

Helical-scan digital component video cassette recording system using 12,65 mm (0,5 in) magnetic tape — Format D-5

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British Standard

ICS 33.160.40

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 128, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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English version

Helican-scan digital component video cassette recording system using 12,65 mm (0,5 in) magnetic tape — Format D-5

(IEC 61835:1998)

Système de magnétoscope numérique à composantes à cassette à balayage hélicoïdal sur bande magnétique de 12,65 mm (0,5 in) — Format D-5 (CEI 61835:1998)

Videokassettensystem mit Schrägspuraufzeichnung digitaler Komponenten-Signale auf Magnetband 12,65 mm (0,5 in) — D5-Format (IEC 61835:1998)

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
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Foreword

The text of document 100B/166/FDIS, future edition 1 of IEC 61835, 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 61835 on 1998-10-01.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 1999-07-01
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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, Annex A, Annex B, Annex C and Annex ZA are normative and Annex D, Annex E and Annex F are informative.

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61835:1998 was approved by CENELEC as a European Standard without any modification.

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

IEC 60735

NOTE Harmonized as EN 60735:1991 (not modified).

IEC 61327

NOTE Harmonized as EN 61327:1995 (not modified).

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Introduction

One video channel and four independent audio channels are recorded in a digital form. The video signal may be input and output in either analogue or digital form. The audio signals may also be input and output in either analogue or digital form. In addition, a cue audio signal is recorded in analogue form.

Figure 1 and Figure 2 provide block diagrams of the processes involved in the recorder.

1 General

1.1 Scope

This International Standard defines the electrical and mechanical characteristics of equipment which permit the interchangeability of 12,65 mm cassettes containing digitally recorded component video programmes.

It specifies the content, format and recording method of the data blocks forming the helical records on the tape containing video, audio and associated data using the 12,65 mm (0,5 in) type D-5 cassettes. In addition, this standard specifies the content, format and recording method of the longitudinal record containing tracking information for the scanning head associated with the helical records, as well as the longitudinal cue audio and time and control code tracks. One video channel and four 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 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").

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 indicated 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 60958:1989, *Digital audio interface*.

IEC 61179:1993, *Helical-scan digital composite video cassette recording system using 19 mm magnetic tape, format D2 (NTSC, PAL, PAL-M)*.

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 656-3:1995, *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*.

1.3 Definitions, symbols and abbreviations

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

1.3.1

ECL

emitter coupled logic, a family of digital logic integrated circuits. In this standard, ECL refers to the 10 000 series of logic integrated circuits

1.3.2

GF

galois Field. A mathematical field containing a finite number of elements in which algebraic operations may be performed

the number of field elements is generally written as an argument in parentheses, for example GF(256)

1.3.3

LSB

least significant bit of a word of data or least significant byte of a data item consisting of 2 or more bytes

1.3.4 MSB

most significant bit of a word of data or most significant byte of a data item consisting of 2 or more bytes

1.3.5 ScH

colour subcarrier to horizontal sync timing relationship

1.3.6 ECC

error correcting code

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: $0,31\text{ N} \pm 0,05\text{ N}^a$;
- tape conditioning: not less than 24 h.

^a The value measured with a tension monitor on the entrance side of the scanner may vary between manufacturers, but should typically be $0,30\text{ N} \pm 0,03\text{ N}$.

1.5 Reference tape

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

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 5 or Table 6 should be reduced by 50 %.

1.6.2 Calibration signals

Two classes of signals should be recorded on the calibration tapes:

- a) A series of conventional test signals

Video

- 100 % saturation colour bars

Audio

- 1 kHz tone at – 20 dB below full scale

Cue

- 1 kHz tone at reference level
- 10 kHz tone at reference level

- b) A signal of constant frequency recorded (i.e., 50 % the Nyquist frequency) only in the tracks of field 0, segment 0 for the purpose of mechanical alignment.

1.6.3 Purchase

The calibration tape may be purchased from the manufacturer given in Annex E.

2 Video tape cassette

2.1 Mechanical parameters

2.1.1 *Cassette dimensions*

2.1.1.1 The dimensions of the three different cassettes used for recording shall be in accordance with Figure 3 to Figure 23. Small and medium size cassettes shall utilize reels with 30 mm and 50 mm hub diameter sizes. Large size cassettes shall use reels with 44 mm hub diameter.

Both hubs within the cassette shall be of the same size.

2.1.1.2 General tolerances for dimensions, except those for which tolerances are otherwise specified, shall be as indicated in Table 1.

Table 1 — Mechanical tolerances

Dimensions in millimetres

Over	To	Tolerance
0	4	$\pm 0,15$
4	16	$\pm 0,2$
16	63	$\pm 0,25$
63	250	$\pm 0,3$
250		$\pm 0,4$

2.1.2 *Identification of cassettes*

The three sizes of cassettes shall be identified as:

- small: S
- medium: M
- large: L

2.1.3 *Tape length, thickness and play time*

The tape length, thickness and play time for the three sizes of cassettes shall be as indicated in Table 2.

Table 2 — Tape thickness, length and play time of S, M, L cassettes

Tape cassette	Hub diameter mm	Thickness μm	Length m	Play time min
S	30	11/14	325/254	32/25
	50	11/14	204/163	20/16
M	30	11/14	632/481	62/47
	50	11/14	506/405	50/40
L	44	11/14	1 237/935	123/93

2.1.4 *Coating face*

The magnetic coating on the tape shall face out of the cassette as specified in Figure 3 to Figure 5.

