carrier.

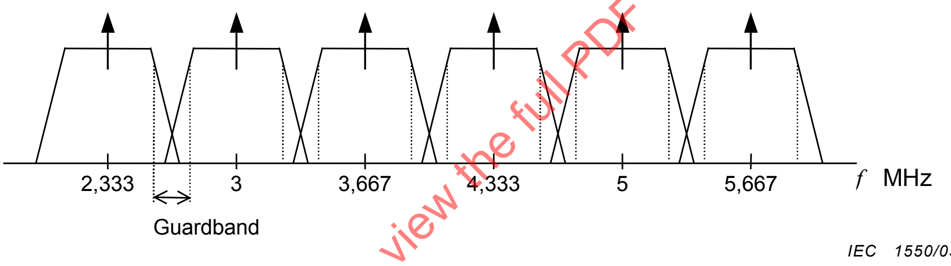


Figure 3 – Band allocation for 6 modulated sub-carriers

Table 1 – Sub-carrier centre frequencies

Sub-carrier	Frequency kHz
CC1	2333,333
CC2	3000
CC3	3666,667
CC4	4333,333
CC5	5000
CC6	5666,667

8.2.4 Occupied bandwidth

The occupied bandwidth is defined as follows.

$$B_{occ} = r_S \cdot (1 + \beta)$$

where

B_{occ} is the occupied bandwidth;

r_s is the symbol rate (= $\frac{r_b}{2}$ for (D)QPSK, r_b is the bit rate (see 8.3));

β is the roll-off factor (see 8.2.6).

8.2.5 Sub-carrier modulation

The modulation method is (D)QPSK. The constellation is shown in Figure 4a. The differential decoding algorithm is shown in Figure 4b. The phase transitions for the differential encoding algorithm are also listed in Table 2.

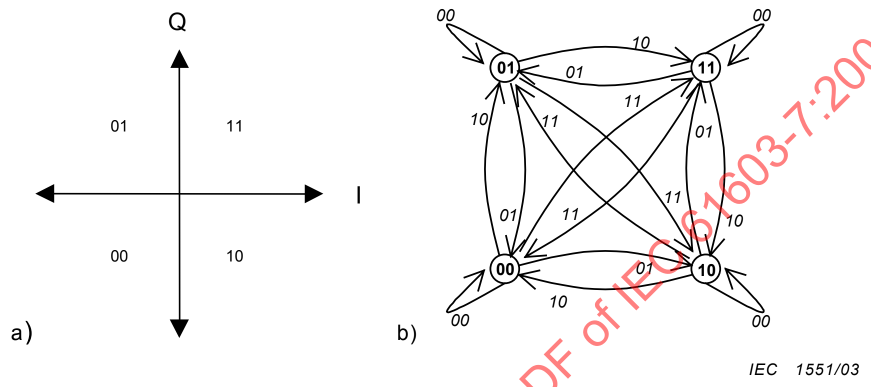


Figure 4 – (D)QPSK constellation and differential decoding algorithm

Table 2 – Phase transitions of the differential encoding algorithm

Phase change	Symbol IQ
0°	00
90°	01
180°	11
–90°	10

8.2.6 Filter characteristics

A channel filter is included. A square root raised cosine (SRRC) characteristic, as illustrated in Figure 5, is implemented in both the transmitter and the receiver resulting in a total transfer characteristic of a raised cosine.

The roll-off factor of the filter is β = 0,4.

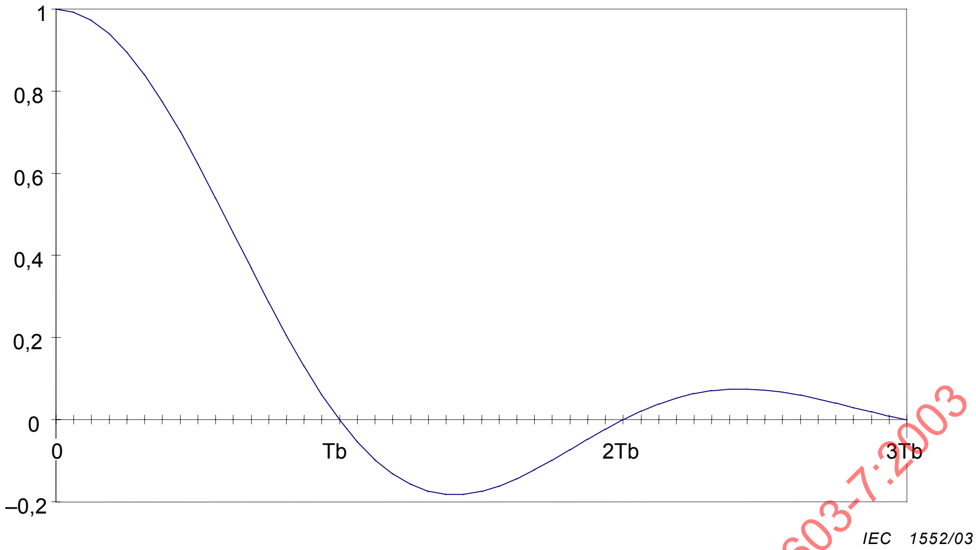


Figure 5 – Pulse response of a raised cosine channel filter

The combined filter characteristic from the transmitting and receiving filter shall be in accordance with the following equation:

$$P_r(f) = \begin{cases} T_b & |f| \le \frac{r_b}{2}(1-\beta) \\ T_b \bullet \cos^2 \frac{\pi}{4\beta}\left(|f| - \frac{r_b}{2}(\beta+1)\right) & \frac{r_b}{2}(1-\beta) < |f| \le \frac{r_b}{2}(1+\beta) \\ 0 & |f| > \frac{r_b}{2}(1+\beta) \end{cases}$$

where

$P_r(f)$ is the power transfer function;

f is the frequency (Hz);

r_b is the bit rate (bit/s);

$T_b = 1/r_b$

β is the roll-off factor.

