

Video recording — Helical-scan digital component video cassette recording format using 12,65mm magnetic tape and incorporating data compression (Format digital-L)

The European Standard EN 61904:2000 has the status of a
British Standard

ICS 33.160.40

National foreword

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EN 61904:2000

The UK participation in its preparation was entrusted by Technical Committee
EPL/100, Audio, video and multimedia systems and equipment, to
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Video recording
Helical-scan digital component video cassette recording format using
12,65 mm magnetic tape and incorporating data compression
(Format digital-L)
(IEC 61904:2000)

Enregistrement vidéo
Format d'enregistrement numérique à
composantes à cassette à balayage
hélicoïdal utilisant la bande magnétique
de 12,65 mm avec compression de
données (Format numérique L)
(CEI 61904:2000)

Videoaufzeichnung
Videokassettenaufzeichnung mit
Schrägspuraufzeichnung digitaler
Komponenten-Signale auf Magnetband
12,65 mm, verbunden mit
Datenkompression (Digital-L-Format)
(IEC 61904:2000)

This European Standard was approved by CENELEC on 2000-06-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of document 100B/248/FDIS, future edition 1 of IEC 61904, prepared by SC 100B, Audio, video and multimedia information storage systems, 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 61904 on 2000-06-01.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
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- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2003-06-01

Annexes designated "normative" are part of the body of the standard.
Annexes designated "informative" are given for information only.
In this standard, annex ZA is normative and annexes A and B are informative.
Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61904:2000 was approved by CENELEC as a European Standard without any modification.

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

- | | |
|-----------|---|
| IEC 60735 | NOTE: Harmonized as EN 60735:1991 (not modified). |
| IEC 60961 | NOTE: Harmonized as EN 60961:1994 (not modified). |

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VIDEO RECORDING –
HELICAL-SCAN DIGITAL COMPONENT VIDEO CASSETTE RECORDING
FORMAT USING 12,65 mm MAGNETIC TAPE AND
INCORPORATING DATA COMPRESSION
(FORMAT DIGITAL-L)

1 General

1.1 Scope

This International Standard applies to the format for video cassette recording of digital component video signals and associated digital audio signals and related control signals, using 12,65 mm magnetic tape. The video data are recorded using data compression.

This standard specifies characteristics of the cassettes, the tape, the recording patterns on the tape, the processes of digital audio and video coding, data compression, error protection and channel coding which are the essential requirements for interchangeability of recordings.

1.2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

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

IEC 60958:1989, *Digital audio interface*

IEC 61213:1993, *Analogue audio recording on video tape – Polarity of magnetization*

IEC 61237-1:1994, *Broadcast video tape recorders – Methods of measurement – Part 1: Mechanical measurements*

ITU-R Recommendation BT.601-5:1995, *Studio encoding parameters of digital television for standard 4:3 and wide-screen 16:9 aspect ratios*

ITU-R Recommendation BS.647-2:1992, *A digital audio interface for broadcasting studios*

ITU-R Recommendation BT.656-4:1998, *Interfaces for digital component video signals in 525-line and 625-line television systems operating at the 4:2:2 level of Recommendation ITU-R BT.601 (Part A)*

EBU Technical Recommendation R68:1995, *Alignment level in digital audio production equipment and in digital audio recorders*

1.3 Abbreviations

For the purposes of this International Standard, the following abbreviations apply.

DCT: Discrete cosine transform
ECC: Error correcting code
TPS: Tracking pilot signal
TTS: Tracking timing signal
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 tension: $0,3\text{ N} \pm 0,05\text{ N}$;
- tape conditioning: not less than 24 h.

1.5 Reference tape

Two kinds of blank tape may be purchased from the following manufacturer:

Sony Corporation
6-7-35 Kitashinagawa,
Shinagawa-ku, Tokyo, Japan

<u>Product name</u>	<u>Purpose</u>
C2B-DB	mechanical alignment
C2A-DB	electrical alignment

1.6 Calibration tape

Manufacturers of video tape recorders designed for this format specification may sell calibration tapes meeting the following requirements. This information is given for convenience of users of this International Standard and does not constitute an endorsement by the IEC of the product named. Equivalent products may be used if they can be shown to lead to the same results.

1.6.1 Record locations and dimensions

Tolerance shown in table 2 should be reduced by 50 %.

1.6.2 Calibration tape for mechanical alignment

This tape is used for the purpose of aligning positions of stationary heads and rotary heads.

Test signals

Video/audio	ch A/C ---	4 MHz/16 MHz/50 % flat field
	ch B/D ---	8 MHz/16 MHz/50 % flat field
Cue track	1 kHz	0 VU
	12 kHz	0 VU
Time code track	25 Hz (7:3 duty rectangle)	
Control track	50 Hz	

1.6.3 Calibration tape for electrical alignment of recorders

This tape is used for RF, digital video, digital audio and cue alignment.

