

Recording — Helical-scan digital video cassette recording system using 6,35 mm magnetic tape for consumer use (525-60, 625-50, 1125-60 and 1250-50 systems) —

Part 2: SD format for 525-60 and 625-50 systems

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English version

**Recording - Helical-scan digital video cassette recording system
using 6,35 mm magnetic tape for consumer use
(525-60, 625-50, 1125-60 and 1250-50 systems)
Part 2: SD format for 525-60 and 625-50 systems
(IEC 61834-2:1998)**

Enregistrement - Système de
magnétoscope numérique à cassette à
balayage hélicoïdal utilisant la bande
magnétique de 6,35 mm, destiné au
grand public (systèmes 525-60,
625-50, 1125-60 et 1250-50)
Partie 2: Format SD pour les systèmes
525-60 et 625-50
(CEI 61834-2:1998)

Aufzeichnung - Videokassettensystem
mit digitaler Schrägschraufzeichnung
auf Magnetband 6,35 mm für den
Heimgebrauch (Systeme 525-60,
625-50, 1125-60 und 1250-50)
Teil 2: SD-Format für die Systeme
525-60 und 625-50
(IEC 61834-2:1998)

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European Committee for Electrotechnical Standardization
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Foreword

The text of document 100B/168/FDIS, future edition 1 of IEC 61834-2, prepared by SC 100B, Recording, of IEC TC 100, Audio, video and multimedia systems and equipment, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61834-2 on 1998-10-01.

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Annexes designated "normative" are part of the body of the standard.

Annexes designated "informative" are given for information only.

In this standard, annexes A, B and ZA are normative and annexes C and D are informative.

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61834-2:1998 was approved by CENELEC as a European Standard without any modification.

In the official version, for annex D, Bibliography, the following notes have to be added for the standards indicated:

IEC 61883-1 NOTE: Harmonized as EN 61883-1:1998 (not modified).

IEC 61883-2 NOTE: Harmonized as EN 61883-2:1998 (not modified).

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RECORDING – HELICAL-SCAN DIGITAL VIDEO CASSETTE RECORDING SYSTEM USING 6,35 mm MAGNETIC TAPE FOR CONSUMER USE (525-60, 625-50, 1125-60 and 1250-50 systems) –

Part 2: SD format for 525-60 and 625-50 systems

1 General

1.1 Scope

This part of IEC 61834 specifies the content, format and recording method of the data blocks forming the helical records on the tape containing audio, video, and system data. It describes the specifications for the 525-line system with a frame frequency of 29,97 Hz (hereinafter referred to as 525-60 system) and 625-line system with a frame frequency of 25,00 Hz (hereinafter referred to as 625-50 system) which are not included in part 1. One video channel and two independent audio channels are recorded in the digital format. Each of these channels is designed to be capable of independent editing. The video channel records and reproduces a component television signal in 525-60 and 625-50 systems.

In this part, the data structure of a track is defined by APT = 000b which consists of four areas as described in 4.3.2 in part 1 and AP1 = AP2 = AP3 = 000b.

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents listed below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60461:1986, *Time and control code for video tape recorders*

IEC 60735:1991, *Measuring methods for video tape properties*

IEC 60958:1989, *Digital audio interface*

ITU-R Recommendation BT601-5:1995, *Studio encoding parameters of digital television for standard 4:3 and wide screen 16:9 aspect ratios*

ITU-R Report 624-4:1990, *Characteristics of television systems*

1.3 Definitions, symbols and abbreviations

For the purpose of this International Standard, the following definitions apply.

AAUX: Audio auxiliary data.

BCH code: Bose-Chaudhuri-Hocquenghem code which is one of the error correction codes.

CGMS: Copy generation management system.

DCT: Discrete cosine transform.

EOB: End of block.

NABTS: North American broadcasting teletext specifications.

OETM events: Optional events except text and maker's optional events.

TOC: Table of contents.

VAUX: Video auxiliary data.

VLC: Variable length coding.

1.4 Environment and test conditions

Tests and measurements made on the system to check the requirements of this standard shall be carried out under the following conditions.

- Temperature: $20\text{ °C} \pm 1\text{ °C}$;
- Relative humidity: $(50 \pm 2)\%$;
- Barometric pressure: from 86 kPa to 106 kPa;
- Tape conditioning: not less than 24 h.

1.5 Reference tape

Blank tape to be used for calibration recordings may be purchased from the manufacturers given in annex C.

1.6 Calibration tape

Manufacturers of video tape recorders designed for this format specification may sell calibration tapes meeting the following requirements.

1.6.1 Record locations and dimensions

Tolerances shown in table 3 in part 1, tables 1 and 2 in part 2 should be reduced by 50 %.

1.6.2 Calibration signals

Test signals should be recorded on the calibration tapes:

- Video: 100 % colour bars;
- Audio: 1 kHz tone at -20 dB below full level.

1.6.3 Purchase

The calibration tape may be purchased from the manufacturers given in annex C.

2 Helical recordings

2.1 Record location and dimensions

Record location and dimensions for continuous recording shall be as specified in figure 1. Each value is described in table 3 of part 1. For recording, helical tracks shall be contained within the tolerance specified in table 3 of part 1.

Each sector location from the start of the SSA shall be as specified in figure 2 and table 1 (525-60 system) or table 2 (625-50 system). The physical tape pattern shall be specified by the centre line of each track.

2.1.1 The effective area upper edge

The effective area upper edge (H_0) is specified by the intersection of the ending line of the subcode postamble and the centre line of the track.

2.1.2 Record and playback guarantee

Every recorder or player shall record or play back the track data from the beginning of the ITI preamble to the end of the subcode sync blocks with interchangeability.

2.1.3 Overwrite margin (OM)

When whole sectors (ITI, audio, video, subcode) are overwritten, the overwrite margin (OM) shall be recorded concatenations of run pattern A and run pattern B as described in 5.5 of part 1 in order to erase the old subcode data. In an insert editing mode using the SSA, it is not necessary to record the overwrite margin. For the areas which are outside the guaranteed heights described in 3.2.3 of part 1, there is no need to record or play back the areas, as they have no effective data.

2.1.4 Switching margin for recording amplifiers

To avoid erasing the information in the optional tracks, the recording amplifier shall be switched to less than or equal to 0,245 mm along the track length before the ITI preamble and 0,133 mm after the overwrite margin. In an insert editing, the recording amplifier shall be switched to less than or equal to 0,102 mm along the track length before and after the recording sector.

2.1.5 Scanner example

Scanner dimensions in table 3 are one possible configuration. Other mechanical configurations are permitted, if the same footprint of recorded information is produced on tape.

3 Programme track data arrangement

3.1 Introduction

Each television frame is recorded on 10 tracks for the 525-60 system and 12 tracks for the 625-50 system.

The helical tracks are recorded with video, audio and system data. These data are arranged in four sectors such as ITI, audio, video and subcode sectors per track. An edit gap between sectors, accommodates timing errors during editing. The ITI sector is already explained in clause 6 of part 1. Figure 3 shows the arrangement of a track for the 525-60 system and figure 4 shows the arrangement of a track for the 625-50 system.

Each track is numbered from the beginning track of the television frame in order. A track which has track number i ($i = 0$ to 9 for the 525-60 system or $i = 0$ to 11 for the 625-50 system) is referred to as track i .

Placement of F0, F1 and F2 tracks is shown in figure 5 for the 525-60 system, and figure 6 for the 625-50 system. In the 525-60 system, there are two types of track 1, which are track F1 or track F2, and two types of pilot frame which are defined as follows:

Pilot frame 0: track 1 is track F1.
Pilot frame 1: track 1 is track F2.

In the 525-60 system, pilot frame 0 and pilot frame 1 alternate with each other. In the 625-50 system, pilot frame 0 repeats.

3.2 Labelling convention

The most significant bit is written on the left and is the first recorded on the tape. The lowest numbered byte is shown on the top left and is the first encountered in the input data stream. Byte values are expressed in binary coded decimal notation unless otherwise noted. An "h" indicates a hexadecimal value. A "b" indicates a binary value.

3.3 Audio sector

3.3.1 Structure

The audio sector consists of an audio preamble, 14 data-sync blocks and audio postamble. Audio preamble begins with run-up of modulated 400 bits and ends with two pre-sync blocks. Audio postamble begins with a post-sync block and ends with a guard area of modulated 500 bits. Details on run-up and guard area are described in 5.5 of part 1. The structure of sync blocks in the audio sector is shown in figure 7.

3.3.2 Sync patterns

Sync patterns of two bytes are already modulated to 17 bits patterns as described in 5.2.1 of part 1. Sync pattern F and sync pattern G are used.