2.1.5 *Datum planes*

2.1.5.1 Datum plane Z is determined by datum areas A, B and C as specified in Figure 6 to Figure 8.

2.1.5.2 Datum area C need not correspond with a fastener.

2.1.5.3 Datum plane X shall be orthogonal to datum plane Z and shall run through the centre of datum hole (a) and datum hole (b) as specified in Figure 9 to Figure 11.

2.1.5.4 Datum plane Y shall be orthogonal to both datum plane X and datum plane Z, and shall run through the centre of datum hole (a) as specified in Figure 9 to Figure 11.

2.1.5.5 The light path shall be as specified in Figure 12 to Figure 14.

2.1.5.6 The cassette positioning surface area shall be as specified in Figure 15 to Figure 17.

2.1.6 Window and labels

2.1.6.1 Window and label areas shall be as specified in Figure 18 to Figure 20.

2.1.6.2 Labels attached to the cassette shall not extend beyond the external dimensions as shown in Figure 18 to Figure 20.

2.1.6.3 Labels shall not even partially cover the identification holes of the users or of the manufacturers.

2.1.6.4 Labels shall not interfere with the hub drive and support mechanism.

2.1.7 Identification holes

2.1.7.1 There shall be 2 sets of identification holes; one for use by the manufacturer, and the other for the user.

2.1.7.2 The dimension and location of manufacturers' coding holes, detailed in Figure 21 to Figure 23, shall be defined as follows. Holes (1), (2) and (3) shall be used in combination to indicate tape thickness and diameter of hub according to the following logic table:

Hole numbers:	(1)	(2)	(3)	
	0	0	0	Class 1600, 11 µm tape, 30 mm diameter hub
	0	0	1	Class 1600, 11 µm tape, 50 mm diameter hub
	0	1	0	Class 1600, 14 µm tape, 30 mm diameter hub
	0	1	1	Class 1600, 14 µm tape, 50 mm diameter hub
	1	0	0	Class 1800, 11 µm tape, 30 mm diameter hub
	1	0	1	Class 1800, 11 µm tape, 50 mm diameter hub
	1	1	0	Class 1800, 14 µm tape, 30 mm diameter hub
	1	1	1	Class 1800, 14 µm tape, 50 mm diameter hub

A "1" in the above table indicates that the indicator tab is removed or open, which results in an undetected state by the recorder/player sensor mechanism.

2.1.7.3 The dimension and location of the users' coding holes, detailed in Figure 21 to Figure 23, shall be defined as follows.

When a "1" state exists, the user holes shall identify the following conditions:

- user hole (a): total record lock-out (audio/video/cue/time and control code/control track);
- user hole (b): video and control track record lock-out;
- user hole (c): reserved and undefined.

2.1.7.4 The user plug mechanism shall withstand an axial force of 0,5 N.

2.1.7.5 The colour of the user plugs shall be red.

2.1.8 Leader/trailer tape

2.1.8.1 The cassette shall include leader and trailer tape. When attached to the hub, the lengths between the splice point and the clamping point on the reel hub shall be as specified in Table 3.

Table 3 — Length of leader and trailer tape

Hub diameter mm	Cassette size	
	S, M mm	L mm
30	165 ± 10	—
44	—	180 ± 10
50	155 ± 10	—

2.1.8.2 The leader/trailer tape material shall be polyester or any equivalent material with a transmissivity of at least 50 % when measured with a 800 nm to 900 nm light source.

2.1.8.3 When attached to the hub, the leader/trailer tape shall not separate when subjected to a force of 20 N or less.

2.1.8.4 The width of the leader/trailer tape shall be 12,650 mm ± 0,020 mm.

2.1.8.5 The thickness of the leader/trailer tape shall be 14 μm to 36 μm .

2.1.8.6 The splicing tape used to attach the leader/trailer tape shall be applied to the non-magnetic coated side.

2.1.9 Reels

2.1.9.1 The dimensions of the reels and the relationship between the reels and reel tables are specified in Figure 24 to Figure 31.

2.1.9.2 The reels shall be locked automatically when the cassette is removed from the recorder/player. The number and shape of the teeth as well as the locking mechanism are not specified.

2.1.9.3 When a cassette is inserted into the recorder/player, the reels shall be unlocked automatically by the light house as specified in Figure 32. The force needed to release the reel lock shall be less than 1,0 N.

2.1.9.4 The reels shall be held in position by a reel spring with a force as shown in Table 4, when the height of the reel table support is 2,0 mm $\pm$ 0,1 mm from datum plane Z as shown in Figure 29 to Figure 31.

Table 4 — Reel spring force

Cassette size	Force N
S	2,5 $\pm$ 0,3
M	3,5 $\pm$ 0,3
L	4,0 $\pm$ 0,3

2.1.10 Lid

2.1.10.1 The lid shall be unlocked and opened by the recorder/player when the cassette is inserted.

2.1.10.1.1 The lid shall be unlocked by a force of less than 0,3 N exerted upon the release pin, as specified in Figure 33 and Figure 35.

2.1.10.1.2 The inner door shall be lifted by the recorder/player to the position shown in Figure 36.

2.1.10.1.3 The outer door shall be lifted by the recorder/player to the position shown in Figure 37 and Figure 39.

2.1.10.2 The minimum space of cassette for the VTR loading mechanism shall be as shown in Figure 40.

2.1.10.3 The outer door when opened shall not exceed 37 mm with respect to datum plane Z, and the angle γ between the front side surface and datum plane X shall be of $93^\circ \pm 2^\circ$, as specified in Figure 41.