Test signals

Video	100 % saturation colour bars	
	ramp	
Audio	1 kHz	-20 dBFS/0 dBFS
	20 kHz	-20 dBFS
	—	- ∞ dBFS
Cue	1 kHz	0 VU/-20 VU
	3 kHz	-20 VU
	7 kHz	-20 VU
	10 kHz	-20 VU
	12 kHz	-20 VU
	90 Hz	-20 VU

1.6.4 Purchase

The calibration tapes may be purchased from the following manufacturer:

Sony Corporation
6-7-35 Kitashinagawa,
Shinagawa-ku, Tokyo, Japan

Calibration tape for mechanical alignment:

<u>Product name</u>	<u>Part number</u>
ZR2-1	8-960073-11 for 525/60 system
ZR2-1P	8-960073-61 for 625/50 system

Calibration tape for electrical alignment:

<u>Product name</u>	<u>Part number</u>
ZR5-1	8-960073-01 for 525/60 system
ZR5-1P	8-960073-51 for 625/50 system

2 Videotape cassette and tape

2.1 Mechanical parameters of cassette

2.1.1 Cassette dimensions

Two sizes of cassettes shall be identified as follows:

S cassette: 96 mm × 156 mm × 25 mm (as shown in figures 1 to 13)

L cassette: 145 mm × 254 mm × 25 mm (as shown in figures 14 to 26)

2.1.2 Tape length and play time

The tape length and the play time are shown in table 1 as a reference only, and other combinations may be chosen.

Table 1 – Tape length and play time

Nominal playing time	Magnetic tape length	
	m	
min	S cassette	L cassette
6	43 to 45	—
12	78 to 80	—
22	136 to 138	—
32	195 to 197	—
34	—	206 to 208
40	241 to 243	—
64	—	382 to 384
94	—	557 to 559
124	—	732 to 734

2.1.3 Datum planes

Datum planes Z shall be determined by three datum spots A, B and C, as shown in figures 3 and 16. Datum plane X shall be orthogonal to datum plane Z and shall include the centres of datum holes (a) and (b). Datum plane Y shall be orthogonal to both datum plane X and datum plane Z and shall include the centre of datum hole (a) as shown in figures 2 and 15.

2.1.4 Tape winding

The magnetic coating side of the magnetic tape shall face outside on both the supply reel and the take-up reel as shown in figures 4 and 17.

2.1.5 Label area and window area

The hatched areas shown in figures 1 and 14 are for the label and window. The label area and the window area shall not protrude above the height of the cassette surface.

2.1.6 Guiding groove

For correct insertion into the VTR, four guiding grooves for S cassettes as shown in figures 1 and 2, and three guiding grooves for L cassettes as shown in figure 15 shall be provided.

2.1.7 Safety tab and safety plug

For S cassettes, a safety plug at the supply reel side and a hole of minimum depth of 10 mm from datum plane Z at the take-up reel side shall be provided as shown in figure 2.

For L cassettes, a safety plug shall be provided at the take-up reel side as shown in figure 15.

2.1.8 Identification holes

Five identification holes (holes 2 to 6) shall be located as specified in figures 2 and 15.

There is no hole for hole 1 (tape type identification).

There shall be two types of reel hub diameter:

- hole 3 closed: cassette with small hub;
- hole 3 open: cassette with large hub.

Hole 2, hole 4 and hole 5 shall be closed and hole 6 shall be open. Other combinations are reserved for future assignment.

2.1.9 Reel

Locations of the reels, ready for rotation, are shown in figures 4 and 17. Dimensions of the reels are shown in figures 6 and 19. Heights of the reels are shown in figures 7 and 20.

The reels shall be automatically unlocked when the cassette is inserted into the video tape recorder and/or player unit and automatically locked when the cassette is ejected from it.

The reel shall be completely released when the cassette lid is opened 23,5 mm minimum from datum plane Z.

The reels assembled in the cassette shall be pressed by the reel spring with a specified force under the conditions specified in figures 11 and 24. The reel spring shape is specified in figure 11 for S cassettes and in figure 24 for L cassettes, and the spring force shall be $1,5 \text{ N} \pm 0,5 \text{ N}$ (153 gf $\pm$ 51 gf) for S cassettes and $3,5 \text{ N} \pm 0,5 \text{ N}$ (357 gf $\pm$ 51 gf) for L cassettes when pressing on a reel 2,4 mm above datum plane Z as shown in figures 11 and 24.

The force (F1, F2) required to pull the tape out from the reel shall not exceed 0,17 N (17 gf), as specified in figures 13a and 26a.

The torque required to wind the tape shall be less than 15 mN m (152 gf cm) for S cassettes and less than 30 mN m (305 gf cm) for L cassettes, as specified in figures 13b and 26b.

2.1.10 Protecting lid

The cassette lid shall be automatically unlocked when the cassette is inserted into the video tape recorder and/or player unit and automatically locked when the cassette is ejected from it.

The unlocking lever insertion area is specified in figures 8 and 21.

The lid shall be unlocked when the lid lock lever is shifted in either direction A or B, as illustrated in figures 9 and 22. The force required to unlock the lid shall be less than 1 N (101 gf) in the A direction or less than 1,5 N (152 gf) in the B direction.

The lid shall open 29,0 mm with a force of 1,5 N (152 gf) or less as specified in figures 10 and 23.