3.3.3 ID part

The ID part consists of ID data (ID0, ID1) of 2 bytes and ID parity (IDP) of one byte. Figure 8 shows the ID data in the audio sector. ID data consists of application ID of area 1 (AP1₂, AP1₁, AP1₀, see table 4), sequence number (Seq₃, Seq₂, Seq₁, Seq₀, see table 5 and table 6), track pair number (Trp₃, Trp₂, Trp₁, Trp₀, see table 7 and table 8) and sync block number (Syb₇, Syb₆, Syb₅, Syb₄, Syb₃, Syb₂, Syb₁, Syb₀).

Sync block numbering goes from 0 to 16, and is stored in ID1 in binary notation. Sync block number = FFh means no information.

The sequence number shall keep the same value during one video frame and is numbered from 0 to 11 sequentially. When a video signal is given from a colour decoder which decodes a composite video signal to the component video signals and the field number can be recognized, the colour phase information should coincide with a sequence number. Definitions of colour frame A and B (525-60 system) and field 1 to field 8 (625-50) are shown in ITU-R Report 624-4.

ID parity is defined as (12, 8, 3) BCH code of which a generator polynomial is $X^4 + X + 1$. The ID code is divided into two ID code-words (ID-CW0, ID-CW1). The bit assignment of ID code-words is shown in figure 9.

ID-CW0: C14, C12, C10, C8, C6, C4, C2, C0, P6, P4, P2, P0
ID-CW1: C15, C13, C11, C9, C7, C5, C3, C1, P7, P5, P3, P1

Parity bits P0 to P7 are given by the following equations.

$$\begin{aligned} P6 &= C14 + C10 + C6 + C4 \\ P4 &= C14 + C12 + C8 + C4 + C2 \\ P2 &= C14 + C12 + C10 + C6 + C2 + C0 \\ P0 &= C12 + C8 + C6 + C0 \end{aligned}$$

$$\begin{aligned} P7 &= C15 + C11 + C7 + C5 \\ P5 &= C15 + C13 + C9 + C5 + C3 \\ P3 &= C15 + C13 + C11 + C7 + C3 + C1 \\ P1 &= C13 + C9 + C7 + C1 \end{aligned}$$

where + is the symbol for "exclusive or".

3.3.4 Pre-sync block

The pre-sync block consists of 6 bytes as shown in figure 7. Byte position number 5 indicates track pitches.

Byte position number 5 = FFh: track pitch 0 for SP mode
 Byte position number 5 = 00h: track pitch 1
 Byte position number 5 = F0h: track pitch 2
 Byte position number 5 = 0Fh: track pitch 3

Track pitch 0 for SP mode shall be 10 µm. Other track pitches shall be different from 10 µm and these values are reserved.

3.3.5 Post-sync block

The post-sync block consists of 6 bytes as shown in figure 7. Byte position number 5 is FFh.

3.3.6 Data-sync block

The data-sync block consists of 90 bytes. Byte position numbers 5 to 9 of sync block numbers 2 to 10 are audio auxiliary data (AAUX, see 6.5). Byte position numbers 10 to 81 of sync block numbers 2 to 10 are audio data (see clause 6). Byte position numbers 82 to 89 of sync block numbers 2 to 15 are inner parities (see 6.2). Byte position numbers 5 to 81 of sync block numbers 11 to 15 are outer parities (see 6.2).

3.4 Video sector

3.4.1 Structure

The video sector consists of a video preamble, 149 data-sync blocks and a video postamble. The video preamble begins with a run-up of modulated 400 bits and ends with two pre-sync blocks. The video postamble starts with a post-sync block and ends with a guard area of modulated 925 bits. Details on run-up and guard area are described in 5.5 of part 1. The structure of data-sync blocks in the video sector is shown in figure 10.

3.4.2 Sync patterns

Same as audio sector.

3.4.3 ID part

Same as audio sector except for application ID of area 2 ($AP2_2$, $AP2_1$, $AP2_0$, see figure 11 and table 9) and sync block number which is numbered from 17 to 168.

3.4.4 Pre-sync block

Same as audio sector.

3.4.5 Post-sync block

Same as audio sector.

3.4.6 Data-sync block

The data sync block consists of 90 bytes. Byte position numbers 5 to 81 of sync block numbers 19, 20 and 156 are video auxiliary data (VAUX, see 7.5). Byte position numbers 5 to 81 of sync block numbers 21 to 155 are video data (see clause 7). Byte position numbers 82 to 89 of sync block numbers 19 to 167 are inner parities and byte position numbers 5 to 81 of sync block numbers 157 to 167 are outer parities (see 7.2).

3.5 Subcode sector

3.5.1 Structure

The subcode sector consists of a subcode preamble, 12 data-sync blocks and a subcode postamble. The subcode preamble has a run-up of modulated 1 200 bits. Subcode postamble begins with a run-up of modulated 1 325 bits (525-60 system) or modulated 1 200 bits (625-50 system) and ends with overwrite margin of modulated 1 250 bits. The subcode sector has the role of an APT saving area. The structure of sync blocks in subcode sector is shown in figure 12.

3.5.2 Sync patterns

Sync patterns of two bytes are already modulated to 17 bit patterns as described in 5.2.1 of part 1. Sync pattern D and sync pattern E are used.

3.5.3 ID part

The ID part consists of ID data ($ID0$, $ID1$) of two bytes and ID parity (IDP) of one byte. ID parity is the same as audio sector and video sector. Figure 13 shows the ID data in subcode sector. ID data consists of application ID of area 3 ($AP3_2$, $AP3_1$, $AP3_0$, see table 10), application ID of a track (APT_2 , APT_1 , APT_0 , see table 16 of part 1), FR ID, Index ID, Skip ID, PP ID, absolute track number ($ABST$) and sync block number (Syb_3 , Syb_2 , Syb_1 , Syb_0).

Sync block numbering goes from 0 to 11, and is stored in $ID1$ in binary notation. Sync block number = Fh means no information. More details are described in clause 8.

3.5.4 Pre-sync block

There is no pre-sync block.

3.5.5 Post-sync block

There is no post-sync block.

3.5.6 Data-sync block

The data-sync block consists of 12 bytes. Byte position numbers 5 to 9 of each sync block are subcode data (see 8.5). Byte position numbers 10 to 11 of each sync block are parities (see 8.2).

4 Audio interface

The principal mode of interface is analogue. The analogue audio signal shall be converted according to 6.4.1.

The audio signal may also be input and output digitally in a bit-serial form. The bit-serial interface for audio data only, if present, shall conform to IEC 60958. When the bit-serial interface for this standard is prepared, the data structure for transmission shall conform to 11. With regard to the interface standard, IEC 61883-1 and IEC 61883-2 should be referred to.

5 Video interface

The principal mode of interface is analogue. The analogue video signal shall be converted according to 7.4.1.

The video signal may also be input and output digitally in a bit-serial form. When the bit-serial interface for this standard is prepared, the data structure for transmission shall conform to clause 11. With regard to the interface standard, IEC 61883-1 and IEC 61883-2 should be referred to.

6 Audio signal processing

6.1 Introduction

The audio signal is recorded on two audio blocks. Each audio block is processed independently and identically. The audio block is composed of five audio sectors in five consecutive tracks (525-60 system) and six audio sectors in six consecutive tracks (625-50 system). Each audio sector is processed in a product block of 77 columns by 9 rows and audio auxiliary data (AAUX) are multiplexed with the audio data in the product block as shown in figure 7. For recording, the audio samples are shuffled in the audio block before the addition of error correction data to the product block.

6.2 Error correction code

Audio data are protected by inner error correction code and outer error correction code.

6.2.1 Inner error correction code

The inner parity as shown in figure 7 is defined as a code-word of an inner error correction code. The inner error correction code is a (85, 77) Reed-Solomon code in GF(256) of which the field generator polynomial is shown as:

$$X^8 + X^4 + X^3 + X^2 + 1$$

where X^i are place-keeping variables in GF(2), the binary field.

The generator polynomial of the code in GF(256) is:

$$g_{in}(X) = (X + 1)(X + \alpha)(X + \alpha^2)(X + \alpha^3)(X + \alpha^4)(X + \alpha^5)(X + \alpha^6)(X + \alpha^7)$$

where α is given by 2h in GF(256).

Parities $K_7, K_6, K_5, K_4, K_3, K_2, K_1, K_0$ as shown in figure 14 are given by the following equation:

$$K_7X^7 + K_6X^6 + K_5X^5 + K_4X^4 + K_3X^3 + K_2X^2 + K_1X + K_0$$

which is a residue of $X^8D(X)$ divided by $g_{in}(X)$, where the data polynomial $D(X)$ is defined as follows:

$$D(X) = D_{76}X^{76} + D_{75}X^{75} + \dots + D_2X^2 + D_1X + D_0$$

and the code-word polynomial is given by the following equation:

$$D_{76}X^{84} + D_{75}X^{83} + \dots + D_1X^9 + D_0X^8 + K_7X^7 + K_6X^6 + \dots + K_1X + K_0$$

6.2.2 Outer error correction code

The outer parity as shown in figure 7 is defined as a code-word of an outer error correction code. The outer error correction code is a (14, 9) Reed-Solomon code in GF(256) of which the field generator polynomial is shown as:

$$X^8 + X^4 + X^3 + X^2 + 1$$

where X^i are place-keeping variables in GF(2), the binary field.