8.2.7 Channel coding

8.2.7.1 Reed-Solomon encoder

A shorted Reed-Solomon encoder (n,k,d) = (28,24,5) on 8-bit symbols is used. The Reed-Solomon encoder operates in Galois Field GF(2^8).

The field generator polynomial is:

$$p(x) = x^8 + x^4 + x^3 + x^2 + 1$$

The code generator polynomial is:

$$g(x) = \prod_{i=0}^{3} \left(x + \alpha^{i}\right)$$

$$= x^4 + \alpha^{75} x^3 + \alpha^{249} x^2 + \alpha^{78} x + \alpha^6$$

α = 02(HEX)

8.2.7.2 Scrambler

The scrambler consists of an XOR gate and a pseudo-random binary sequence (PRBS) generator. The length of the PRBS is 11 bits and is initialized after every frame sync. The polynomial that is used for the PRBS is

$$1 + x^9 + x^{11}$$

and the initial pattern is

Initial pattern = “10010101000”

A diagram of the scrambler is shown in Figure 6. Scrambling is not applied to the frame sync.

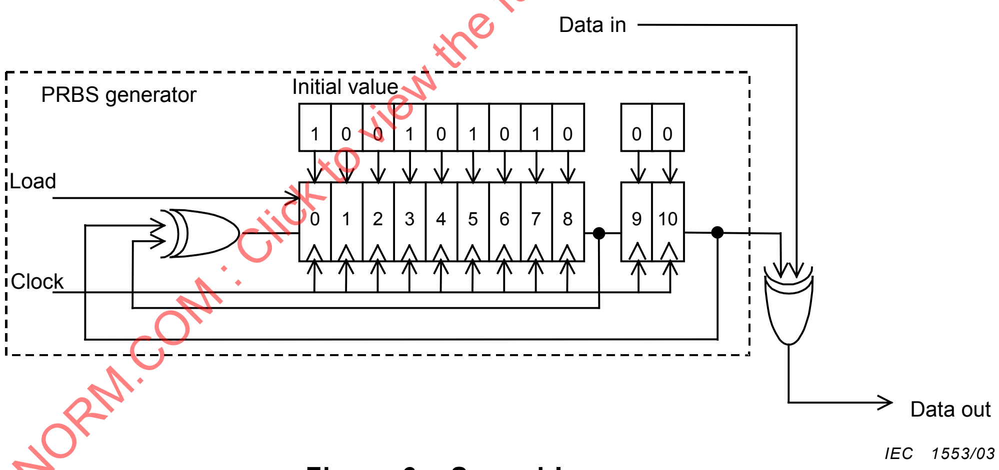


Figure 6 – Scrambler

8.2.8 Audio source coding

8.2.8.1 General

The linear PCM audio signal (f_s = 44,1 kHz) is divided into 4 sub-band signals by an (analysis) filter bank. The 4 sub-band signals are decimated by a factor 4 and quantized by an adaptive pulse code modulation (APCM) coding scheme. A block diagram of the encoder is shown in Figure 7.

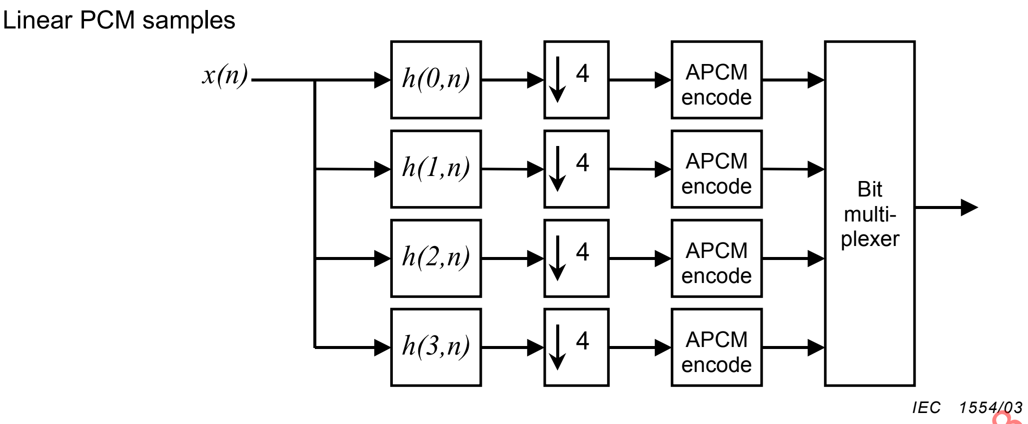


Figure 7 – Block diagram of sub-band APCM encoder

Two coding qualities are available: medium quality (MQ) and high quality (HQ). The characteristics are shown in Table 3.