2.1.10.4 When the cassette is removed from the recorder/player, the lid shall be locked automatically.

2.1.10.5 The maximum force to open the lid shall be less than 1 N for S and M cassettes and 1,5 N for L cassettes up to the 25 mm minimum height defined in Figure 41.

2.1.10.6 The force required to open the lid shall be applied $93^\circ \pm 2^\circ$ to the datum plane Z at the opening and closing areas as shown in Figure 36 to Figure 41.

2.2 Video tape specification

2.2.1 Base

The base material shall be polyester or equivalent.

2.2.2 Width

The tape width shall be 12,650 mm $\pm$ 0,008 mm.

The tape, covered with glass, is measured without tension at a minimum of five different positions along the tape using a calibrated comparator with an accuracy of 1/1 000 mm = 1 μm . The tape width is defined as the average of the five readings.

2.2.3 Width fluctuation

Tape width fluctuation shall not exceed 5 μm peak-to-peak. Measurement of tape width fluctuation shall be made over a tape length of 900 min. The value of tape width fluctuation shall be evaluated by measuring the tape width at 10 points, each separated by a distance of 100 mm.

2.2.4 Tape thickness

Two types of tape thickness shall be permitted by this standard. The first tape thickness shall be 10,2 μm to 11,0 μm , the second tape thickness shall be 13,0 μm to 14,0 μm .

2.2.5 Transmissivity

Transmissivity shall be less than 5 %, measured over the range of wavelengths 800 nm to 900 nm.

2.2.6 Offset yield strength

The offset yield strength shall be greater than 9 N for 11 mm tapes and 10 N for 14 mm tapes. The force required to produce 0,2 % tangential elongation of a 1 000 mm test sample with a pull rate of a 10 mm/min. shall be applied in order to confirm the offset yield strength. The line beginning at 0,2 % elongation parallel to the initial tangential slope is drawn and then read at the point of intersection of the line and the stress-strain curve.

2.2.7 Magnetic coating

The magnetic tape used shall have a coating of metal particles or equivalent.

2.2.8 Coating coercivity

The coating coercivity shall be a class 1 800 Oe (144 000 A/m), with an applied field of 400 000 A/m (5 000 Oe) as measured by a 50 Hz or 60 Hz B-H meter or vibrating sample magnetometer (VSM).

2.2.9 Particle orientation

The metal particles shall be longitudinally oriented.

3 Helical recordings

3.1 Tape speed

The tape speed shall be 167,228 mm/s. The tolerance shall be $\pm 0,2$ %.

3.2 Record location and dimensions

3.2.1 Erasure

The format requires a full-width erasure for continuous recording and a flying erasure for insert editing.

3.2.2 Record location and dimensions

Record location and dimensions for continuous recording shall be as specified in Figure 42 and Figure 43 and Table 5 (525/60 system) or Table 6 (625/50 system). When recording, sector locations on each helical track shall be contained within the tolerance specified in Figure 42 and Table 5 (525/60 system) or Table 6 (625/50 system).

3.2.3 Reference edge

The reference edge of the tape for dimensions specified in this standard shall be the lower edge as shown in Figure 42. The magnetic coating, with the direction of tape travel as shown in Figure 42, is on the side facing the observer (see Annex B).

3.2.4 Track pitch

As indicated in Figure 42, this standard anticipates a zero guard band between recorded tracks, and the record head width should be equivalent to the track pitch of 20 μm (525/60 system) or 18 μm (625/50 system). The scanner head configuration should be chosen so that the recorded track widths are contained within the limits of 18 μm to 22 μm (525/60 system) or 16 μm to 20 μm (625/50 system).

3.2.5 Flying erasure

In insert editing, this standard provides a guard band of 2 μm (nominal) between the previously recorded track and the inserted track at editing points only. A typical track pattern for insert editing is shown in Figure C.1 of Annex C.

3.3 Helical track record tolerance zones

The lower edges of any 8 consecutive tracks starting at the first track in each video frame shall be contained within the pattern of the 8 tolerance zones established in Figure 44. Each zone is defined by 2 parallel lines which are inclined at an angle of 4,938 4° basic (525/60 system) or 4,934 5° basic (625/50 system) with respect to the tape reference edge.

The centre lines of all zones shall be spaced apart 0,020 0 mm basic (525/60 system) or 0,018 mm basic (625/50 system). The width of zones 1 to 3 and 5 to 8 shall be 0,006 mm basic. The width of zone 4 shall be 0,004 mm basic. These zones are established to contain track angle errors, track straightness errors and vertical head offset tolerance (see Annex B).

3.4 Relative positions of recorded information

3.4.1 Relative positions of the longitudinal tracks

Audio, video, control, time and control code, and cue tracks with information intended to be time coincident shall be positioned as shown in Figure 42 and Figure 43.

3.4.2 Programme area reference point

The programme area reference point is determined by the intersection of a line parallel to the reference edge of the tape at a distance Y from the reference edge and the centre line of the first track in each video field (segment 0, track 0) (see Figure 42 and Figure 43).

The end of the preamble and start of the video sector shall be recorded at the programme area reference point, and the tolerance is dimension X1. The locations are shown in Figure 42 and Figure 43, dimensions X1 and Y are in Table 5 and Table 6. The relationship between sectors and contents of each sector is specified in clause 4.