The generator polynomial of the code in GF(256) is:

$$g_{aout}(X) = (X + 1)(X + \alpha)(X + \alpha^2)(X + \alpha^3)(X + \alpha^4)$$

where α is given by 2h in GF(256).

Parities, K_4, K_3, K_2, K_1, K_0 as shown in figure 15 are given by the following equation:

$$K_4X^4 + K_3X^3 + K_2X^2 + K_1X + K_0$$

which is a residue of $X^5D(X)$ divided by $g_{aout}(X)$, where the data polynomial $D(X)$ is defined as follows:

$$D(X) = D_8X^8 + D_7X^7 + \dots + D_2X^2 + D_1X + D_0$$

And the code-word polynomial is given by the following equation:

$$D_8X^{13} + D_7X^{12} + \dots + D_1X^6 + D_0X^5 + K_4X^4 + K_3X^3 + \dots + K_1X + K_0$$

6.3 Randomization pattern

Tables 11 and 12, which are derived from 5.1 of part 1, show the randomization pattern used for pre-sync blocks and post-sync blocks and data-sync blocks of the audio sector, respectively. In the table, the randomization pattern was divided into bytes from first serial bit to the end in order and is expressed in hexadecimal notation. This randomization pattern is performed by the “exclusive or” operation to the byte position number 2 to 5 for pre-sync blocks and post-sync blocks and 2 to 89 for data-sync blocks (see figure 7) with consistency from MSB to LSB.

6.4 Audio encoding

6.4.1 Encoding mode

Encoding modes are defined in each audio block. They are classified by the type of sampling frequency, quantization and the audio block channel number. This standard provides four types of audio encoding modes whose parameters are defined in table 13.

In 48k mode, 44,1k mode and 32k mode, one channel of audio signal shall be recorded in an audio block with the sampling frequency of 48 kHz, 44,1 kHz and 32 kHz, respectively. The encoded data are expressed by 2s complement representation with 16 bits linear.

In 32k two-channel mode, two channels of audio signal shall be recorded in an audio block with the sampling frequency of 32 kHz. The encoded data are expressed by 2s complement representation with 12 non-linear bits. The compressing rule of 16 bits linear code to 12 bits non-linear code is shown in figure 16.

In consumer digital VCR, the reproducing function for these four audio-encoding modes should be provided.

6.4.2 Emphasis

Audio encoding is carried out with the linear frequency characteristics or with the first order pre-emphasis of 50/15 μ s.

NOTE 1 – It is desirable that each channel has the same emphasis condition in each encoding mode.

NOTE 2 – For analog-input recording, emphasis should be off in the default state.

6.4.3 Audio error code

Within the audio encoded data, the following codes are assigned as the audio error code to indicate the invalid audio sample.

For 16 bits linear code	1000000000000000b (8000h)
For 12 bits nonlinear code	100000000000b (800h)

These codes correspond to the negative full-scale value in ordinary 2's complement representation. When the encoded data include these codes, they shall be converted in the following rule before audio processing and recording.

For 16 bits linear code	1000000000000000b (8000h) → 1000000000000001b (8001h)
For 12 bits nonlinear code	100000000000b (800h) → 100000000001b (801h)

6.4.4 Sample to data byte conversion

Samples of 16 bits or a pair of 12 bits are converted to data bytes. These data bytes are defined as D_n ($n = 0, 1, 2, \dots$) and are shuffled by each D_n unit.

In 48k mode, 44,1k mode and 32k mode, the 16 bits-encoded data are divided into two bytes, that is the most significant byte and the least significant byte as shown in figure 17.

In 32k-2ch mode, a pair of the 12 bits-encoded data Y and Z are divided into three bytes, that is the most significant byte Y, the most significant byte Z and the least significant byte, as shown in figure 18.

6.5 Audio channel allocation

6.5.1 Audio block

Audio block is the physical recording channel for audio signal on tape. In this standard, a pair of audio blocks named CH1 and CH2 are provided. The construction of these audio blocks is shown in table 14. Audio signals with the same encoding mode shall be recorded in CH1 and CH2.

In 48k mode, 44,1k mode and 32k mode, the signal of one audio channel is recorded in an audio block. Since two audio channels are available, these modes are called SD-2ch audio.

In 32k-2ch mode, the signals of two audio channels are recorded in an audio block. Since four audio channels are available, this mode is called SD-4ch audio.

The contents of the audio block are decided by the channel allocation rule.

6.5.2 Channel allocation for SD-2ch audio

Encoded data in CH1 and CH2 correspond to encoded data *X* in figure 17. Basic channel allocation rule for SD-2ch audio are described in table 15. For the channel described as "no information" in CH2, the invalid data which is described in 6.9 or the same data as CH1 may be recorded.

6.5.3 Channel allocation for SD-4ch audio

Each audio channel in the SD-4ch audio is named CHa, CHb, CHc and CHd. CHa and CHb are recorded in CH1; CHc and CHd are recorded in CH2. Encoded data in CHa and CHc correspond to encoded data *Y*, and encoded data in CHb and CHd correspond to encoded data *Z*, indicated in figure 18. The basic channel allocation rules for SD-4ch audio are described in table 16.

For the channel described as "no information" in CHb or CHd, all zero data or the same data as CHa or CHc may be recorded. For the channel described as "no information" in CH2, the invalid data which is described in 6.9 or the same data as CH1 may be recorded.

The audio signals which are recorded simultaneously with the video signal shall be recorded in CH1.

6.6 Frame structure

6.6.1 Relative audio-video timing

Audio signals are recorded separately by the video frame period, and the duration of one audio frame is defined as one video frame. An audio frame begins with the audio sample acquired within the duration of minus 50 samples to zero sample from the first pre-equalizing pulse of the vertical blanking period of the input video signal. The first pre-equalizing pulse means the beginning of line number 1 for 525-60 system, and the middle of line number 623 for 625-50 system.

6.6.2 Audio frame processing

This standard provides two types of audio frame processing modes which are classified as unlocked mode and locked mode by the dividing rule of audio frame.

Unlocked mode

Unlocked mode is applied to 48k mode, 44,1k mode, 32k mode and 32k-2ch mode whose sampling frequency of audio signal is not synchronous with the video frame frequency. The number of audio samples per frame are variable within the range between the maximum and the minimum as shown in table 17. The number of audio samples per frame are rounded to

integer. The recording capacity of audio data for each audio block corresponds to the maximum in 48k mode. For the lack of samples for filling the audio block, undefined values, "1" or "0", which mean "don't-care data", shall be recorded.

Locked mode

Locked mode is applied to 48k mode, 32k mode and 32k-2ch mode whose sampling frequency of audio signal is synchronous with the video frequency. The audio sampling frequency (f_s) is related to the horizontal video frequency (f_h) by the following equations.

$$\begin{aligned} \text{48k mode:} \quad & f_s = f_h \times 1\,144 / 375 \text{ for the 525-60 system} \\ & f_s = f_h \times 384 / 125 \text{ for the 625-50 system} \\ \text{32k mode and 32k-2ch mode:} \quad & f_s = f_h \times 2\,288 / 1125 \text{ for the 525-60 system} \\ & f_s = f_h \times 256 / 125 \text{ for the 625-50 system} \end{aligned}$$

The number of audio samples per frame keep a regular sequence or fixed value as shown in table 19.

6.7 Shuffling method

Audio samples and undefined values are shuffled over tracks and data-sync blocks within a frame. Firstly audio data are shuffled then undefined values are set. Data D_n that is sampled at n th order ($n = 0, 1, 2, \dots$) within a frame is located on the position derived from the following equations.

6.7.1 48k, 44,1k, 32k modes

Audio shuffling patterns are shown in figure 19 for the 525-60 system and figure 20 for the 625-50 system.