Table 3 – Characteristics of sub-band APCM encoder

Parameter	MQ	HQ
Audio bandwidth (kHz)	10	20
Number of used sub-bands	2	4
Bit-pool	11	22
Output bit-rate (kbit/s)	136	272

8.2.8.2 Filter banks

The analysis filters are represented by $h(k,n)$. These filters are derived from a prototype filter $p(n)$ with length L = 40 (see Annex A). With k the number of the sub-band, $k \in (0,3)$ and n the index of the prototype filter $n \in (0,L-1)$ the following is given:

$$h(k,n) = c_a(k,n) \times p(n)$$

with

$$c_a = \cos\left(\frac{\pi}{4} \times (n-2) \times \left(k + \frac{1}{2}\right)\right)$$

8.2.8.3 Sub-band APCM coding

The decimator output samples are saved in buffers. Each 24-sample period (544 µs), 4 blocks of 6 sub-band samples are filled and available for APCM coding.

The sub-band APCM coding operates on 16 bit samples and performs the steps listed below.

NOTE At the output of the decimators all samples have to be quantized to 16 bits.

The value k specifies the index of the sub-band, $k \in (0,3)$ for HQ and $k \in (0,1)$ for MQ coding. The value n_{bands} specifies the number of coded sub-bands, 4 for HQ and 2 for MQ coding.

a) The largest absolute value in each block is searched for: $M(k)$.

b) From the value of $M(k)$, the scale factor (SF) $F_{\text{scale}}(k)$ is calculated:
$$F_{\text{scale}}(k) = \left\lfloor {}^{2}\log(M(k)) \right\rfloor$$

c) From the SF values, the number of bits per sub-band is calculated: $n_{\text{bits}}(k) \leftarrow F_{\text{scale}}(k)$

– $n_{\text{bits}}(k) = \max\left(F_{\text{scale}}(k) - W, 0\right)$

with $W = \left\lceil \dfrac{\sum_{\forall k} F_{\text{scale}}(k) - B}{n_{\text{bands}}} \right\rceil$

where B = bit-pool (see Table 3)

– while $\sum_{\forall k} n_{\text{bits}}(k) < B \rightarrow$ increment $n_{\text{bits}}(k)$ by 1, starting with k = 0 and increasing k until $\sum_{\forall k} n_{\text{bits}}(k) = B$

while $\sum_{\forall k} n_{\text{bits}}(k) > B \rightarrow$ decrement $n_{\text{bits}}(k)$ by 1, starting with k = 3 (HQ) or k = 1 (MQ) and decreasing k until $\sum_{\forall k} n_{\text{bits}}(k) = B$

d) quantize all samples in the block of sub-band k to $n_{\text{bits}}(k)$ bits (see example of 7-bit quantization in Figure 8)

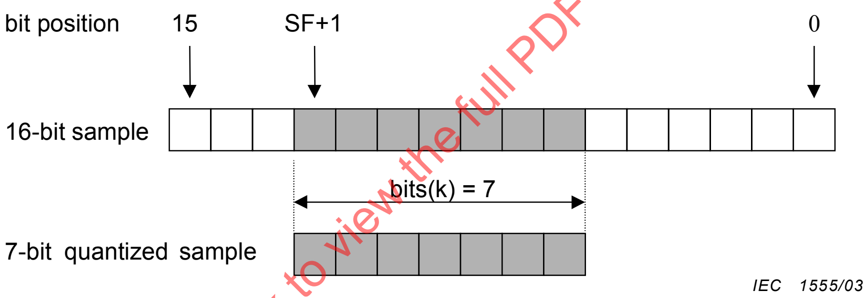


Figure 8 – Quantization of sub-band samples

The output of the sub-band APCM coder consists of all quantized sub-band samples together with the scale factors.

8.3 Data link layer

8.3.1 General

The major building block of the data link layer protocol is a superframe (see Figure 9).