3.5 Gap azimuth

3.5.1 Cue track, control track, time and control code track

The azimuth angle of the cue, control track, and time and control code head gaps used to produce longitudinal track records shall be perpendicular to the track record.

3.5.2 Helical track

The azimuth of the head gaps used for the helical track shall be inclined at angles α_0 and α_1 as specified in Table 5 and Table 6 with respect to a line perpendicular to the helical track. The azimuth of the first track of every field (segment 0, track 0) shall be oriented in the counterclockwise direction with respect to the line perpendicular to the helical track direction when viewed from the side of the tape containing the magnetic record.

3.6 Transport and scanner

The effective drum diameter, tape tension, helix angle, and tape speed taken together determine the track angle. Different methods of design and/or variations in drum diameter and tape tension can produce equivalent recordings for interchange purposes.

A possible configuration of the transport uses a scanner with an effective diameter of 76,000 mm. Scanner rotation is in the same direction as tape motion during normal playback mode. Data is recorded by 2 groups of 4 heads mounted 180° apart. Figure 45 (525/60 system) and Figure 46 (625/50 system) show a possible mechanical configuration of the scanner and Table 7 shows the corresponding mechanical parameters. Figure 47 (525/60 system) and Figure 48 (625/50 system) show the relationship between the longitudinal heads and the scanner.

Other mechanical configurations are allowable provided the same footprint of recorded information is produced on tape.

Erase heads are shown in Figure 45 to Figure 46.

4 Programme track data arrangement

4.1 Introduction

Each TV field is recorded on 12 tracks (525/60 system) or 16 tracks (625/50 system).

The helical tracks contain digital data from the video channel and 4 audio channels. The audio data is contained in 4 recorded sectors per track at the middle part of the track. The video data is recorded in 2 sectors per track at both ends of each track. An edit gap between sectors accommodates timing errors during editing. Figure 49 shows the arrangement of video and audio sectors on the tape.

Each sector (audio or video) is divided into the following elements:

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

— 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 (2 bytes) and an inner code block. Each inner code block contains an identification pattern (2 bytes) and 85 data bytes (525/60 system) or 76 data bytes (625/50 system) (outer check bytes are considered data) plus 8 inner check bytes. The inner code block protects the 2 bytes of the identification pattern together with 85 data bytes (525/60 system) or 76 data bytes (625/50 system). Figure 50 (525/60 system) and Figure 51 (625/50 system) show the sync block format.

4.3.2 Sync pattern

- a) Length: 16 bits (2 bytes).
- b) Pattern: 97F1 (in hexadecimal notation).

	LSB							MSB
Byte 0	1	1	1	0	1	0	0	1
Byte 1	1	0	0	0	1	1	1	1

- c) Protection: none.
- d) Randomization: none.

4.3.3 Identification pattern

The first byte, and the bit 0 and 7 of the second byte of the identification pattern identify a particular sync block of a helical track. The bits 1 – 6 of the second byte of the identification pattern identify a particular track. Figure 52 (525/60 system) and Figure 53 (625/50 system) show the format of the identification pattern.

- a) Length: 16 bits (2 bytes).
- b) Arrangement: the sync block number (byte 2 and the bit 0 of byte 3) follows a coded sequence along the track. Figure 54 shows the sequence of sync block numbers.

The sector ID (bits 1–7 of the byte 3) identifies a particular sector.
The segment count is modulo 3 (525/60 system) or modulo 4 (625/50 system). For the 525/60 system, the field count for video sectors is modulo 4 (F2 = 0 in byte 3). The field count for audio sectors is modulo 4 (for F0 and F1 in byte 3) and F2 (in byte 3) is used for the identification of the five field sequences. For the 625/50 system, the field count for video sectors is modulo 8 and the field count for audio sectors is modulo 4 (F2 = 0).

- c) The field address F0, F1, F2 (bits 4, 5 and 6 of the byte 3) for video sync blocks shall identify the 4 field colour sequences (525/60 system) or 8 field colour sequences (625/50 system) as defined in ITU-R Report 624-4 and have the values as shown below:

525/60 system		F0	F1	F2
—	Colour frame A, field I	0	0	0
—	Colour frame A, field II	1	0	0
—	Colour frame B, field III	0	1	0
—	Colour frame B, field IV	1	1	0

625/50 system

— Colour field 1	0	0	0
— Colour field 2	1	0	0
— Colour field 3	0	1	0
— Colour field 4	1	1	0
— Colour field 5	0	0	1
— Colour field 6	1	0	1
— Colour field 7	0	1	1
— Colour field 8	1	1	1

For the 525/60 system, the field address F0 and F1 (bits 4 and 5 of the byte 3) for audio sync blocks shall identify the 4 fields in the five field sequence. When audio sectors are edited, the 4 field sequences shall be maintained. The field address F2 (bit 6 of the byte 3) for audio sync blocks shall identify the number of audio samples in the current field as shown below:

Number of audio samples

in the current field	F2
801	0
800	1

d) Protection: the identification pattern is protected by inner code block.

e) Randomization: the identification pattern is randomized before being channel-coded. The randomization is equivalent to performing the exclusive-OR operation between the serial data stream and serial stream generated by the polynomial function:

$$x^8 + x^4 + x^3 + x^2 + 1 \text{ [in GF(2)]}.$$

The first term is the most significant and the first to enter the division computation. The polynomial generator noted above is preset to 15h (525/60 system) or 0Ch (625/50 system) at the first byte of the identification pattern and continues to cycle until the end of the sync block.