525-60 system

$$\begin{aligned} \text{Track number:} \quad & (\text{INT}(n / 3) + 2 \times (n \bmod 3)) \bmod 5 \quad \text{for CH1} \\ & (\text{INT}(n / 3) + 2 \times (n \bmod 3)) \bmod 5 + 5 \quad \text{for CH2} \\ \text{Sync block number:} \quad & 2 + 3 \times (n \bmod 3) + \text{INT}((n \bmod 45) / 15) \\ \text{Byte position number:} \quad & 10 + 2 \times \text{INT}(n / 45) \text{ for the most significant byte} \\ & 11 + 2 \times \text{INT}(n / 45) \text{ for the least significant byte} \\ \text{where} \quad & n = 0 \text{ to } 1\,619 \text{ for 48k mode} \\ & n = 0 \text{ to } 1\,488 \text{ for 44,1k mode} \\ & n = 0 \text{ to } 1\,079 \text{ for 32k mode} \end{aligned}$$

625-50 system

$$\begin{aligned} \text{Track number:} \quad & (\text{INT}(n / 3) + 2 \times (n \bmod 3)) \bmod 6 \quad \text{for CH1} \\ & (\text{INT}(n / 3) + 2 \times (n \bmod 3)) \bmod 6 + 6 \quad \text{for CH2} \\ \text{Sync block number:} \quad & 2 + 3 \times (n \bmod 3) + \text{INT}((n \bmod 54) / 18) \\ \text{Byte position number:} \quad & 10 + 2 \times \text{INT}(n / 54) \text{ for the most significant byte} \\ & 11 + 2 \times \text{INT}(n / 54) \text{ for the least significant byte} \\ \text{where} \quad & n = 0 \text{ to } 1\,943 \text{ for 48k mode} \\ & n = 0 \text{ to } 1\,785 \text{ for 44,1k mode} \\ & n = 0 \text{ to } 1\,295 \text{ for 32k mode} \end{aligned}$$

6.7.2 32k-2ch modes

Audio shuffling patterns are shown in figure 21 for the 525-60 system and figure 22 for the 625-50 system.

525-60 system

Track number: $(\text{INT}(n / 3) + 2 \times (n \bmod 3)) \bmod 5$ for CH1
 $(\text{INT}(n / 3) + 2 \times (n \bmod 3)) \bmod 5 + 5$ for CH2
 Sync block number: $2 + 3 \times (n \bmod 3) + \text{INT}((n \bmod 45) / 15)$
 Byte position number: $10 + 3 \times \text{INT}(n / 45)$ for the most significant byte Y
 $11 + 3 \times \text{INT}(n / 45)$ for the most significant byte Z
 $12 + 3 \times \text{INT}(n / 45)$ for the least significant byte

where $n = 0$ to 1079

625-50 system

Track number: $(\text{INT}(n / 3) + 2 \times (n \bmod 3)) \bmod 6$ for CH1
 $(\text{INT}(n / 3) + 2 \times (n \bmod 3)) \bmod 6 + 6$ for CH2
 Sync block number: $2 + 3 \times (n \bmod 3) + \text{INT}((n \bmod 54) / 18)$
 Byte position number: $10 + 3 \times \text{INT}(n / 54)$ for the most significant byte Y
 $11 + 3 \times \text{INT}(n / 54)$ for the most significant byte Z
 $12 + 3 \times \text{INT}(n / 54)$ for the least significant byte

where $n = 0$ to 1 295

6.8 Audio auxiliary data (AAUX)

AAUX data in CH1 and CH2 are defined independently. All data except for ML of AAUX SOURCE pack and all data except for GENRE CATEGORY of AAUX SOURCE CONTROL pack shall be set with the correct values.

AAUX SOURCE pack:

The encoding parameters	SMP:	the sampling frequency
	QU:	the quantization
	CHN:	the number of channel in the audio block
	AF SIZE:	the number of audio samples per frame
	LF:	the state of audio frame processing mode
According to the video signal	50/60:	50-field system or 60-field system
	STYPE:	video signal type
The state of emphasis	EF:	emphasis on/off
	TC:	time constant
The contents of audio block	AUDIO MODE:L, R etc.	

AAUX SOURCE CONTROL pack:

Copy generation	CGMS:	copy generation management system
Recording start point	REC ST:	recording start point or not
Recording end point	REC END:	recording end point or not
The recording mode	REC MODE:	original, insert or invalid recording

More details and other items are described in 8.2 and 9.4 of part 4.

6.9 Invalid recording

For recording invalid values as audio data, REC MODE in AAUX1 shall be set to 111b. The values of the invalid data are not taken into account.

7 Video signal processing

7.1 Introduction

Video signals are sampled at 13,5 MHz for luminance and 6,75 MHz for colour differences. The data of the vertical blanking areas and the horizontal blanking areas are discarded, then the rest of video data are shuffled in the frame. The amount of the video data is reduced by bit rate reduction technique which adopt DCT and VLC.

The process of the bit rate reduction is as follows. Video data are assigned in a DCT block. Six DCT blocks make a macro block. Five macro blocks make a video segment. A video segment is compressed to five compressed macro blocks by DCT and VLC technique. The compressed macro blocks are recorded on tape.

Video auxiliary data (VAUX) are multiplexed with the compressed video data, and the multiplexed data are processed in a product block of dimension 77 columns by 138 rows. The data in the product block are protected with the error correction data added to the product block.

7.2 Error correction code

Video data are protected by inner error correction code and outer error correction code.

7.2.1 Inner error correction code

See 6.2.1.

7.2.2 Outer error correction code

The outer parity as shown in figure 10 is defined as a code-word of an outer error correction code. The outer error correction code is a (149, 138) Reed-Solomon code in GF(256) of which the field generator polynomial is shown below:

$$X^8 + X^4 + X^3 + X^2 + 1$$

where X^i are place-keeping variables in GF(2), the binary field.

The generator polynomial of the code in GF(256) is:

$$g_{\text{vout}}(X) = (X + 1)(X + \alpha)(X + \alpha^2)(X + \alpha^3) \dots (X + \alpha^9)(X + \alpha^{10})$$

where α is given by 2h in GF(256).

Parities, K_{10} , K_9 , K_8 , K_7 , K_6 , K_5 , K_4 , K_3 , K_2 , K_1 , K_0 , as shown in figure 23 are given by the equation below:

$$K_{10}X^{10} + K_9X^9 + K_8X^8 + K_7X^7 + K_6X^6 + K_5X^5 + K_4X^4 + K_3X^3 + K_2X^2 + K_1X + K_0$$

which is a residue of $X^{11}D(X)$ divided by $g_{\text{vout}}(X)$, where the data polynomial $D(X)$ is defined as follows:

$$D(X) = D_{137}X^{137} + D_{136}X^{136} + \dots + D_2X^2 + D_1X + D_0$$

The code-word polynomial is given by the following equation:

$$D_{137}X^{148} + D_{136}X^{147} + \dots + D_1X^{12} + D_0X^{11} + K_{10}X^{10} + K_9X^9 + \dots + K_1X + K_0$$

7.3 Randomization pattern

See 6.3.

7.4 Video structure

7.4.1 Sampling structure

The sampling structure is the same as a sampling structure of 4:2:2 component television signals which is described in ITU-R Recommendation BT601-5. Sampling structures of luminance (Y) and two colour difference signals (CR, CB) are shown in table 20.

Pixel and line structures in one frame

The sampling starting point in the active period of CR and CB signals shall be the same as the sampling starting point in the active period of Y signals. Each pixel has a value from -127 to 126 which is obtained by a subtraction of 128 from the input video signal level.

525-60 system

For Y signals, 720 pixels per line shall be transmitted. CR and CB signals shall be transmitted from alternate lines and 180 pixels per line shall be transmitted as shown in figure 24.

The active lines shall be from line 23 to line 262 and from line 285 to line 524 as shown in table 20.

From each field, 240 lines for Y, CR and CB signals shall be transmitted.

625-50 system

For Y signals, 720 pixels per line shall be transmitted. CR and CB signals shall be transmitted from alternate lines and 360 pixels per line shall be transmitted as shown in figure 25.

The active lines shall be from line 23 to line 310 and from line 335 to line 622 as shown in table 20. From each field, 288 lines for Y signals and 144 lines for CR and CB signals shall be transmitted.

Filter characteristics

Filter characteristics are recommended as follows:

525-60 system

- less than or equal to -12 dB at 6,75 MHz for a luminance signal;
- less than or equal to -6 dB at 1,687 5 MHz for a chrominance signal;

625-50 system

- less than or equal to -12 dB at 6,75 MHz for a luminance signal;
- less than or equal to -6 dB at 3,375 MHz for a chrominance signal.

7.4.2 DCT block

The Y, CR and CB pixels in one frame shall be divided into DCT blocks as shown in figure 26. All DCT blocks for the 625-50 system and DCT blocks except for the rightmost DCT blocks in CR and CB for the 525-60 system are structured with a rectangular area of eight vertical lines and eight horizontal pixels in a frame.

The value of x shows the horizontal coordinate from the left and the value of y shows the vertical coordinate from the top. Odd lines of $y = 1, 3, 5, 7$ are the horizontal lines of field 1, and even lines of $y = 0, 2, 4, 6$ are those of field 2.

For the 525-60 system, the rightmost DCT blocks in CR and CB are structured with the 16 vertical lines and four horizontal pixels. The rightmost DCT block shall be reconstructed to eight vertical lines and eight horizontal pixels by moving the lower part of eight vertical lines and four horizontal pixels to the higher part of eight vertical lines and four horizontal pixels as shown in figure 27. The above reconstructed DCT block is used for signal processing.