2.2 Magnetic tape

2.2.1 Base

The base material shall be polyester or equivalent.

2.2.2 Tape width

The tape width shall be 12,650 mm $\pm$ 0,005 mm.

2.2.3 Tape thickness

The tape thickness shall be from 12,5 μ m to 13,8 μ m.

2.2.4 Transmissivity

Transmissivity, measured in the range of wavelength from 700 nm to 900 nm, shall be less than 5 %.

2.2.5 Offset yield strength

The offset yield strength shall be greater than 20 N.

2.2.6 Magnetic coating

The magnetic tape used shall have a coating of metal particles or equivalent, longitudinally oriented, and having a coercivity in the range of 117 000 A/m to 133 000 A/m.

3 Helical recordings

3.1 Tape speed

The tape speed shall be 96,7 mm/s. The tape speed tolerance shall be $\pm$ 0,2 %.

3.2 Record location and dimensions

Geometrical location and dimensions of the recordings on the tape and their relative positions in regard to timing relations of the recorded signals shall be as specified in figure 27 and table 2.

The reference edge of the tape for the dimensions specified in this standard shall be the lower edge as shown in figure 27. The magnetic coating, with the direction of tape travel as shown in figure 27, is on the side facing the observer.

The programme area reference point is determined by the intersection of a line which is parallel to the reference edge of the tape at the distance Y from the reference edge and the centre line of the first track in each video field, that is track 0 of segment 1. The end of the preamble and the start of the first video sector shall be recorded at the programme area reference point.

3.3 Helical track record tolerance zones

The lower edges of any four consecutive tracks shall be contained within the pattern of the four tolerance zones established in figure 28.

Each zone is defined by two parallel lines which are inclined at an angle of $4,626\ 44^\circ$ for the 525/60 system or $4,630\ 32^\circ$ for the 625/50 system with respect to the tape reference edge.

The centre lines of all zones shall be spaced apart by 0,0217 mm for the 525/60 system or by 0,026 mm for the 625/50 system. The width of zones 2, 3 and 4 shall be 0,008 mm for both systems. The width of zone 1 shall be 0,004 mm for both systems. These zones are established to contain track angle errors, track straightness errors and vertical head offset tolerance.

Measuring techniques are given in IEC 61237-1.

3.4 Gap azimuth

3.4.1 Cue track, control track, time and control code track

The azimuth angle of the head gaps used for recording longitudinal tracks shall be perpendicular to the tracks.

3.4.2 Helical track

The azimuth angle of the head gaps used for recording the helical tracks shall be at an angle of α_0 or α_1 to the line perpendicular to the helical tracks, as specified in figure 27 and table 2.

The azimuth of the first track of every field, that is track 0 of segment 1, shall be orientated in the counterclockwise direction with respect to the line perpendicular to the track direction when viewed from the side of the tape carrying the magnetic recording.

**Table 2 – Record location and dimensions
for 525/60 and 625/50 systems**

Dimensions		Dimensions mm		
		Nominal		Tolerance
		525/60	625/50	
A	Time and control code track lower edge	0	0	Basic
B	Time and control code track upper edge	0,4	0,4	±0,065
C	Control track lower edge	0,7	0,7	±0,065
D	Control track upper edge	1,1	1,1	±0,065
E	Programme area lower edge	1,35	1,348	Derived
F	Programme area upper edge	11,306	11,312	Derived
G	Audio cue track lower edge	11,85	11,85	±0,06
H	Audio cue track upper edge	12,45	12,45	±0,06
J	Pitch between helical track pairs	0,0434	0,0520	Reference
K	Video sector V1,V2 length	53,159	53,536	Derived
L	Helical track total length	122,941	122,838	Derived
M0	Audio sector A0 length	2,824	2,817	Derived
M	Audio sector A1, A2 and A3 length	2,713	2,733	Derived
N	Tracking servo signal area length	0,997	0,845	Derived
P1	Control track reference to programme reference	49,621	49,304	±0,07
P2	Cue/Time and control code signal, start of code word to programme reference	175,945	176,470	±0,2
X1	Location of start of video sector V1	0	0	±0,07
X2	Location of start of video sector V2	69,771	69,302	±0,07
X3	Location of start of audio sector A0	55,817	55,780	±0,07
X4	Location of start of audio sector A1	58,807	58,738	±0,07
X5	Location of start of audio sector A2	61,797	61,696	±0,07
X6	Location of start of audio sector A3	64,787	64,654	±0,07
X7	Location of start of tracking timing signal S1	53,823	54,090	±0,06
X8	Location of start of tracking pilot signal S2	68,276	68,035	±0,06
Y	Programme area reference	1,387	1,383	Basic
W	Tape width	12,65	12,65	±0,005
Dimensions		Angles °		
		Nominal		Tolerance
		525/60	625/50	
θ	Track angle	4,626 44	4,630 32	Basic
α_0	Azimuth angle (track 0)	–15,269	–15,273	±0,17
α_1	Azimuth angle (track 1)	15,231	15,227	±0,17
NOTE The above measurements shall be made under the conditions specified in 1.4.				