4.3.4 Data field

This block is used for all video and audio data and the associated error correction data.

a) Length: one inner code block. For the 525/60 system, the inner code block contains 95 bytes consisting of 2 identification pattern bytes, 85 data bytes (outer ECC check bytes are considered data), plus 8 inner ECC check bytes. For the 625/50 system, the inner code block contains 86 bytes consisting of 2 identification pattern bytes, 76 data bytes (outer ECC check bytes are considered data), plus 8 inner ECC check bytes.

b) Arrangement: see Figure 50 and Figure 51.

c) Interleaving: none.

d) Protection: inner ECC code.

Type is Reed Solomon.

Galois Field is GF(256).

Field generator polynomial is: $x^8 + x^4 + x^3 + x^2 + 1$

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

Order of use: left-most term is most significant, the “oldest” in time computationally, and the first written to tape.

Code Generator Polynomial in GF(256) is:

$$G(x) = (x + 1)(x + a)(x + a^2)(x + a^3)(x + a^4)(x + a^5)(x + a^6)(x + a^7)$$

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

Check characters: $K_7, K_6, K_5, K_4, K_3, K_2, K_1, K_0$ in $K_7x^7 + K_6x^6 + K_5x^5 + K_4x^4 + K_3x^3 + K_2x^2 + K_1x + K_0$ obtained as the remainder after dividing $x^8D(x)$ by $G(x)$,

where $D(x) = ID_0x^{86} + ID_1x^{85} + B_{84}x^{84} + \dots + B_2x^2 + B_1x + B_0$ (525/60 system);

$D(x) = ID_0x^{77} + ID_1x^{76} + B_{75}x^{75} + \dots + B_2x^2 + B_1x + B_0$ (625/50 system).

Polynomial of full code:

$ID_0x^{94} + ID_1x^{93} + B_{84}x^{92} + B_{83}x^{91} + \dots + B_1x^9 + B_0x^8 + K_7x^7 + K_6x^6 + \dots + K_2x^2 + K_1x + K_0$ (525/60 system);

$ID_0x^{85} + ID_1x^{84} + B_{75}x^{83} + B_{72}x^{82} + \dots + B_1x^9 + B_0x^8 + K_7x^7 + K_6x^6 + \dots + K_2x^2 + K_1x + K_0$ (625/50 system).

e) Randomization: all data and error correction check characters are randomized before being channel-coded. The randomization is equivalent to randomization as defined in 4.3.3 e).

4.3.5 Sector preamble

All sectors are preceded by a preamble consisting of a clock run-up sequence, sync pattern (2 bytes), identification pattern (2 bytes) and fill pattern (4 bytes). The clock run-up sequence varies in length depending on the sector. The remaining elements of the preamble have the same format for all sectors.

When a sector is edited, the appropriate preamble, including run-up sequence, shall be recorded.

4.3.5.1 Track preamble (T)

The track preamble precedes the first sector of every track. The total length of track preamble is 58 bytes long and contains 50 bytes of run-up pattern "2Ch", which is followed by 2 bytes of sync pattern, 2 bytes of identification pattern, and 4 bytes of fill pattern "00h".

LSB				MSB			
0	0	1	1	0	1	0	0

a) Arrangement: see Figure 55a.

b) Total length: 58 bytes.

c) Run-up pattern: 2Ch.

d) Sync pattern: (see 4.3.2).

e) Identification pattern: (see 4.3.3).

f) Fill pattern: 00h.

g) Protection: none.

h) Randomization: only the identification pattern and fill pattern are randomized before being channel-coded. The randomization is equivalent to randomization as defined in 4.3.3 e).

4.3.5.2 In-track preamble (E)

An in-track preamble precedes every sector except the first sector of a track. The total length is 28 bytes long and contains 20 bytes of run-up pattern "2Ch" followed by 2 bytes of sync pattern, 2 bytes of identification pattern, and 4 bytes of fill pattern "00h".

a) Arrangement: see Figure 55b.

b) Total length: 28 bytes.

c) Run-up pattern: 2Ch.

LSB				MSB			
0	0	1	1	0	1	0	0

d) Sync pattern: (see 4.3.2).

e) Identification pattern: (see 4.3.3).

f) Fill pattern: 00h.

g) Protection: none.

- h) Randomization: only the identification pattern and fill pattern are randomized before being channel-coded. The randomization is equivalent to randomization as defined in 4.3.3 e).

4.3.6 Sector postamble (P)

All sectors are followed by a postamble. The total length is 4 bytes and contains 2 bytes of sync pattern and 2 bytes of identification pattern.

- a) Arrangement: see Figure 55c.
- b) Total length: 4 bytes.
- c) Sync pattern: (see 4.3.2).
- d) Identification pattern: (see 4.3.3).
- e) Protection: none.
- f) Randomization: only the identification pattern is randomized before being channel-coded. The randomization is equivalent to randomization as defined in 4.3.3 e).

4.4 Edit gaps

The space between individual sectors of a track, exclusive of preamble and postamble, is nominally 162 bytes long in 525/60 system and 144 bytes long in 625/50 system, and is used to accommodate timing errors during editing. In an original recording, the edit gap shall contain a pattern 2Ch. During an edit, the edit gap may be partially overwritten with 2Ch code provided that the preamble and/or postamble of the adjacent unedited track sectors are not overwritten.