DCT block arrangement in one frame for the 525-60 system

The arrangement of horizontal DCT blocks in one frame is shown in figure 28. The same horizontal arrangement is repeated to 60 DCT blocks in a vertical direction. Pixels in one frame are divided into 8 100 DCT blocks.

Y: Vertical 60 DCT blocks × horizontal 90	DCT blocks = 5 400 DCT blocks
CR: Vertical 60 DCT blocks × horizontal 22,5	DCT blocks = 1 350 DCT blocks
CB: Vertical 60 DCT blocks × horizontal 22,5	DCT blocks = 1 350 DCT blocks

DCT block arrangement in one frame for the 625-50 system

The arrangement of horizontal DCT blocks in one frame is shown in figure 29. The same horizontal arrangement is repeated for 72 DCT blocks for Y and 36 DCT blocks for CR and CB in the vertical direction. Pixels in one frame are divided into 9 720 DCT blocks.

Y: Vertical 72 DCT blocks × horizontal 90	DCT blocks = 6 480 DCT blocks
CR: Vertical 36 DCT blocks × horizontal 45	DCT blocks = 1 620 DCT blocks
CB: Vertical 36 DCT blocks × horizontal 45	DCT blocks = 1 620 DCT blocks

7.4.3 Macro block

Each macro block consists of six DCT blocks. Figure 30 shows the relationship between the macro block and DCT blocks.

For the 525-60 system, each macro block consists of four DCT blocks of Y horizontally adjacent, one DCT block of CR and one DCT block of CB on a TV screen. The rightmost macro blocks on the TV screen consist of four DCT blocks of Y vertically and horizontally adjacent, one DCT block of CR and one DCT block of CB.

Macro block arrangement in one frame for the 525-60 system

The arrangement of macro blocks in one frame is shown in figure 31. The small rectangle shows a macro block. Pixels in one frame are divided into 1 350 macro blocks.

$$60 \text{ vertical macro blocks} \times 22,5 \text{ horizontal macro blocks} = 1\,350 \text{ macro blocks}$$

Macro block arrangement in one frame for the 625-50 system

The arrangement of macro blocks in one frame is shown in figure 32. The small rectangle shows a macro block. Pixels in one frame are divided into 1 620 macro blocks.

$$36 \text{ vertical macro blocks} \times 45 \text{ horizontal macro blocks} = 1\,620 \text{ macro blocks}$$

7.4.4 Super block

Each super block consists of 27 macro blocks.

Super block arrangement in one frame for the 525-60 system

The arrangement of super blocks in one frame is shown in figure 31. Each super block is structured with 27 adjacent macro blocks enclosed by a thick line. The pixels in a frame are divided into 50 super blocks.

10 vertical super blocks $\times$ 5 horizontal super blocks = 50 super blocks

Super block arrangement in one frame for the 625-50 system

The arrangement of super blocks in one frame is shown in figure 32. Each super block is structured with 27 adjacent macro blocks enclosed by a thick line. The pixels in a frame are divided into 60 super blocks.

12 vertical super blocks $\times$ 5 horizontal super blocks = 60 super blocks

7.4.5 Definition of super block number, macro block number and value of the pixel**Super block number**

The super block number in a frame is expressed as $S_{i,j}$ as shown in figures 31 and 32.

$S_{i,j}$ where i is the vertical order of the super block
 $i = 0, \dots, 9$ for the 525-60 system
 $i = 0, \dots, 11$ for the 625-50 system
 j is the horizontal order of the super block
 $j = 0, \dots, 4$

Macro block number

The macro block number is expressed as $M_{i,j,k}$. The symbol k is the macro block order in the super block as shown in figure 33 for the 525-60 system and figure 34 for the 625-50 system. The small rectangle in these figures shows a macro block, and a number in the small rectangle expresses k .

$M_{i,j,k}$ where i,j is the super block number
 k is the macro block order in the super block
 $k = 0, \dots, 26$

Value of the pixel

The value of the pixel is expressed as $P_{i,j,k,l}(x,y)$. The pixel is indicated as the suffix of i,j,k,l (x,y). The symbol l is the DCT block order in a macro block as shown in figure 30. The rectangle in the figure shows a DCT block, and a DCT number in the rectangle expresses l . The symbol x and y are the pixel coordinate in the DCT block as described in 7.4.2.

$P_{i,j,k,l}(x,y)$ where i, j, k are the macro block number
 l is the DCT block order in the macro block
 (x,y) are the pixel coordinate in the DCT block
 $x = 0, \dots, 7$
 $y = 0, \dots, 7$

7.4.6 Definition of video segment and compressed macro block

A video segment consists of five macro blocks which are gathered from various areas as shown below:

$M a,2,k$ where $a = (i + 2) \bmod n$

$M b,1,k$ where $b = (i + 6) \bmod n$

$M c,3,k$ where $c = (i + 8) \bmod n$

$M d,0,k$ where $d = (i + 0) \bmod n$

$M e,4,k$ where $e = (i + 4) \bmod n$

where i is the vertical order of the super block

$i = 0, \dots, n - 1$

n is the number of vertical super blocks in a video frame

$n = 10$ for the 525-60 system

$n = 12$ for the 625-50 system

k is the macro block order in the super block

$k = 0, \dots, 26$

Each video segment before the bit rate reduction is expressed as $V i,k$ which consists of $M a,2,k$, $M b,1,k$, $M c,3,k$, $M d,0,k$ and $M e,4,k$.

The bit rate reduction is executed from $M a,2,k$ to $M e,4,k$. The data in a video segment are compressed and transformed to the data of 385 bytes. A compressed video data consists of five compressed macro blocks. Each compressed macro block consists of 77 bytes and is expressed as CM. Each video segment after the bit rate reduction is expressed as $CV i,k$ which consists of $CM a,2,k$, $CM b,1,k$, $CM c,3,k$, $CM d,0,k$ and $CM e,4,k$ as shown below.

CM $a,2,k$:

This block includes all or most of the compressed data of the macro block $M a,2,k$ and may include the compressed data of the macro block $M b,1,k$ or $M c,3,k$ or $M d,0,k$ or $M e,4,k$.

CM $b,1,k$:

This block includes all or most of the compressed data of the macro block $M b,1,k$ and may include the compressed data of the macro block $M a,2,k$ or $M c,3,k$ or $M d,0,k$ or $M e,4,k$.

CM $c,3,k$:

This block includes all or most of the compressed data of the macro block $M c,3,k$ and may include the compressed data of the macro block $M a,2,k$ or $M b,1,k$ or $M d,0,k$ or $M e,4,k$.

CM $d,0,k$:

This block includes all or most of the compressed data of the macro block $M d,0,k$ and may include the compressed data of the macro block $M a,2,k$ or $M b,1,k$ or $M c,3,k$ or $M e,4,k$.

CM $e,4,k$:

This block includes all or most of the compressed data of the macro block $M e,4,k$ and may include the compressed data of the macro block $M a,2,k$ or $M b,1,k$ or $M c,3,k$ or $M d,0,k$.

7.5 DCT processing

The DCT block is structured with pixels from two fields, each field structured with four vertical lines and eight horizontal pixels. In this subclause, the DCT transforming method from 64 pixels in a DCT block with numbers $i,j,k,l (x,y)$ to 64 coefficients with numbers $i,j,k,l (h,v)$ is described. $P i,j,k,l (x,y)$ is the value of the pixel and $C i,j,k,l (h,v)$ is the value of the coefficient. For $h = 0$ and $v = 0$, the coefficient is called "DC coefficient". Other coefficients are called "AC coefficients".

7.5.1 DCT mode

There are two DCT modes called 8-8-DCT mode and 2-4-8-DCT mode to improve the picture quality after the bit rate reduction. The 8-8-DCT mode should be selected when the difference between two fields is small. The 2-4-8-DCT mode should be selected when the difference between two fields is big.

Two DCT mode are defined below.