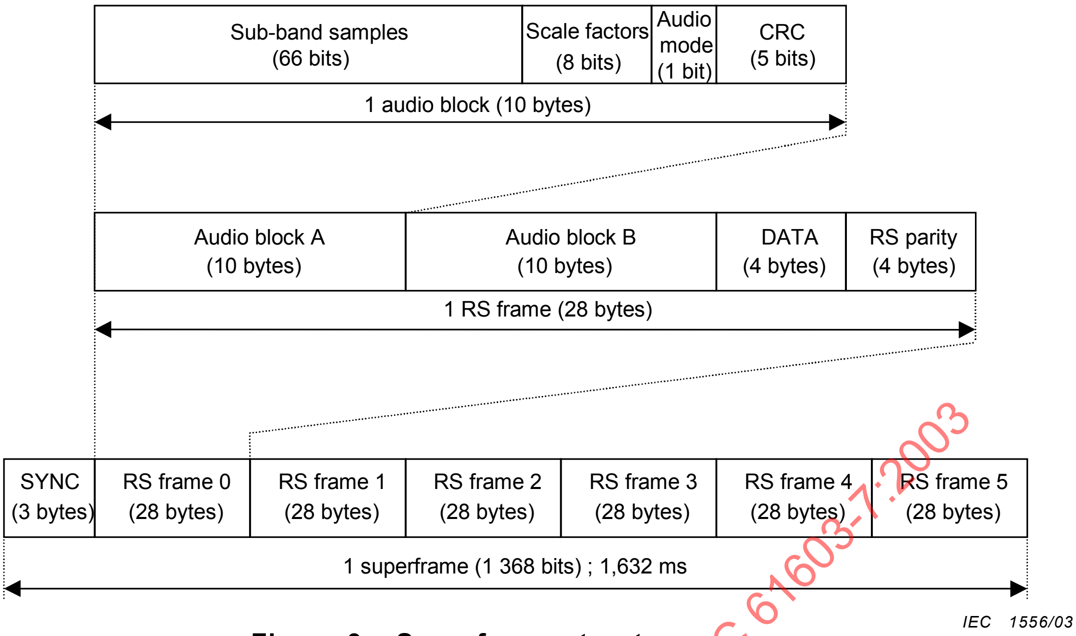


Figure 9 – Superframe structure

A superframe consists of a SYNC pattern followed by 6 RS frames. This results in a size of 1 368 bits per superframe. With a bit-rate of 837,9 kbit/s, the total length of a superframe is 1,632 ms. This is exactly 3 times the length of an APCM frame (at the input of an encoder).

8.3.2 Synchronization information

Before 6 consecutive RS frames a SYNC word is transmitted. The SYNC word equals the hexadecimal value D21DB8.

8.3.3 Error coding redundancy

A Reed-Solomon encoder is applied to protect the audio and data information from transmission errors. The Reed-Solomon encoder adds 4 bytes of redundant information, to each pair of audio blocks in combination with 1 data slot. An RS(28,24) in GF(2^8) has been chosen (see 8.2.7). The structure of an RS frame is shown in Figure 10.

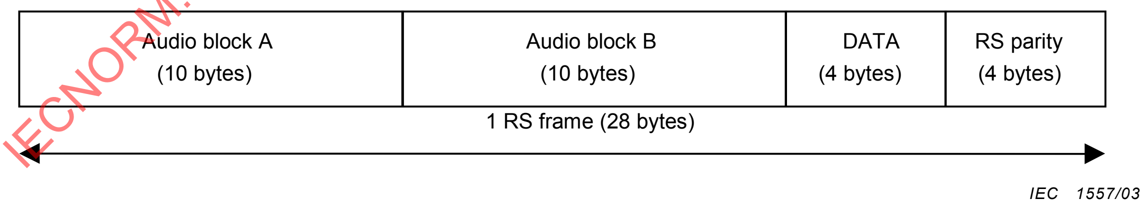


Figure 10 – RS frame structure

8.3.4 Audio blocks

One audio block carries 10 bytes of audio information. These 80 bits are divided into 66 bits for APCM sub-band samples, 8 bits for APCM scale factors, 1 bit for the audio mode, and 5 bits for the CRC protection on the scale factor and audio mode bits. The structure of an audio block is shown in Figure 11.

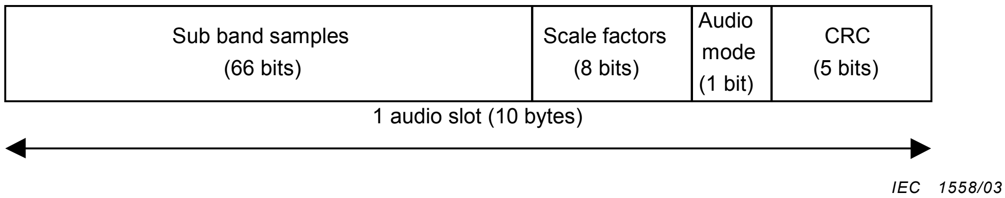


Figure 11 – Audio block structure

8.3.5 Data slots

The data slots carry control, configuration, display, … information. This information is sent as messages in a consecutive sequence of data slots. Each data slot is 4 bytes.

NOTE The data protocol is described in Clause 9.

8.4 Detailed overview of audio frame structures

8.4.1 Audio mode

Each pair of audio blocks (slot A and slot B) contains 2 audio mode bits. These bits indicate the audio mode carried by slot A and slot B (as indicated in Table 4). Bit1 is located in audio block A and bit0 is located in audio block B (see also 8.4.3).

Table 4 – Definition of audio mode bits

Bit1	Bit0	Both audio blocks contain audio information of mode
0	0	MMQ
0	1	SMQ
1	0	MHQ
1	1	SHQ

8.4.2 CRC

An additional CRC protection on the scale factors and audio quality bits is added. The polynomial used for the CRC is:

$$G(x) = x^{10} + x^{9} + x^{5} + x^{4} + x^{1} + 1$$

This CRC calculation is performed with the following circuit (Figure 12), consisting of a shift register containing 10 stages and XORs inserted at the appropriate places.

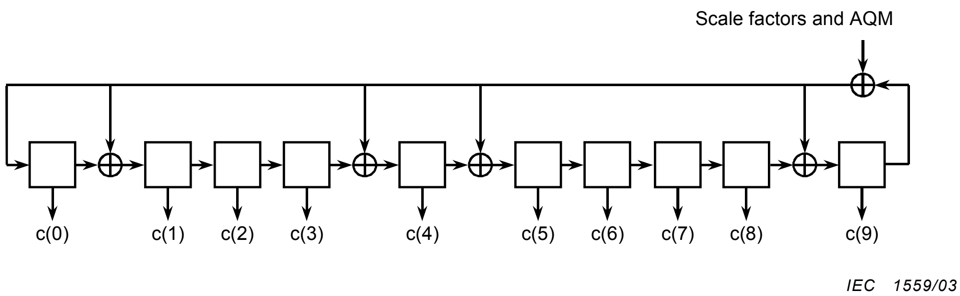


Figure 12 – CRC calculation

Before the start of the CRC calculation, the shift register is initialized to all zeros.