- a) Protection: none.
- b) Randomization: none.

4.5 Channel coding

4.5.1 Coding rules

The channel coding shall be 8–14 modulation which is defined by the following coding rules.

NOTE 1 DSV is an abbreviation for digital sum variation and indicates the integral value which is counted from the beginning of the 8–14 modulated wave form, taking high level as 1 and low level as – 1.

NOTE 2 CDS is an abbreviation for code word digital sum and indicates the DSV of one symbol modulation code.

NOTE 3 8-bit data entries in Table 8 and Table 9 are in hexadecimal notation.

For selecting the current 14-bit code, the following steps shall be taken:

- a) Select a 14-bit code satisfying the following conditions of item 1) and 2) from Table 8 and Table 9:
 - 1) The number of consecutive identical bits at the joint portion with the preceding 14-bit code is 2 to 7.
 - 2) The absolute value of the DSV at the end of the code (hereinafter called end DSV) is equal to or less than 2.
- b) When 2 or more 14-bit codes are selected at step a), choose a 14-bit code that gives the smallest absolute value of the end DSV.
- c) When 2 or more 14-bit codes are still chosen in step b), select a 14-bit code by calculating the DSV for each bit of the code (called bit DSV hereinafter), determining for the bit DSV the absolute value of which is minimum for each code, and choosing the code with the bit DSV whose minimum absolute value is smallest.
- d) When 2 or more 14-bit codes are further found in step c), select a 14-bit code by finding the maximum absolute value of the bit DSV of each code, and choosing a code with the bit DSV whose maximum absolute value is equal to or less than six.
- e) When 2 or more codes are still found in step d), select a 14-bit code satisfying the condition that the number of consecutive identical bits at the joint portion with the preceding 14-bit code is equal to or less than six.
- f) When any codes selected at step d) do not satisfy step e), or 2 or more modulation codes satisfy step e), select a 14-bit code satisfying the condition that the number of consecutive identical bits in that code is equal to or less than six.

g) When any codes selected at step d) do not satisfy step e) and step f), or when any codes selected at step e) do not satisfy step f), or when 2 or more codes are further found at step f), the following 2 steps shall be taken.

1) When the end DSV of the code is -2 , select from Table 10 a code of higher priority corresponding to the smallest number in Table 10). Likewise, when the end DSV of the code is $+2$, select from Table 11 a code of higher priority (corresponding to the smallest number in Table 11).

2) When 2 or more codes belonging to the equal highest priority are found in step 1), select all of them temporarily. When the end DSV is zero, select a code satisfying the last six bits which is neither 111 111 nor 000 000.

h) When any codes selected at step d) do not satisfy steps e), f), and g), or when any codes selected at step e) do not satisfy step f) and step g), or when any codes selected at step f) do not satisfy step g), or when 2 or more codes are further found at step g), select a code with the bit DSV whose maximum absolute value is smallest.

i) When 2 or more codes are still found at step h), select a 14-bit code with the bit DSV whose minimum absolute value appears earliest in the bit string of the code.

j) When 2 or more codes are further found at step i), select a 14-bit code whose bit will be reversed earliest after the joint portion with the preceding code.

4.5.2 Data rate and wavelength

The recorder data rate (for the scanner configuration defined in 3.6) and the shortest recorded wavelength are given in Table 12, provided for reference only:

Table 12 — Data rate and wavelength

Parameter	525/60 system	625/50 system
Total average data rate	300,6 Mb/s	303,4 Mb/s
Instantaneous channel data rate	76,5 Mb/s	77,8 Mb/s
Shortest recorded wavelength	0,64 μm	0,70 μm

4.6 Magnetization

4.6.1 Polarity

The recorder shall operate in reproduction without regard to the polarity of the recorded flux on the helical tracks.

4.6.2 Recorded equalization

The record head current applied to a head should generate a constant flux level within a gap from the lowest recorded frequency (i.e. approximately one-third the Nyquist frequency) to the Nyquist frequency.

4.6.3 Record level

The level of the record head current applied to the head should be optimized for best reproduced signal-to-noise ratio at the highest constant recorded frequency (i.e. the Nyquist frequency of the channel). Other methods of setting the record level are permitted, providing they achieve the same results.

5 Video interface

The video signal interface conforms to the following standard:

525/60 system

Analogue interface	ITU-R Report 624-4
Digital parallel interface	SMPTE 125M
Digital serial interface	SMPTE 259M

625/50 system

Analogue interface	ITU-R Report 624-4
Digital parallel interface	ITU-R Recommendation 601-3
Digital serial interface	IEC 61179

6 Audio interface

6.1 Encoding parameters

The digital audio signal is encoded according to the following parameters:

6.1.1 Sampling

- a) The sampling frequency is 48,000 kHz and shall be related to the horizontal frequency F_H as follows:

$$48 \text{ kHz} = F_H \times 1\,144/375 \quad (525/60 \text{ system})$$

$$48 \text{ kHz} = F_H \times 384/125 \quad (625/50 \text{ system}).$$

- b) The resolution of each sample is 16 bits minimum, 20 bits maximum.

- c) The coding is 2's complement linear PCM.

6.1.2 Reference level

For 525/60 system The recommended recorded audio levels should be 20 dB below the system maximum (according to SMPTE RP 155).