8-8 DCT mode

DCT:

$$C_{i,j,k,l}(h,v) = C(v) C(h) \sum_{y=0}^7 \sum_{x=0}^7 (P_{i,j,k,l}(x,y) \cos(\pi v(2y+1)/16) \cos(\pi h(2x+1)/16))$$

Inverse DCT:

$$P_{i,j,k,l}(x,y) = \sum_{v=0}^7 \sum_{h=0}^7 (C(v) C(h) C_{i,j,k,l}(h,v) \cos(\pi v(2y+1)/16) \cos(\pi h(2x+1)/16))$$

where

$$\begin{aligned} C(h) &= 0,5 / \sqrt{2} & \text{for } h = 0 \\ C(h) &= 0,5 & \text{for } h = 1 \text{ to } 7 \\ C(v) &= 0,5 / \sqrt{2} & \text{for } v = 0 \\ C(v) &= 0,5 & \text{for } v = 1 \text{ to } 7 \end{aligned}$$

2-4-8-DCT mode

DCT:

$$C_{i,j,k,l}(h,u) = C(u) C(h) \sum_{z=0}^3 \sum_{x=0}^7 ((P_{i,j,k,l}(x,2z) + P_{i,j,k,l}(x,2z+1)) KC)$$

$$C_{i,j,k,l}(h,u+4) = C(u) C(h) \sum_{z=0}^3 \sum_{x=0}^7 ((P_{i,j,k,l}(x,2z) - P_{i,j,k,l}(x,2z+1)) KC)$$

Inverse DCT:

$$P_{i,j,k,l}(x,2z) = \sum_{u=0}^3 \sum_{h=0}^7 (C(u) C(h) (C_{i,j,k,l}(h,u) + C_{i,j,k,l}(h,u+4)) KC)$$

$$P_{i,j,k,l}(x,2z+1) = \sum_{u=0}^3 \sum_{h=0}^7 (C(u) C(h) (C_{i,j,k,l}(h,u) - C_{i,j,k,l}(h,u+4)) KC)$$

where

$$\begin{aligned} u &= 0, \dots, 3 \\ z &= \text{INT}(y/2) \\ KC &= \cos(\pi u(2z+1)/8) \cos(\pi h(2x+1)/16) \\ C(h) &= 0,5 / \sqrt{2} & \text{for } h = 0 \\ C(h) &= 0,5 & \text{for } h = 1 \text{ to } 7 \\ C(u) &= 0,5 / \sqrt{2} & \text{for } u = 0 \\ C(u) &= 0,5 & \text{for } u = 1 \text{ to } 7 \end{aligned}$$

7.5.2 Weighting

DCT coefficients shall be weighted by the process described below. $W(h,v)$ expresses weight for $C_{i,j,k,l}(h,v)$ of the DCT coefficient.

8-8-DCT mode

$$\begin{aligned} \text{For } h = 0 \text{ and } v = 0 & \quad W(h,v) = 1/4 \\ \text{For others} & \quad W(h,v) = w(h) w(v) / 2 \end{aligned}$$

2-4-8-DCT mode

For $h = 0$ and $v = 0$	$W(h, v) = 1/4$
For $v < 4$	$W(h, v) = w(h) w(2 - v) / 2$
For others	$W(h, v) = w(h) w(2 - (v - 4)) / 2$

where

$$\begin{aligned}w(0) &= 1 \\w(1) &= CS4 / (4 \times CS7 \times CS2) \\w(2) &= CS4 / (2 \times CS6) \\w(3) &= 1 / (2 \times CS5) \\w(4) &= 7 / 8 \\w(5) &= CS4 / CS3 \\w(6) &= CS4 / CS2 \\w(7) &= CS4 / CS1\end{aligned}$$

where $CS_m = \cos(m\pi/16)$ $m = 1$ to 7

7.5.3 Output order

Figure 35 shows the output order of the weighted coefficients.

7.5.4 Tolerance of DCT with weighting

Output error between the reference DCT and the tested DCT should satisfy the tolerances of the following cases:

- probability of occurrence of error;
- mean square errors for all coefficients;
- maximum value of mean square error for each DCT block;
- all input pixel values of a DCT block are the same.

Details are described in annex A.

7.6 Quantization

7.6.1 Introduction

Weighted DCT coefficients are transformed into 9 bits. The 9 bits transformed data are then divided by quantization step in order to limit the amount of data in one video segment to five compressed macro blocks.

7.6.2 Bit assignment for quantization

Weighted DCT coefficients are represented as follows:

- DC coefficient value (9 bits): b8 b7 b6 b5 b4 b3 b2 b1 b0
2's complement (–255 to 255)
- AC coefficient value (10 bits): s b8 b7 b6 b5 b4 b3 b2 b1 b0
1 sign bit + 9 bits of absolute value (–511 to 511)

7.6.3 Class number

Each DCT block shall be classified into four classes by the definitions as described in table 21. For selecting quantization step, class number is used. Both c1 and c0 express the class number and are stored in the DC coefficient of the compressed DCT block as described in 7.8. For reference, table 22 shows an example of the classification.

7.6.4 Initial scaling

Initial scaling is an operation for AC coefficients to transform from 10 bits to 9 bits. Initial scaling shall be carried out as shown below:

For class numbers 0, 1, 2

- input data: s b8 b7 b6 b5 b4 b3 b2 b1 b0
- output data: s b7 b6 b5 b4 b3 b2 b1 b0

For class number 3

- input data: s b8 b7 b6 b5 b4 b3 b2 b1 b0
- output data: s b8 b7 b6 b5 b4 b3 b2 b1

7.6.5 Area number

The area number is used for the selection of the quantization step. AC coefficients within a DCT block shall be classified into four areas with area number as shown in figure 36.

7.6.6 Quantization step

The quantization step shall be decided by the class number, area number and quantization number (QNO) as specified in table 23. QNO is selected in order to limit the amount of data in one video segment to five compressed macro blocks.

7.7 Variable length coding (VLC)

Variable length coding is an operation for transforming from quantized AC coefficients to variable length codes. One or some successive AC coefficients within a DCT block are coded into one variable length code according to the order as shown in figure 35. Run length and amplitude are defined as follows:

- Run length: the number of successive AC coefficients quantized to "0"
(run = 0, ..., 61);
- Amplitude: absolute value just after successive AC coefficients quantized to "0"
(amp = 0, ..., 255);
- (run, amp): the pair of run length and amplitude.

Table 24 shows the length of code-words corresponding to (run, amp). In the table, sign bit is not included in the length of code-words. When the amplitude is not zero, the code length shall be +1, because the sign bit is needed. For an empty column, the length of code-words of the (run, amp) equals that of the (run – 1, 0) plus that of the (0, amp).

The code of variable length coding shall be as shown in table 25. The most left bit of code-words is MSB and the rightmost bit of code-words is LSB in table 25. The MSB of the subsequent code-word is next to the LSB of the code-word just before. The sign bit "s" shall be as follows:

- for the quantized AC coefficient greater than zero s = 0;
- for the quantized AC coefficient less than zero s = 1.

When the values of all of the remaining quantized coefficients are zero within a DCT block, the coding process is ended by adding the EOB (end of block) code-word 0110b just after the last code-word.

7.8 The arrangement of a compressed macro block

A compressed video segment consists of five compressed macro blocks. Each compressed macro block has 77 bytes data. The arrangement of the compressed macro block shall be as shown in figure 37. The areas of Y0, Y1, Y2, Y3, CR and CB are defined as compressed-data areas and each one of the Y0, Y1, Y2 and Y3 zones consists of 112 bits and each CR and CB consists of 80 bits.

STA expresses the error and concealment of the compressed macro block and consists of four bits, s3 s2 s1 s0. Table 26 shows the definitions of STA.

QNO is the quantization number applied to the macro block. Code-words for QNO shall be those shown in table 27.

DCI (where l is the DCT block order in the macro block, $l = 0, \dots, 5$) consists of a DC coefficient, the DCT mode and the class number of the DCT block.

where

b8 to b0 are the DC coefficient values;
m0 is the DCT mode, m0 = 0 for 8-8-DCT mode,
m0 = 1 for 2-4-8-DCT mode;
c1 c0 are the class numbers.

AC is a generic term of variable length coded AC coefficients within the video segment $V_{i,k}$.

DCI and variable length code for AC coefficients in the DCT block whose DCT block number is i, j, k, l are assigned from the beginning of the compressed data area in the compressed macro block CM i, j, k . In figure 37, the variable length code-word is located starting from MSB which is shown in the upper left side, and LSB is shown in the lower right side. Therefore, AC data are distributed from the upper left side to the lower right side.

This subclause describes the distribution method of quantized AC coefficients. Figure 38 shows the arrangement of a video segment CV i, k after bit rate reduction. The column shows a compressed macro block, and symbol $F_{i,j,k,l}$ expresses a compressed data area for a DCT block whose DCT block number is i, j, k, l .

Bit sequence which shall be concatenated with the DC coefficient, information of DCT mode, class number and code-words for AC coefficients of the DCT block whose DCT block number is i, j, k, l , is defined as $B_{i,j,k,l}$. Code-words for AC coefficients of $B_{i,j,k,l}$ shall be concatenated according to the order as shown in figure 35 and the last code-word shall be EOB. The MSB of the subsequent code-word shall be next to the LSB of the code-word just before.

- pass 1: the distribution of $B_{i,j,k,l}$ in the compressed data area;
- pass 2: the distribution of the overflow $B_{i,j,k,l}$ which remain after the pass 1 operation in the same compressed macro block;
- pass 3: the distribution of the overflow $B_{i,j,k,l}$ which remain after the pass 2 operation in the same video segment.