The 18 bits of the scale factors and the audio quality mode are offered to the CRC generator MSB first (i.e. SF audio block A, AQM Bit1, SF audio block B, AQM Bit0).

8.4.3 Audio block structure

8.4.3.1 Medium quality

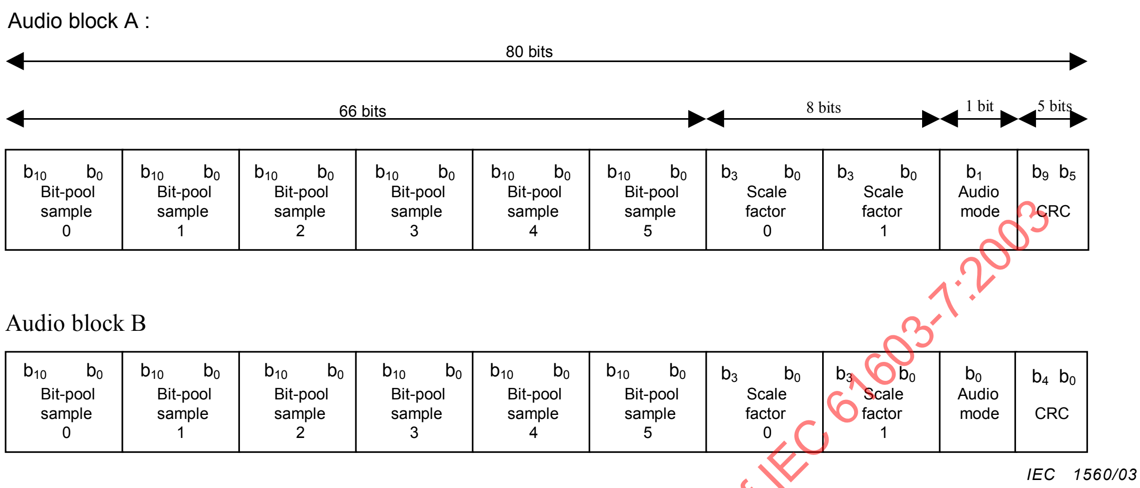


Figure 13 – Audio block structure for medium quality

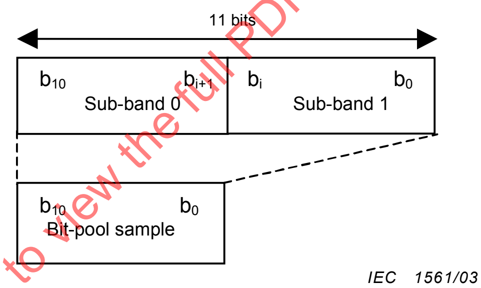


Figure 14 – Bit-pool sample structure for medium quality

8.4.3.2 High quality

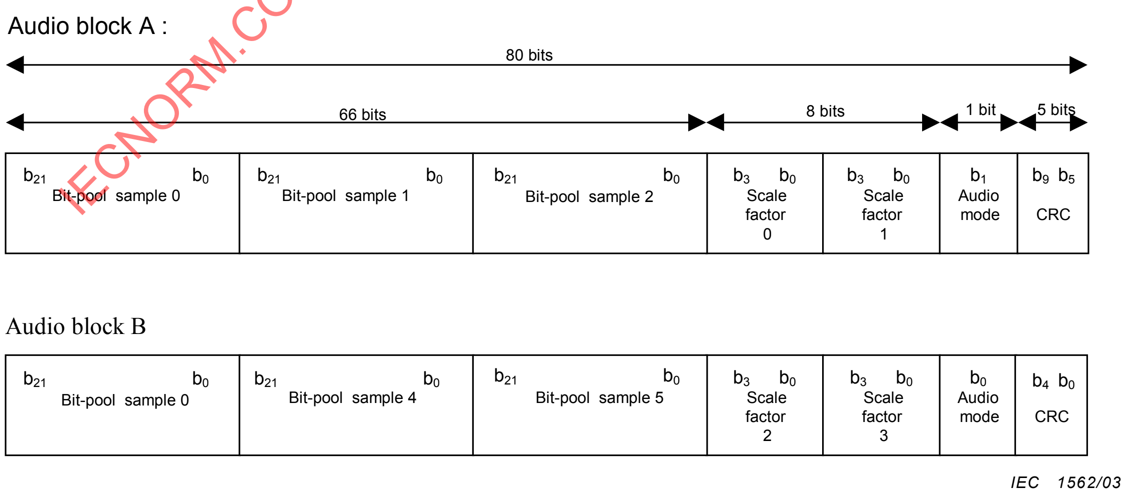


Figure 15 – Audio block structure for high quality

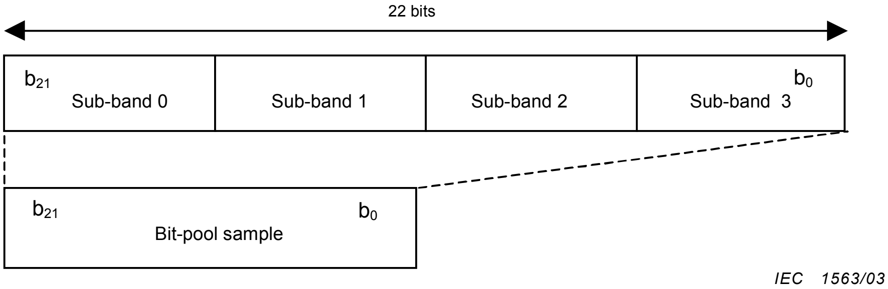


Figure 16 – Bit-pool sample structure for high quality

8.4.4 Audio blocks and audio quality

Table 5 shows all possible quality combinations within a superframe (i.e. on a single sub-carrier) and the way the data is divided among the different RS frames.