4 Programme track data arrangement

4.1 Introduction

Each television field is recorded on six helical tracks.

The helical tracks contain digital data from the video channel, from four audio channels and from the tracking servo signals. The audio data is contained in four recorded sectors per track, in the middle part of each track. The video data is contained in two recorded sectors per track, at both ends of each track. The tracking servo signals are recorded between the video and audio sectors. An edit gap between sectors accommodates timing errors during editing. Figure 29 shows the arrangement of video and audio sectors and the tracking servo signals on a quartet of helical tracks for the 525/60 system and 625/50 systems.

Each sector is divided into the following elements:

- a) preamble containing clock run-up sequence;
- b) sync blocks containing sync pattern and identification pattern, followed by a fixed length data block with error control;
- c) postamble containing sync pattern and identification pattern.

4.2 Labelling convention

The least significant bit is written on the left and is the first recorded to tape. The lowest numbered byte is shown at the top-left and is the first encountered in the input data stream. Byte values are expressed in hexadecimal notation unless otherwise noted. A subscript "h" indicates a hexadecimal value.

4.3 Sector details

4.3.1 Sync block

The sync block format is common to both audio and video sectors. Each sync block contains a sync pattern (two bytes) and an inner code block (178 bytes). Each inner code block contains an identification pattern (two bytes), data (162 bytes) and inner check bytes (14 bytes). Figure 30 shows the sync block format.

4.3.2 Sync pattern

- a) Length: 16 bits (two bytes)
- b) Pattern: 2E D3_h

	LSB							MSB
Byte 0 (SY 0)	0	1	1	1	0	1	0	0
Byte 1 (SY 1)	1	1	0	0	1	0	1	1

- c) Protection: None

4.3.3 Identification pattern

The first byte of the identification pattern (ID0) identifies a specified sync block of a helical track. The second byte of the identification pattern (ID1) identifies a specified sector, track, segment and field. Figure 31 shows the track, segment and field number in a frame.

a) Length: 16 bits (two bytes)

b) Arrangement:

ID0: The sync block number (byte 2) follows a coded sequence, as shown in table 3. The last ID0 code of each sector is for postamble.

Table 3 – ID0 Sync block number

Sector	Sync block number	
	525/60	625/50
Video sector V1	FF to 95	FF to 81
Video sector V2	7F to 15	7F to 01
Audio sector A0	FF to FA	FF to F9
Audio sector A1	7F to 7A	7F to 79
Audio sector A2	3F to 3A	3F to 39
Audio sector A3	1F to 1A	1F to 19

ID1: The sector identification (byte 3) contains the following information.

LSB				MSB			
0	1	2	3	4	5	6	7
V/A	TR	SG0	SG1	F0	F1	F2	C/C

The V/A bit distinguishes between audio (= 0) and video (= 1) sectors.

The TR bit distinguishes between two tracks corresponding to track 0 and 1.

The SG bit distinguishes among three segments corresponding to segment 1, 2 and 3.

The F bit distinguishes among

four field colour sequence (0 to 3) for 525/60 system,
eight field colour sequence (0 to 7) for 625/50 system,
and five field audio sequence (0 to 4) for 525/60 system.
(0: 800 sample field, 1 to 4: 801 sample fields)

The C/C bit distinguishes between composite source (= 0)
and component source (= 1).

c) Protection: The identification pattern is protected by inner ECC.

4.3.4 Data field

a) The data field contains 162 data bytes (outer ECC check bytes are considered data) and 14 inner ECC check bytes

b) Interleaving: None

c) Protection: Inner ECC code

Type: Reed Solomon

Galois Field: GF (256)

Field generator polynomial: $X^8 + X^4 + X^3 + X^2 + 1$,

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

Order of use: the leftmost term is algebraically the most significant, the first in time computationally and the first written to tape.

Code generator polynomial (GF(256)):

$$G(X) = (X + 1)(X + a)(X + a^2)(X + a^3)(X + a^4)(X + a^5)(X + a^6)(X + a^7)(X + a^8)(X + a^9)(X + a^{10})(X + a^{11})(X + a^{12})(X + a^{13})$$

where a is given by 02_h in GF(256).

Check characters are $K_{13}, K_{12}, K_{11}, K_{10}, K_9, K_8, K_7, K_6, K_5, K_4, K_3, K_2, K_1, K_0$,

in

$$K_{13}X^{13} + K_{12}X^{12} + K_{11}X^{11} + K_{10}X^{10} + K_9X^9 + K_8X^8 + K_7X^7 + K_6X^6 + K_5X^5 + K_4X^4 + K_3X^3 + K_2X^2 + K_1X^1 + K_0$$

obtained as the remainder after dividing $X^{14}D(X)$ by $G(X)$,

where

$$D(X) = ID_0X^{163} + ID_1X^{162} + B_{161}X^{161} + B_{160}X^{160} + \dots + B_2X^2 + B_1X^1 + B_0$$

Equation of full inner code block:

$$ID_0X^{177} + ID_1X^{176} + B_{16}X^{175} + B_{160}X^{174} + \dots + B_2X^{16} + B_1X^{15} + B_0X^{14} + K_{13}X^{13} + K_{12}X^{12} + \dots + K_2X^2 + K_1X^1 + K_0$$

4.3.5 Sector preamble

All sectors are preceded by data FF_h which is converted to a sector preamble through the channel coding described in 4.5. The preamble consists of a clock run-up sequence which shall contain the pattern CC_h.