Arrangement algorithm of a video segment

```

if (525-60 system)  $n = 10$  else  $n = 12$ ;
for ( $i = 0$ ;  $i < n$ ;  $i++$ ) {
     $a = (i + 2) \bmod n$ ;
     $b = (i + 6) \bmod n$ ;
     $c = (i + 8) \bmod n$ ;
     $d = (i + 0) \bmod n$ ;
     $e = (i + 4) \bmod n$ ;
    for ( $k = 0$ ;  $k < 27$ ;  $k++$ ) {
         $q = 2$ ;
         $p = a$ ;
         $VR = 0$ ;
        /* VR is the bit sequence for the data */
        /* which are not distributed to video segment CV  $i, k$  by pass 2. */

/* pass 1 */
        for ( $j = 0$ ;  $j < 5$ ;  $j++$ ) {
             $MRq = 0$ ;
            /* MRq is the bit sequence for the data */
            /* which are not distributed to macro block  $M i, q, k$  by pass 1. */
            for ( $l = 0$ ;  $l < 6$ ;  $l++$ ) {
                 $remain = \text{distribute}(B p, q, k, l, F p, q, k, l)$ ;
                 $MRq = \text{connect}(MRq, remain)$ ;
            }
            if ( $q == 2$ ) { $q = 1$ ;  $p = b$ ;}
            else if ( $q == 1$ ) { $q = 3$ ;  $p = c$ ;}
            else if ( $q == 3$ ) { $q = 0$ ;  $p = d$ ;}
            else if ( $q == 0$ ) { $q = 4$ ;  $p = e$ ;}
            else if ( $q == 4$ ) { $q = 2$ ;  $p = a$ ;}
        }

/* pass 2 */
        for ( $j = 0$ ;  $j < 5$ ;  $j++$ ) {
            for ( $l = 0$ ;  $l < 6$ ;  $l++$ ) {
                 $MRq = \text{distribute}(MRq, F p, q, k, l)$ ;
            }
             $VR = \text{connect}(VR, MRq)$ ;
            if ( $q == 2$ ) { $q = 1$ ;  $p = b$ ;}
            else if ( $q == 1$ ) { $q = 3$ ;  $p = c$ ;}
            else if ( $q == 3$ ) { $q = 0$ ;  $p = d$ ;}
            else if ( $q == 0$ ) { $q = 4$ ;  $p = e$ ;}
            else if ( $q == 4$ ) { $q = 2$ ;  $p = a$ ;}
        }

/* pass 3 */
        for ( $j = 0$ ;  $j < 5$ ;  $j++$ ) {
            for ( $l = 0$ ;  $l < 6$ ;  $l++$ ) {
                 $VR = \text{distribute}(VR, F p, q, k, l)$ ;
            }
            if ( $q == 2$ ) { $q = 1$ ;  $p = b$ ;}
            else if ( $q == 1$ ) { $q = 3$ ;  $p = c$ ;}
            else if ( $q == 3$ ) { $q = 0$ ;  $p = d$ ;}
            else if ( $q == 0$ ) { $q = 4$ ;  $p = e$ ;}
            else if ( $q == 4$ ) { $q = 2$ ;  $p = a$ ;}
        }
    }
}

```

```

distribute (data0, area0 ) {      /* Distribute data0 from MSB into empty area of area0. */
                                /* The area0 is filled starting from the MSB. */
    remain = (remaining_data); /* remaining_data are the data which are not distributed.*/
    return (remain);
}
connect (data1, data2 ) {        /* Connect the MSB of data2 with the LSB of data1. */
    data3 = (connecting_data); /* connecting_data are the data which are connected */
                                /* data2 with data1. */
    return (data3);
}

```

The remaining data shall be ignored when the data are not completely distributed. Consequently, if error concealment is performed for a compressed macro block, the data distributed by pass 3 may not be reproduced.

Video error code processing

If errors are detected in a compressed macro block which is reproduced and processed with error correction, the compressed data area including these errors should be replaced with the video error code. This process replaces the first two bytes data of the compressed data area with the following code:

```

MSB                      LSB
10000000000000110b

```

The first nine bits are DC error code, the next three bits are the information of DCT mode and class number and the last four bits are the EOB as shown in figure 39. When the compressed macro blocks after error code processing are entered into the decoder which does not operate with video error code, all data in this compressed macro block should be processed as invalid.

7.10 Data-sync block and compressed macro block

A compressed macro block data is distributed to data-sync blocks as shown in figure 40. A compressed macro block whose compressed macro block number is CM i,j,k is distributed to a data-sync block whose sync block number is as follows:

$27j + k + 21$ of track i

where

$i = 0, \dots, n - 1$

$j = 0, \dots, 4$

$k = 0, \dots, 26$

$n = 10$ for the 525-60 system

$n = 12$ for the 625-50 system

7.11 Video auxiliary data (VAUX)

50/60 and STYPE of VAUX0, REC ST, REC MODE, BCSYS and DISP of VAUX1 shall be set to the correct values for an expected playback.

VAUX SOURCE pack:

According to the video signal	50/60:	50 fields system or 60 fields system
	STYPE:	video signal type

VAUX SOURCE CONTROL pack:

Copy generation	CGMS:	copy generation management system
Recording start point	REC ST:	recording start point or not
The recording mode	REC MODE:	original, insert or invalid recording
Broadcasting	BCSYS:	broadcast system
	DISP:	4:3 or 16:9 etc.

Other data in the main area should be set to the correct values.

More details and other items are described in 9.5 and 9.2 of part 4.

7.12 Invalid recording

For recording invalid values as video data, REC MODE in VAUX1 shall be set at 11b as well as STA shall be set at 1111b, although 50/60 and STYPE of VAUX0 shall be set to the correct values. The values of the invalid data are not taken into account.

8 Subcode signal processing**8.1 Introduction**

There are several reasons for using a subcode sector. The main purpose of the subcode sector is to search for a starting point on tape at high speed where a user wants to see and/or listen. Other purposes are recognizing the tape position, skipping a discarded area, recording menu and TOC data for pre-recorded tape (see part 5) and so on. The subcode sector also has the role of an APT saving area (see figure 13).

8.2 Error correction codes

For AP3 = 000b, subcode data consist of 5 bytes and subcode parity consists of 2 bytes which is defined as a code-word of a subcode error correction code. Subcode error correction code is a (14, 10) Reed-Solomon code on GF(16) of which the field generator polynomial is shown below:

$$X^4 + X + 1$$

where X^i are place-keeping variables in GF(2), the binary field.

The generator polynomial of the code in GF(16) is

$$g_{\text{sub}}(X) = (X + 1)(X + \alpha)(X + \alpha^2)(X + \alpha^3)$$

where α is given by 2h in GF(16).

Parities K_3, K_2, K_1, K_0 as shown in figure 41 are given by the following equation:

$$K_3X^3 + K_2X^2 + K_1X + K_0$$

which is a residue of $X^4 D(X)$ divided by $g_{\text{sub}}(X)$, where the data polynomial $D(X)$ is defined as follows:

$$D(X) = D_9 X^9 + D_8 X^8 + \dots + D_2 X^2 + D_1 X + D_0$$

And the code-word polynomial is given by the following equation:

$$D_9 X^{13} + D_8 X^{12} + \dots + D_1 X^5 + D_0 X^4 + K_3 X^3 + K_2 X^2 + K_1 X + K_0$$

8.3 Randomization pattern

Table 28, which is derived from 5.1 in part 1, shows the randomization pattern used for data-sync blocks of subcode sector. In the table, the randomization pattern is divided into bytes from first serial bit to the end in order, and is expressed in hexadecimal notation. This randomization pattern performs the "exclusive or" operation to the byte position numbers 2 to 11 (see figure 12) with consistency from MSB to LSB.

8.4 ID data

The structure of ID data is shown in figure 42 from MSB to LSB of ID0 and from MSB to LSB of ID1 with sync block numbers.

8.4.1 FR ID (first half ID)

FR ID is an identification for the first half or the second half of the video frame:

FR = 1: first half of the video frame;
FR = 0: second half of the video frame.

8.4.2 AP3 and APT

For AP3 = 000b, area 3 is determined to be used as subcode sector and the data structure of subcode and error correction code are determined. APT shall have the same value in the ITI sector. Through the video frame (10 tracks for the 525-60 system, 12 tracks for the 625-50 system), AP3 and APT shall have the same value.

8.4.3 TAG ID (index ID, skip ID, PP ID)

TAG ID is a general term for index ID, skip ID and PP ID (picture/photo ID). Each bit of the TAG ID shall have the same value through the video frame and may be inserted and erased. "0" means mark and "1" means no mark.

- Index ID: Position marker for searching a recorded area such as a programme "0" shall be recorded from the start point onwards for 1 500, 1 510 or 1 520 tracks (525-60 system) or 1 500, 1 512 or 1 524 tracks (625-50 system).
- Skip ID: Position marker for starting to skip a discarded area. At the ending position of the discarded area in the forward direction of tape, index ID shall be recorded. "0" shall be recorded from the start point onwards for 300, 310 or 320 tracks (525-60 system) or 300, 312 or 324 tracks (625-50 system).
- PP ID: Position marker for searching a picture. "0" shall be recorded from the start point onwards for 1 500, 1 510 or 1 520 tracks (525-60 system) or 1 500, 1 512 or 1 524 tracks (625-50 system).