Table 5 – Audio blocks and audio quality

Audio modes	**RS frame 0** **RS frame 2** **RS frame 4**		**RS frame 1** **RS frame 3** **RS frame 5**	
	Audio block A	**Audio block B**	**Audio block A**	**Audio block B**
4 * MMQ	MMQ	MMQ	MMQ	MMQ
2 * MMQ; 1 * MHQ	MMQ	MMQ	MHQ	
1 * MHQ; 2 * MMQ	MHQ		MMQ	MMQ
2 * MMQ; 1 * SMQ	MMQ	MMQ	SMQ left	SMQ right
1 * SMQ; 2 * MMQ	SMQ left	SMQ right	MMQ	MMQ
1 * SMQ; 1 * MHQ	SMQ left	SMQ right	MHQ	
1 * MHQ; 1 * SMQ	MHQ		SMQ left	SMQ right
1 * SMQ; 1 * SMQ	SMQ left	SMQ right	SMQ left	SMQ right
1 * MHQ; 1 * MHQ	MHQ		MHQ	
1 * SHQ	SHQ left		SHQ right	

9 Data protocol

9.1 General

This clause describes the protocol and frame structures for the transmission of application data messages. Application data messages are sub-carrier-independent and therefore transmitted on each sub-carrier. The data protocol is used to translate the asynchronous application messages onto the synchronous transmission protocol (see 8.3).

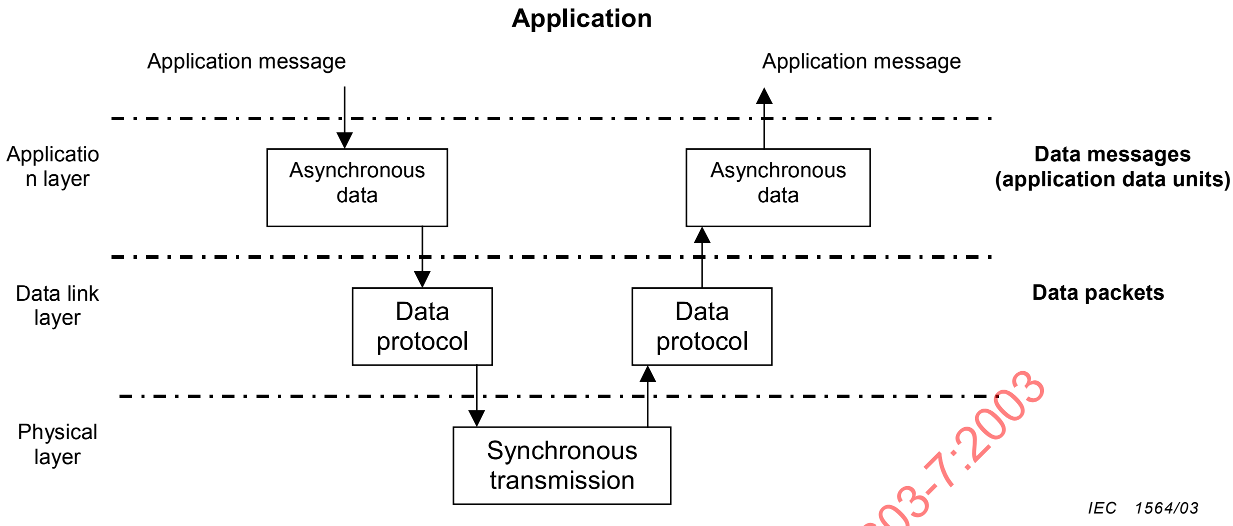


Figure 17 – Positioning of the data protocol

9.2 Data messages

9.2.1 General

Application messages will be transmitted on request by the application, so they will be sent asynchronously. Data messages consist of a data message identifier (8-bit), which identifies the type of data message, a data message length (8-bit) and a data message CRC (32-bit) to detect erroneous reception. The structure of the data messages is shown in Figure 18.

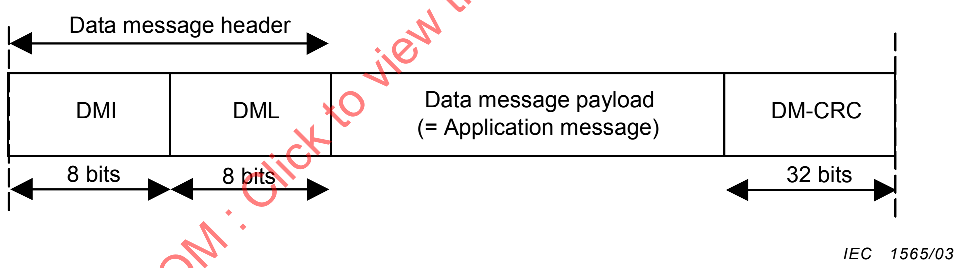


Figure 18 – Data message build-up

9.2.2 Data message identifier (DMI)

9.2.2.1 General

The DMI field (8-bit) defines the type of data carried in the payload. The following types have been defined (the remaining types are reserved for future definition).