LSB				MSB			
0	0	1	1	0	0	1	1

The preamble that precedes a video sector or the first audio sector in a track shall be 120 bytes long. The preamble that precedes either the second, the third or the fourth audio sector in a track shall be 80 bytes long.

When a sector is edited, an appropriate preamble shall be recorded.

4.3.6 Sector post-amble

All sectors are followed by a post-amble, the length of which shall be four bytes. It shall consist of a sync pattern and an identification pattern.

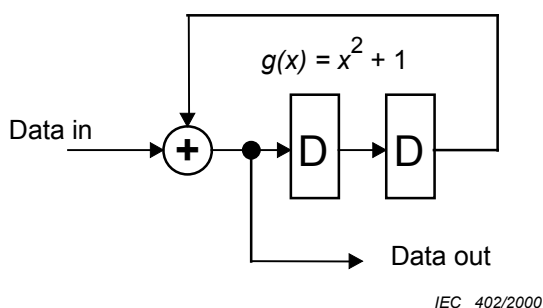
4.4 Edit gap

The space between sectors on a track, exclusive of post-amble and preamble is used to accommodate timing errors during editing. In an original recording the edit gap shall contain the pattern CC_n . The length of the edit gap varies according to the position.

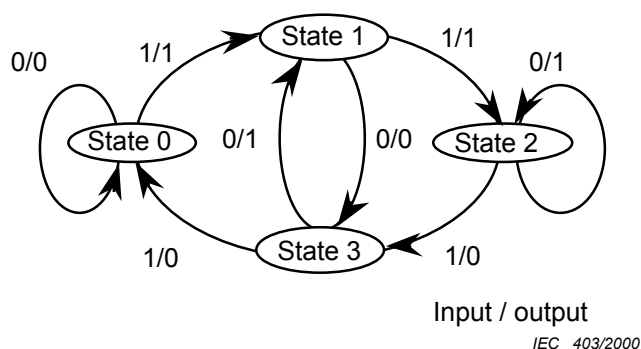
4.5 Channel coding

The channel code shall be scrambled I-NRZI modulation code, and partial response class IV precoding shall be employed.

a) The precoding is established by the polynomial generator $g(x) = x^2 + 1$ as shown below:



b) The state transition diagramme of I-NRZI is as shown below:



c) Precoded data shall be scrambled by the field generator polynomial:

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

d) LSB shall be written first to tape.

e) The preamble shall be a consecutive rectangular wave of which the period is $2T_{\min}$, where $T_{\min}$ is a minimum data length.

4.6 Tracking servo signals

Two kinds of tracking servo signals, named the tracking pilot signal (TPS) and the tracking timing signal (TTS), shall be recorded on the helical tracks. The locations of these signals in the helical tracks are shown in figure 27, table 2 and figure 29. These signals should not be over-written during insert editing.

4.6.1 TPS (tracking pilot signal)

A nominal 4 MHz rectangular wave signal is recorded on track A and track C, between the fourth audio sector and the second video sector, as the TPS. The precise frequencies shall be 4,13 MHz for the 525/60 system and 4,06 MHz for the 625/50 system. The length of recording area shall be equivalent to two sync blocks.

4.6.2 TTS (tracking timing signal)

A nominal 400 kHz rectangular wave signal is recorded on track A, between the first video sector and the first audio sector, as the TTS. The precise frequencies shall be 413 kHz for the 525/60 system and 406 kHz for the 625/50 system. The length of recording area shall be equivalent to two sync blocks. Seventeen waves are recorded on the TTS area.

4.7 Magnetization

4.7.1 Polarity

The polarity of the recorded flux on the helical tracks is not specified.

4.7.2 Record equalization

The frequency characteristics of the recording current applied to the head shall be such that the highest frequency to be recorded, that is 32,02 MHz for the 525/60 system and 31,6 MHz for the 625/50 system, is emphasized by 2,4 dB for the 525/60 system and 3,4 dB for the 625/50 system with reference to the response at 1 MHz.

4.7.3 Record level

The level of the recording current applied to the head shall be optimized for the best signal to noise ratio in reproduction in the frequency range from half the Nyquist frequency to the Nyquist frequency of the channel.

5 Data arrangement in video sectors

5.1 Introduction

This section explains the arrangement of the data in the video sectors. The video data in one video field are recorded in 12 video sectors in three pairs of helical tracks.

5.2 Recorded data

One thousand four hundred and forty samples, consisting of 720 samples of Y and 360 samples each of both Cr and Cb components per digital active line are recorded as defined in ITU-R Recommendation BT.601-5.

The relationship between video signals in the analogue and digital domains together with the address numbers of the digitized samples is shown in figure 32 (525/60 system) or in figure 33 (625/50 system).