When PP ID is recorded with the video signal in successive recording, the active areas of PP ID shall have the interval of at least 10 frames between two of the active areas of PP ID.

As long as still camera pictures with SC = 0 in VAUX SOURCE CONTROL pack are recorded successively, it is permitted to lengthen the active areas of PP ID.

8.4.4 Absolute track number

Numbering of absolute track number

Every track shall have a number called the absolute track number for determining the position on the tape. Figure 43 shows the structure of the absolute track number. The absolute track number should begin from 0 at the recording start position of a tape. It is important to record the absolute track number continuously from the recording start position of the tape to the end. The blank flag BF represents the continuity of the absolute track number.

BF = 0: Discontinuity exists before current absolute track number.
BF = 1: Discontinuity does not exist before current absolute track number.

For a continuous recording, the absolute track number and the blank flag shall be determined by tracks just before the current track. For a discontinuous recording in a blank area of the tape, the absolute track number shall be determined by estimation and the blank flag shall be set to 0. The absolute track number shall be increased by 1 for each successive recording track and the same value written four times in a track as shown in figure 42.

Recording start position and invalid tracks

It is recommended that the recording start position of the tape in figure 44 should be the track of the absolute track number = 0 for the benefit of maintaining interchangeability. In figure 44, LST is the length from the end position of the leader tape to the recording start position of the ITI preamble in the track of the absolute track number = 0.

It is permitted to record invalid tracks before the recording start position of the tape LST.

The invalid tracks before the recording start position of a tape are specified below.

- | | |
|-----------------|---|
| ITI sector: | All data shall be ordinary. |
| Audio sector: | Audio data should not be taken into account. REC MODE in AAUX SOURCE CONTROL pack should be 111b. |
| Video sector: | Video data should not be taken into account. STA in byte position number 5 of video data-sync blocks should be 1111b. REC MODE in VAUX SOURCE CONTROL pack should be 11b. |
| Subcode sector: | AP3 and APT shall be 000b. Absolute track number shall be as specified in figure 45. NO INFO packs shall be recorded instead of TITLE TIME CODE packs. |

8.4.5 Sync block number

The sync block number is numbered in order from the entrance side of the subcode sector.

8.5 Subcode data

8.5.1 Main area and optional area

Subcode data in a subcode-sync block consists of 5 bytes which makes a pack as described in clause 9. The main area consists of subcode data in subcode-sync block numbers 3, 4, 5, 9, 10 and 11. An optional area consists of subcode data in subcode-sync block numbers 0, 1, 2, 6, 7 and 8. The same packs shall be recorded multiple times as shown in figure 46 for the 525-60 system and in figures 47 for the 625-50 system.

All VCR shall write the main and optional areas. If there exist pack-locations which are not used, NO INFO packs shall be recorded. Unused data inside a pack shall be filled with "1" which indicates no information.

8.5.2 User's tape

Main area

Table 29 shows the subcode data of the main area for user's tape. In a video frame, subcode data are separated into two parts, the first half and the second half.

In the first half of a video frame, there is a TITLE TIME CODE pack, a TITLE BINARY GROUP pack and a NO INFO pack. In the second half of a video frame, there is a TITLE TIME CODE pack, a VAUX REC DATE pack, a VAUX REC TIME pack, an AAUX REC DATE pack, an AAUX REC TIME pack and a NO INFO pack. Details of each pack are shown in part 4.

The time code in the TITLE TIME CODE pack adopts the SMPTE/EBU based time code (see IEC 60461). A drop frame time code shall be used for the consumer digital VCR. The blank flag (BF) shall be included in the TITLE TIME CODE pack.

- BF = 0: Discontinuity exists before current time code. Current time code is reset at the discontinuous point.
- BF = 1: Discontinuity does not exist before current time code.

The TITLE BINARY GROUP pack is prepared mainly for professional use. For no use of TITLE BINARY GROUP pack, TITLE TIME CODE pack or NO INFO pack shall be recorded.

The VAUX REC DATE pack, VAUX REC TIME pack, AAUX REC DATE pack and AAUX REC TIME pack are used for recording the recording date and time. When these packs are recorded in the second half of a video frame, the same group packs (VAUX group or AAUX group) shall be selected. For no use of these packs, NO INFO pack shall be recorded.

It is recommended that VAUX REC DATE pack and VAUX REC TIME pack are used for recording the recording date and time.

Optional area

The optional area is permitted to record any packs. When using the TAG ID NO. pack (pack header = 06h) in an active area of TAG ID, it shall be recorded in an optional area.

For no optional use, the same data packs of the main area should be recorded in the optional area as shown in table 29.

8.5.3 Pre-recorded tape

Main area

Table 30 shows the subcode data of the main area for pre-recorded tape. The following packs exist: TITLE TIME CODE, PART NO. and CHAPTER START. The same data shall be recorded in the first half and the second half of a video frame. Details of each pack are shown in part 4. The TITLE TIME CODE pack shall be the same and the blank flag in the pack shall be "1".

The PART NO. pack includes the part number and the current chapter number. The CHAPTER START pack shows the starting position of the current chapter. These packs are used for searching positions on tape. For no use of PART NO. pack or CHAPTER START pack, the TITLE TIME CODE pack shall be recorded.

Optional area

The optional area is mainly used for recording menu and TOC data which are described in the full mode of the character information system (see 9.5).

For no optional use, same data packs of main area should be recorded in the optional area as shown in table 30.

8.6 Rewrite of subcode sector

8.6.1 Rewrite of TAG ID and subcode data

When a "0" is rewritten in each TAG ID, a "1" shall be recorded for 10 to 12 frames just before the "0" rewrite area.

When TAG ID or subcode data are rewritten, at least AP3, APT, absolute track number, TITLE TIME CODE pack, VAUX REC DATE pack, VAUX REC TIME pack, AAUX REC DATE pack and AAUX REC TIME pack should be kept with consistency.

8.6.2 Insert recording

When both the video and audio sector are inserted, the subcode sector should be rewritten at the same time. When the video sector is inserted, the subcode sector should be rewritten at the same time. When the audio sector is inserted, the subcode sector should be kept. When the subcode sector is inserted, tracking should be done by using the pilots in the video sector.

8.6.3 Invalid recording of video and/or audio

The subcode sector shall be recorded even if the invalid data are recorded in video and/or audio sectors.

9 System data

9.1 System data for APT = 000b and APM = 000b

For APT = 000b, three areas exist after ITI sector (area 0) in a track as shown in figure 2. APT = 000b defines their positions in a track (see table 1 and table 2), sync block structures (see clause 3), storing areas of each application ID (see figures 8, 11, 13) and ECC structures. AP1, AP2 and AP3 define the data structure of each area.

For AP1 = 000b, the recording data shall be audio data as described in clause 6 and AAUX (see figure 7).

For AP2 = 000b, the recording data shall be video data as described in clause 7 and VAUX (see figure 10).

For AP3 = 000b, the recording data shall be subcode data as described in clause 8 and ID data (see figure 12 and figure 13).

Therefore, all application IDs are 000b for consumer digital VCRs.

9.2 Pack structure

A pack is defined as a unit of some data groups. For APT = 000b and APM = 000b, only the pack header table shown in table 1 in part 4 is defined. For AP1 = AP2 = AP3 = 000b, the contents of packs as described in part 4 are defined. Using this table, system data of AAUX, VAUX, subcode and MIC shall be formed.

9.2.1 Fixed length pack

The consumer digital VCR adopts a fixed length pack structure with one exception (see 9.2.2). A pack consists of 5 bytes. The first byte is a pack header, the other 4 bytes are pack data which are related to a pack name as shown in part 4.

9.2.2 Variable length pack

Only text packs written in MIC shall be variable length packs for the benefit of saving memory space. Details are described in figure 55.

9.2.3 Pack header

Each pack header has an 8 bits length. The most significant 4 bits of pack header shall be an upper header which has a group of 16 packs. The pack adopts a layered structure. Using bit allocation, up to three levels of the layer are permitted as shown in figure 48.

9.2.4 Error expression

When a byte of a pack data has an error during playback and cannot be concealed, the byte may be replaced with FFh which is indicative of no information byte or the whole pack shall be replaced with NO INFO pack which is indicative of no information pack.

When a pack header has an error during playback and cannot be concealed, the header shall be replaced with FFh and the pack data should be all FFh which means NO INFO pack.

9.3 Main area and optional area

9.3.1 Concept of main area and optional area

For consumer digital VCR, each AAUX, VAUX, subcode and MIC has a main area and an optional area.