Table 6 – Data message identifier definition

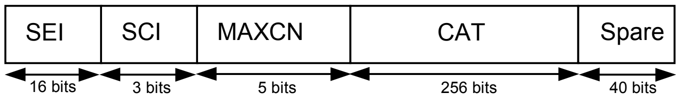
DMI	Description	Data message Type $b_7 \ldots b_3$	Version number $b_2 .. b_0$
CM	Configuration message	00000	000
DM	ASCII display message	00001	000
	Bitmap display message	00001	001
…	Reserved for future use	00010	xxx
…	…	…	
…	Reserved for future use	11111	xxx

Bit 7 ... 3 Data message type 0 … 31 (see Table 6)

Bit 2 ... 0 Data message version number 0 … 7 (000 … 111) (see Table 6)
The data message version number is included to allow different versions of the same message type.

9.2.2.2 Configuration message (CM)

The purpose of the configuration message is to transmit data for configuration of the receiver. This message has been built up so that it comprises 40 bytes. A CM will take 2 super-frames, so 2*1,632 ms = 3,264 ms. The structure of the CM is shown in Figure 19.



IEC 1566/03

Figure 19 – Configuration message structure

a) **Setting changed identifier (SEI) (16-bit)**

The setting changed identifier is used by the system to signal that one or more configuration settings have been changed. The setting changed identifier will be incremented by the transmitter each time a setting has changed. The stored SEI is set to 0 when the receiver goes to stand-by mode. Therefore, the SEI sent by the transmitter may never be 0.

b) **Source coding identifier (SCI) (3-bit)**

The source coding identifier is used to identify the audio compression algorithm that is used at the transmitter side. The normative compression algorithm (APCM, see 8.2.8) has SCI value 000, as shown in Table 7.

Table 7 – SCI definition

SCI	Compression algorithm
000	APCM f_s = 44,1 kHz
001..111	Reserved

c) **Maximum channel number (MAXCN) (5-bit)**

The MAXCN is used to identify the maximum number of logical channels that is used within the system.

d) **Channel allocation table (CAT) (32 × 8-bit)**

The channel allocation table keeps the mapping information between logical to physical channels (audio blocks). The CAT is dimensioned to allow up to 32 logical channels. The structure of the CAT is shown in Table 8.

NOTE Different logical channels can be mapped to the same physical channel.

Table 8 – Channel allocation table

Index	Start audio block 6-bit	Audio quality mode 2-bit
0	000000	11
1	000100	00
.	000101	00
.		
31	111111	NOT IN USE
Index = Logical channel		

The audio blocks have an absolute value, which correspond with the sub-carrier number and position within this sub-carrier. The start audio block denotes the audio block of the channel. Column 2 gives the corresponding quality mode, which translates into a number of audio blocks as shown in Table 9.

Table 9 – Audio quality mode (AQM) to number of audio blocks used

Audio quality		No. of audio blocks	Code
MMQ	Mono medium quality	1	00
SMQ	Stereo medium quality	2	01
MHQ	Mono high quality	2	10
SHQ	Stereo high quality	4	11

When a logical channel is NOT IN USE, this will be signalled by the use of start slot 63. Start slot 63 automatically corresponds with NOT IN USE.

e) **Spare field (SPARE) (40-bit)**

The configuration message can be transmitted in 2 data packets (see 9.3). To fit exactly in the packet payload, the message is extended with a spare field containing zeros.

9.2.2.3 Display message (DM)

9.2.2.3.1 General

The purpose of this message is to transmit data for the receiver's display, such as channel numbers or language names. There are two types of display messages: ASCII for textual displays and bitmap data for graphical displays.

9.2.2.3.2 ASCII display message

The ASCII display message consists of a logical channel number, a display changed identifier DCI and the ASCII data itself. If the logical channel number carries the value 63, the display message has to become visible on all receivers. Each logical channel has its own 2-bit DCI. The DCI is incremented when the ASCII display data of its corresponding logical channel has been changed. The ASCII display data consist of 12 characters and is 12 * 8-bit = 96-bit.

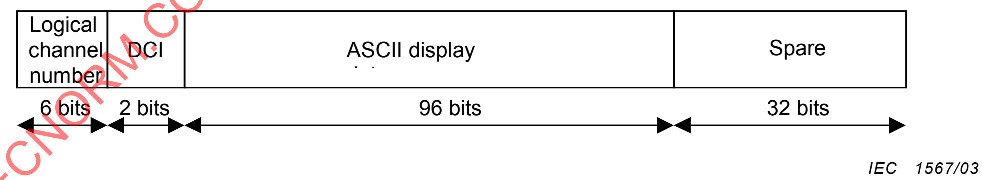


Figure 20 – Display message structure for ASCII display data

The ASCII display message can be transmitted in one packet. To fit it exactly in the packet payload the message is extended with a spare field containing zeros.

9.2.2.3.3 Bitmap display message

The bitmap display message consists of a logical channel number, a display changed identifier DCI and the bitmap data itself. If the logical channel number carries value 63, the display message has to become visible on all receivers. Each logical channel has its own 2-bit DCI. The DCI is incremented when the bitmap display data of its corresponding logical channel has been changed. The bitmap display data consist of 1280 bits. Each of the five characters has 16 by 16 pixels, resulting in 1280 pixels.