The digital video data to be recorded on tape are those which are contained within the active lines of 256 consecutive lines (525/60 system) or 304 consecutive lines (625/50 system) from each field although the five lines in vertical blanking periods shown in figure 34 are fixed to pedestal level for 525/60 system. Any information outside the digital active lines and in the six and seven lines shown in figure 34 (525/60 system) or in the eight and nine lines shown in figure 35 (625/50 system), is not recorded on tape.

All the video data and information data to be recorded are processed as video image data in the following data compression scheme.

5.3 Data shuffling

The sequence of the video data shall be shuffled in the following process.

5.3.1 Formation of data groups for video sectors

The video data in a television field shall be divided into two groups, group A and group B, by taking every other sample, for each of the luminance and two chrominance components, as illustrated in figure 36a.

The video data in each group, A and B, shall be divided into DCT blocks, each of which consists of four samples horizontally by four samples vertically.

Each group, A and B, shall be divided into six subgroups in the following manner, as illustrated in figure 36b.

Each DCT block in the odd rows is given a number 1, 5, 3, 1, 5, 3, ... starting from the left end to the right end of the row, and each DCT block in the even rows is given a number 2, 6, 4, 2, 6, 4, ... in the same way.

The DCT blocks with a same number are gathered to form a data group, that is a total of 12 subgroups in total, A1, A2, ..., A6, B1, B2, ..., B6. Each group is recorded in each video sector as shown in figure 36c.

5.3.2 Intrasector shuffling

The DCT blocks in each subgroup shall be recorded in a specified sync block of the shuffled video sector.

A DCT block number (Z) in a subgroup numbered as shown in figure 36d which will be recorded in a certain position of a sync block, shall be derived from the recording order in the sync block (sblk) and sync block number (sync) with the following formula.

$$Z = (\text{PRM} \times b) \% (\text{HBLK} \times \text{VBLK})$$

$$b = \text{SPRM} \times \text{SBLK} \times \text{int} [(\text{sync} + \text{SCOFF} + \text{CRMOFF})/2] \times 2 + 2 \times \text{sblk} + (\text{sync} \% 2)$$

where

%	indicates that the remainder after division is taken;
int []	indicates an integral part of operation;
sync	is the sync block number in the sector = from 0 to 95 for 525/60, 0 to 113 for 625/50;
sblk	is the order of DCT block in a sync block = from 0 to 19 for Y, 0 to 9 for Cr and Cb;
SCOFF	is the sector offset which is given in table 4;
PRM	is a prime number = 913 for 525/60; 1 087 for 625/50;
HBLK	is the number of DCT blocks in a row = 30 for Y, 15 for Cr and Cb;
VBLK	is the number of DCT blocks in a column = 32 for 525/60, 38 for 625/50;
SPRM	is a prime number = 47 for 525/60, 35 for 625/50;
SBLK	is the number of DCT blocks in a sync block = 20 for Y, 10 for Cr and Cb;
CRMOFF	is a constant = 0 for Y, 2 for Cr and Cb.

Table 4 – Sector offset for 525/60 and 625/50 systems

Subgroup	Sector offset	
	525/60	625/50
A1	0	0
A2	48	58
B6	16	20
B5	64	76
A3	32	38
A4	80	96
B2	48	58
B1	0	0
A5	64	76
A6	16	20
B4	80	96
B3	32	38

5.4 DCT (discrete cosine transform)

The following formula shall be applicable for DCT.

$$X_{uv} = C_u C_v \sum_{j=0}^{N-1} \sum_{k=0}^{N-1} x_{jk} a_{uj} b_{vk}$$

$$\text{where } a_{uj} = \cos \frac{(2j+1)u\pi}{2N}, \quad b_{vk} = \cos \frac{(2k+1)v\pi}{2N}$$

$$N = 4 \quad \text{for } u, v = 0, 1, \dots, N-1$$

$$C_u = \frac{1}{\sqrt{2}} \quad \text{for } u = 0$$

$$= 1 \quad \text{for other cases}$$

$$C_v = \frac{1}{\sqrt{2}} \quad \text{for } v = 0$$

$$= 1 \quad \text{for other cases}$$

The DCT bases are 16 bits. The DCT coefficient of DCT output consists of 12-bit integer and 4-bit fraction.

5.5 Quantization

The DCT coefficients shall be quantized in accordance with the following formula and with table 5.

The absolute value for AC coefficients is given by the first equation. The absolute value for DC coefficients is given by the second equation. The positive or negative sign of a quantized output corresponds to the sign of the input DCT coefficient. The values of qq_ac, sft_ac and sft_dc corresponding to each quantization index n are given in table 5.

$$\text{Absolute value of quantized DCT coefficient (AC)} = \text{int} \left(\frac{C \times \text{qq_ac}(n) + 2^{\text{sft_ac}(n)-1}}{2^{\text{sft_ac}(n)}} \right)$$

$$\text{Absolute value of quantized DCT coefficient (DC)} = \text{int} \left(\frac{C + 2^{\text{sft_dc}(n)-1}}{2^{\text{sft_dc}(n)}} \right)$$

where

C is the absolute value of AC/DC DCT coefficient,

n is the quantization index.