For 625/50 system The recommended recorded audio levels should be 18 dB below the system maximum (according to EBU Technical Recommendation R68).

6.2 Digital signal interface

The principal mode of interface is analogue. The audio signal may also be input and output digitally in a bit-serial form. The bit-serial interface, if present, shall conform to the IEC 60958.

7 Video processing

7.1 Introduction

The purpose of video processing operation is to transform the input component video digital data into a form suitable for tape recording.

By re-assembling odd and even samples of the luminance data, 2 equal size data blocks are produced. All 4 data blocks, odd luminance Y_o , even luminance Y_e , colour difference C_R , colour difference C_B , are of equal data volume.

Additional data space, 24 samples in duration, is added to each horizontal line of data for all 4 data blocks. Colour difference samples C_R , C_B , and even luminance samples Y_e , are handled together as one group. Odd luminance samples are handled independently. (See Figure E.4 to Figure E.5.)

The total video data is distributed into 12 video blocks (four channels, each channel with three video blocks) for 525/60 system, and 16 video blocks (four channels, each channel with 4 video blocks) for 625/50 system.

Those data is converted from 10 bit word to 8 bit word (see Figure E.3) and randomized. Column shuffling, outer error correction code addition, and interleaving operations, are performed. Sync, ID and inner error correction code are added to each sync block, the smallest data block. Prior to recording, randomization and 8–14 conversion are performed.

7.2 Recorded data

7.2.1 Recorded samples and lines of the television frame

Video samples and reserve data are recorded as follows. The relationship between video signals in the analogue and digital domains is shown in ITU-R Recommendation 601-3.

Y : 720 sample/line for luminance sample (Y) plus 48 samples/line for reserve data.

C_R : 360 sample/line for colour difference sample (C_R) plus 24 samples/line for reserve data.

C_B : 360 sample/line for colour difference sample (C_B) plus 24 samples/line for reserve data.

255 consecutive lines (525/60 system) or 304 consecutive lines (625/50 system) from each field are recorded. The first recorded sample of each field shall vary over a 4 field sequence (525/60 system) or 8 field sequence (625/50 system) as follows, with the numbers defined as in ITU-R Recommendation 601-3 and ITU-R Recommendation 656-1.

525/60 system

- from colour frame A, field I, the first recorded sample is number 0 of line 9;
- from colour frame A, field II, the first recorded sample is number 0 of line 271;

- from colour frame B, field III, the first recorded sample is number 0 of line 9;
- from colour frame B, field IV, the first recorded sample is number 0 of line 271.

625/50 system

- from field 1, the first recorded sample is number 0 of line 7;
- from field 2, the first recorded sample is number 0 of line 320;
- from field 3, the first recorded sample is number 0 of line 7;
- from field 4, the first recorded sample is number 0 of line 320;
- from field 5, the first recorded sample is number 0 of line 7;
- from field 6, the first recorded sample is number 0 of line 320;
- from field 7, the first recorded sample is number 0 of line 7;
- from field 8, the first recorded sample is number 0 of line 320.

When the first recorded line in the vertical blanking period of each field is not used, all samples shall be set to 040h for luminance samples and 200h for colour difference samples.

Figure 56 and Figure 57 show track, segment and field number on the tape.

7.2.2 Non-recorded data

- a) Information received during the following lines are not recorded on tape. The appropriate blanking, sync and burst data are recreated for output during playback.

525/60 system

- from colour frame A, field I, line 1 through line 8;
- from colour frame A, field II, line 264 through line 270;
- from colour frame B, field III, line 1 through line 8;
- from colour frame B, field IV, line 264 through line 270.

625/50 system

- from field 1, from line 624 of previous field through line 6 of field 1;
- from field 2, from line 311 through line 319 of field 2;
- from field 3, from line 624 of previous field through line 6 of field 3;
- from field 4, from line 311 through line 319 of field 4;
- from field 5, from line 624 of previous field through line 6 of field 5;
- from field 6, from line 311 through line 319 of field 6;
- from field 7, from line 624 of previous field through line 6 of field 7;
- from field 8, from line 311 through line 319 of field 8.

- b) The digital horizontal blanking interval is defined in ITU-R Recommendation 601-3.

7.2.3 Source precoding

No source precoding is applied to the input video data.

7.3 Luminance separation and video reserve data

Luminance samples are separated into 2 groups consisting of odd and even samples (Y_o and Y_e). The separated 2 groups of luminance samples Y_o , Y_e , with colour difference samples C_R and C_B , shall contain the picture content of 255 lines (525/60 system) or 304 lines (625/50 system) of video data signal. These 4 signals (Y_o , Y_e , C_R , C_B) are formatted into 4 groups of 360 samples each for each line of video data. These 360 samples on each line (see Figure 58 and Figure 59) are followed by 24 samples of video reserve data which is set to 000h and reserved for future use.

7.4 Channel and video block distribution

The data of each sample shall be distributed by channel and segment as follows:

Let L be the television line number within a video field,

- $L = 0, 1, \dots, 254$ (525/60 system);
- $L = 0, 1, \dots, 303$ (625/50 system).

Let H be the horizontal sample location within line L ,

$$H = 0, 1, \dots, 767.$$

Luminance even sample group Y_e , shall be handled together with colour difference sample C_B and C_R . Luminance odd sample group Y_o , shall be handled separately to the others. Each horizontal sample index follows the channel distribution (Ch) and video block distribution (Vblk) in accordance with Figure 60 and Figure 61.