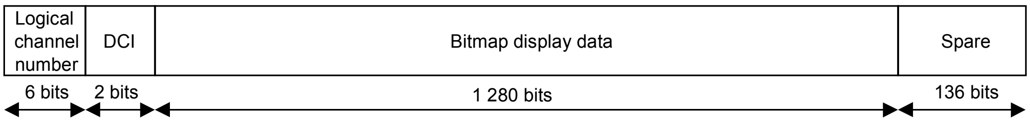


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Figure 21 – Display message structure for bitmap display data

The bitmap display message can be transmitted in 8 packets. To fit it exactly in the packet payload, the message is extended with a spare field containing zeros.

9.2.3 Data message length (DML)

The value 0 ... 255 denotes the message length in a number of superframes. Message contents should preferably be processed by the application so that they exactly fit within a multiple of superframes.

9.2.4 Data message CRC (DM-CRC)

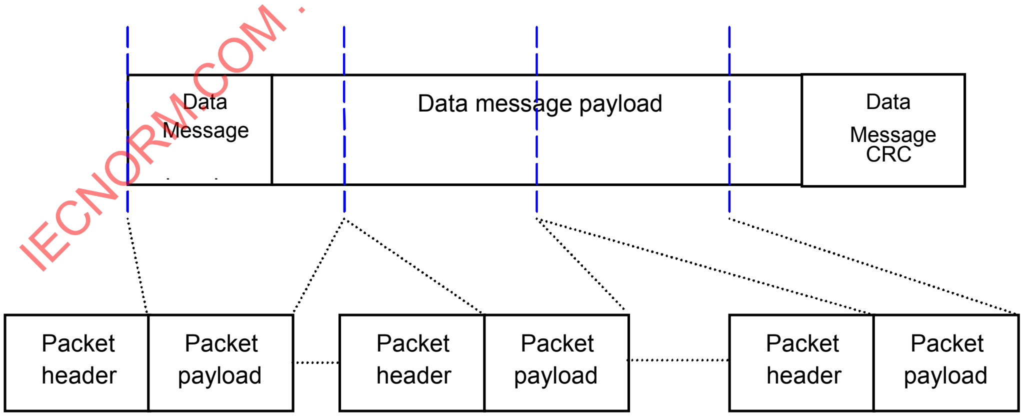
The data message CRC is a 32-bit CRC word calculated on the DMI, DML and data message payload based on polynomial:

$$G(x) = x^{32} + x^{26} + x^{23} + x^{22} + x^{16} + x^{12} + x^{11} + x^{10} + x^{8} + x^{7} + x^{5} + x^{4} + x^{2} + x + 1$$

At the beginning of each CRC word calculation, all shift register stage contents shall be initialized to “0”.

9.3 Data packet structure

The data message contents shall be mapped onto superframe data slots, so the data message contents have to be segmented into one or more packets (see Figure 22). To make it possible for the receiver to reassemble the original message from the packets, each packet has a packet sequence number. A packet sequence number with a value 0 indicates the start of a new data message.



IEC 1569/03

Figure 22 – Segmentation of data messages

The packet size equals the amount of data bytes in a superframe (i.e. 24 bytes). The packet header is synchronized to a superframe SYNC word as shown in Figure 23.

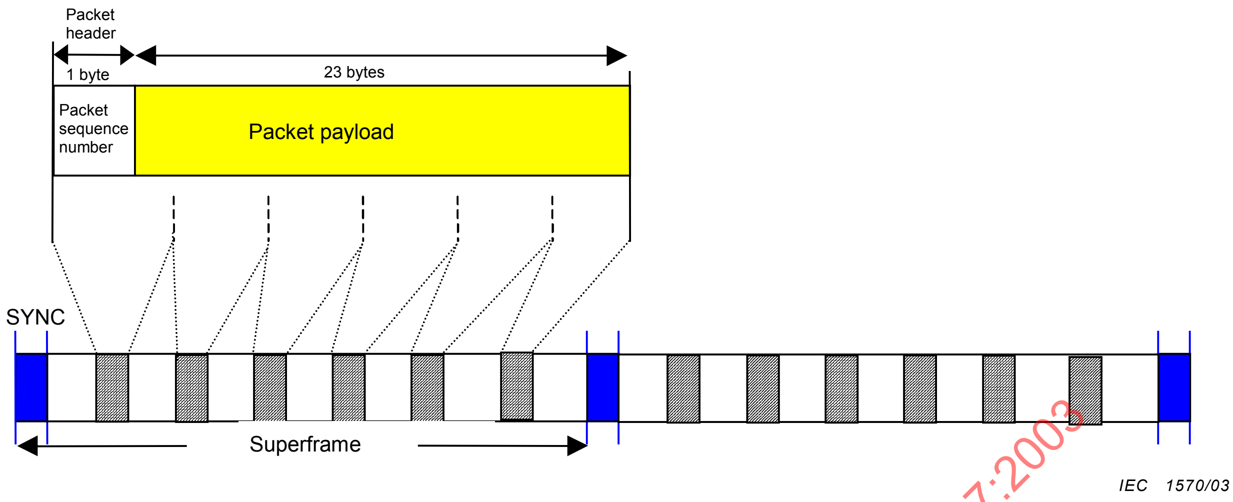


Figure 23 – Data packets fitted on to the superframe structure

With an 8-bit packet sequence number 0 ... 255 packets can be specified. This results in a maximum data message size of 256 × 23 bytes = 5888 bytes (with a transmission delay of 256 × 1,632 ms = 418 ms).