Table 5 – Quantization

Index <i>n</i>	sft_ac	qq_ac	sft_dc	Index <i>n</i>	sft_ac	qq_ac	sft_dc
0	9	128	2	64	15	153	6
1	10	181	2	65	15	146	6
2	10	128	3	66	15	140	6
3	11	181	3	67	15	134	6
4	11	128	4	68	15	128	6
5	12	245	4	69	16	245	6
6	12	235	4	70	16	235	6
7	12	225	4	71	16	225	6
8	12	216	4	72	16	216	6
9	12	207	4	73	16	207	6
10	12	198	4	74	16	198	6
11	12	190	4	75	16	190	6
12	12	182	4	76	16	182	6
13	12	174	4	77	16	174	6
14	12	167	4	78	16	167	6
15	12	160	4	79	16	160	6
16	12	153	4	80	16	153	6
17	12	146	4	81	16	146	6
18	12	140	4	82	16	140	6
19	12	134	4	83	16	134	6
20	12	128	5	84	16	128	6
21	13	245	5	85	17	245	6
22	13	235	5	86	17	235	6
23	13	225	5	87	17	225	6
24	13	216	5	88	17	216	6
25	13	207	5	89	17	207	6
26	13	198	5	90	17	198	6
27	13	190	5	91	17	190	6
28	13	182	5	92	17	182	6
29	13	174	5	93	17	174	6
30	13	167	5	94	17	167	6
31	13	160	5	95	17	160	6
32	13	153	5	96	17	153	6
33	13	146	5	97	17	146	6
34	13	140	5	98	17	140	6
35	13	134	5	99	17	134	6
36	13	128	6	100	17	128	6
37	14	245	6	101	18	245	6
38	14	235	6	102	18	235	6
39	14	225	6	103	18	225	6
40	14	216	6	104	18	216	6
41	14	207	6	105	18	207	6
42	14	198	6	106	18	198	6
43	14	190	6	107	18	190	6
44	14	182	6	108	18	182	6
45	14	174	6	109	18	174	6
46	14	167	6	110	18	167	6
47	14	160	6	111	18	160	6
48	14	153	6	112	18	153	6
49	14	146	6	113	18	146	6
50	14	140	6	114	18	140	6
51	14	134	6	115	18	134	6
52	14	128	6	116	18	128	6
53	15	245	6	117	19	245	6
54	15	235	6	118	19	235	6
55	15	225	6	119	19	225	6
56	15	216	6	120	19	216	6
57	15	207	6	121	19	207	6
58	15	198	6	122	19	198	6
59	15	190	6	123	19	190	6
60	15	182	6	124	19	182	6
61	15	174	6	125	19	174	6
62	15	167	6	126	19	167	6
63	15	160	6	127	19	128	6

5.6 VLC (variable length code)

Sixteen quantized DCT coefficients in a DCT block are scanned from the top-left corner to the bottom right corner in zigzag fashion, and each DCT coefficient is given a number from 0 to 15 in the order of the scanning, as shown below.

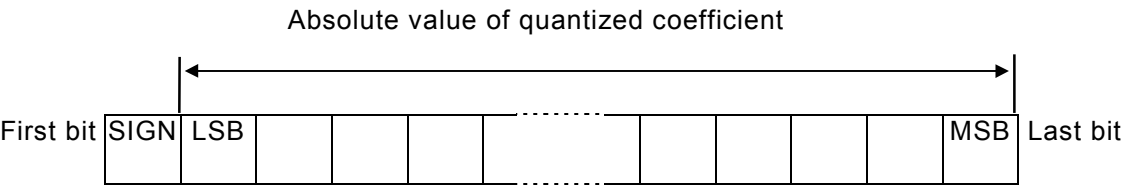
DC 0	AC01 1	AC02 5	AC03 6
AC10 2	AC11 4	AC12 7	AC13 12
AC20 3	AC21 8	AC22 11	AC23 13
AC30 9	AC31 10	AC32 14	AC33 15

DC 0	AC01 1	AC02 5	AC03 6
AC10 2	AC11 4	AC12 7	EOB 12
AC20 3	AC21 8	AC22 11	13
AC30 9	AC31 10	14	15

5.6.1 VLC of 0 (DC component)

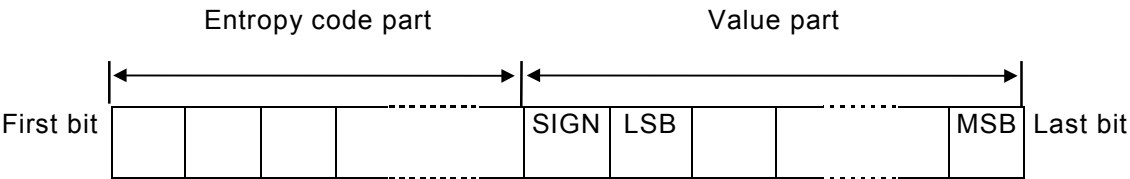
The VLC of the coefficient 0 shall be as shown below.

- a) The first bit shall indicate the positive or negative sign of the quantized DCT coefficient 0; 0 for positive or zero, 1 for negative.
- b) The other bits shall indicate the absolute value of the quantized DCT coefficient 0, with the LSB first and a code length of 16 – sft_dc(*n*) bits.



5.6.2 VLC of 1 to 15 (AC components)

The VLC of an AC component consists of two parts, the entropy code part (ECP) and the value part (VP), as illustrated below.



5.6.2.1 Entropy code part (ECP)

Each of the quantized DCT coefficients 1 to 15 shall be classified to category 0 to 13 depending on its absolute value according to table 6, and to category 14 mentioned below.

The ECP for quantized DCT coefficient *n* is obtained by referring to table 7 and 8 with the category number of the coefficient *n*, which is named CCCC, and the category number of the coefficient *n*–1, which is named PPPP. When *n* is 1, the category number PPPP shall be category 14.

In the case where the DCT coefficients n to 15 are all zero, category 14 which means end of bits (EOB), may be chosen as CCCC for n , ignoring $n+1$ onwards, instead of choosing category 0 as CCCC for each of n to 15.

Table 6 – Category conversion

Category	Absolute value of quantized DCT coefficient
0	0
1	1
2	2 to 3
3	4 to 7
4	8 to 15
5	16 to 31
6	32 to 63
7	64 to 127
8	128 to 255
9	256 to 511
10	512 to 1 023
11	1 024 to 2 047
12	2 048 to 4 095
13	4 096 to 8 191

5.6.2.2 Value part (VP)

When CCCC is 0 or 14, the VP does not exist.

When CCCC is 1, the first bit indicates the positive or negative sign of the quantized DCT coefficient, 1 for negative, and the other bits do not exist.

When CCCC is 2 to 13, the first bit indicates the positive or negative sign of the quantized DCT coefficient, and the other bits indicate a code of absolute value of the quantized DCT coefficient, that is, absolute value of quantized DCT coefficient minus 2^{CCCC-1} , with the LSB first and a code length of CCCC.

The positive or negative sign indicates as 0 for positive or zero, 1 for negative.

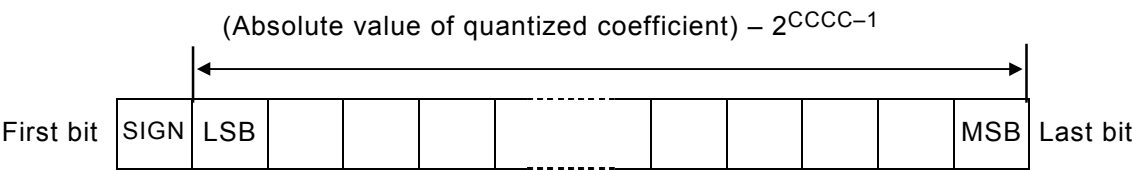


Table 7 – VLC for luminance component

PPPP	CCCC	VLC	PPPP	CCCC	VLC
0	0	00	3	12	11111111110
0	1	01	3	13	11111111111
0	2	10	3	14	11111110
0	3	110	4	0	1110
0	4	1110	4	1	010
0	5	11110	4	2	011
0	6	111110	4	3	00
0	7	1111110	4	4	10
0	8	11111110	4	5	110
0	9	1111111100	4	6	11110
0	10	1111111101	4	7	111110
0	11	1111111110	4	8	1111110
0	12	11111111110	4	9	111111100
0	13	11111111111	4	10	111111101
1	0	00	4	11	111111110
1	1	01	4	12	1111111110
1	2	10	4	13	1111111111
1	3	110	4	14	11111110
1	4	1110	5	0	11110
1	5	11110	5	1	1110
1	6	111110	5	2	110
1	7	1111110	5	3	00
1	8	11111110	5	4	01
1	9	1111111100	5	5	10
1	10	1111111101	5	6	11110
1	11	1111111110	5	7	111110
1	12	11111111110	5	8	1111110
1	13	11111111111	5	9	111111100
1	14	111110	5	10	111111101
2	0	110	5	11	111111110
2	1	00	5	12	1111111110
2	2	01	5	13	1111111111
2	3	10	5	14	11111110
2	4	1110	6	0	11110
2	5	11110	6	1	1110
2	6	111110	6	2	010
2	7	1111110	6	3	011
2	8	11111110	6	4	00
2	9	1111111100	6	5	10
2	10	1111111101	6	6	110
2	11	1111111110	6	7	11110
2	12	11111111110	6	8	1111110
2	13	11111111111	6	9	11111110
2	14	11111110	6	10	111111100
3	0	1110	6	11	111111101
3	1	110	6	12	111111110
3	2	00	6	13	111111111
3	3	01	6	14	111110
3	4	10	7	0	11110
3	5	11110	7	1	1010
3	6	111110	7	2	1011
3	7	1111110	7	3	100
3	8	11111110	7	4	110
3	9	1111111100	7	5	00
3	10	1111111101	7	6	01
3	11	1111111110	7	7	1110