For 525/60 system

$$Ch = \{Chi (H \bmod 6) + \text{int} (H/6) + L\} \bmod 4,$$

$$Vblk = Vblk_i (H \bmod 6)$$

For 625/50 system

$$Ch = \{Chi (H \bmod 8) + \text{int} (H/8) + L\} \bmod 4,$$

$$Vblk = Vblk_i (H \bmod 8),$$

where “Chi” and “Vblk_i” are constant values as follows:

For 525/60 system

$H \bmod 6$	0	1	2	3	4	5
Chi	0	2	1	1	3	0
Vblk _i	0	2	1	0	2	1

For 625/50 system

$H \bmod 8$	0	1	2	3	4	5	6	7
Chi	0	2	1	3	0	2	1	3
Vblk _i	0	0	1	1	2	2	3	3

Spls means the sample number of the horizontal direction of Figure 60 or Figure 61,

$$Spls = \text{int} (H/32) \quad (525/60 \text{ system});$$

$$Spls = \text{int} (H/24) \quad (625/50 \text{ system}).$$

where

$$Spls = 0, 1, 2, \dots, 31 \quad (525/60 \text{ system});$$

$$Spls = 0, 1, 2, \dots, 23 \quad (625/50 \text{ system}).$$

7.5 10/8 bit arrangement

Each sample has 10 bit data. The samples shall be separated into MSB 8 bits group and LSB 2 bits group. LSB 2 bits of C_B , C_R , Y_e , Y_o shall be combined to 8 bit data for each video block as shown in Figure 62 (525/60 system) and Figure 63 (625/50 system).

Combined data stream is shown below:

LSB				MSB			
C_{B0}	C_{B1}	C_{R0}	C_{R1}	Y_{e0}	Y_{e1}	Y_{o0}	Y_{o1}

where subscripts 0 and 1 mean the LSB 2 bits.

Let Spll be the sample number of combined LSB 2 bits data,

$$Spll = 0, 1, 2, \dots, 31 \quad (525/60 \text{ system});$$

$$Spll = 0, 1, 2, \dots, 23 \quad (625/50 \text{ system}).$$

Let Comp be the component signal number as follows,

$$\text{Comp} = 0: C_B \text{ signal};$$

$$\text{Comp} = 1: C_R \text{ signal};$$

Comp = 2: Y_e signal;

Comp = 3: Y_o signal.

For 525/60 system

$S_{pll} = S_{pls}$ (Comp = 0)

$S_{pll} = S_{pls}$ (Comp = 1)

$S_{pll} = S_{pls}$ (Comp = 2)

$S_{pll} = (S_{pls} + 16) \bmod 32$ (Comp = 3)

For 625/50 system

$S_{pll} = S_{pls}$ (Comp = 0)

$S_{pll} = S_{pls}$ (Comp = 1)

$S_{pll} = S_{pls}$ (Comp = 2)

$S_{pll} = (S_{pls} + 12) \bmod 24$ (Comp = 3)

Combined LSB 2 bits group shall be relocated as described in Figure 62 and Figure 63.

Let O_c be the outer code number within a horizontal video line,

$O_c = 0, 1, 2, 3$.

Let S_{pla} be the sample number within a video block of each outer code block,

$S_{pla} = 0, 1, \dots, 39$ (525/60 system);

$S_{pla} = 0, 1, \dots, 29$ (625/50 system).

The group of MSB 8 bits sample:

For 525/60 system

$O_c = \text{Comp}$

$S_{pla} = \{S_{pls} + 20 * Ch + A(V_{blk}) + 39 * L\} \bmod 40$ ($O_c = 0, 1, 2$)

$S_{pla} = \{S_{pls} + 20 * Ch + A(V_{blk}) + 39 * L + 19\} \bmod 40$ ($O_c = 3$)

where $A(0) = 0$

$A(1) = 14$

$A(2) = 8$

For 625/50 system

$O_c = \text{Comp}$

$S_{pla} = \{S_{pls} + 15 * Ch + A(V_{blk}) + 10 * L\} \bmod 30$ ($O_c = 0, 1, 2$)

$S_{pla} = \{S_{pls} + 15 * Ch + A(V_{blk}) + 10 * L + 21\} \bmod 30$ ($O_c = 3$)

where $A(0) = 0$

$A(1) = 26$

$A(2) = 23$

$A(3) = 19$

The group of LSB 2 bits sample:

For 525/60 system

$O_c = S_{pll} \bmod 4$

$S_{pla} = \{32 + \text{int}(S_{pll}/4) + 20 * Ch + A(V_{blk}) + 39 * L\} \bmod 40$ ($O_c = 0, 1, 2$)

$S_{pla} = \{32 + \text{int}(S_{pll}/4) + 20 * Ch + A(V_{blk}) + 39 * L + 19\} \bmod 40$ ($O_c = 3$)

where $A(0) = 0$

$$A(1) = 14$$

$$A(2) = 8$$

For 625/50 system

$$Oc = Sp_{ll} \bmod 4$$

$$Spla = \{24 + \text{int}(Sp_{ll}/4) + 15 * Ch + A(V_{blk}) + 10 * L\} \bmod 30 \quad (Oc = 0, 1, 2)$$

$$Spla = \{24 + \text{int}(Sp_{ll}/4) + 15 * Ch + A(V_{blk}) + 10 * L + 21\} \bmod 30 \quad (Oc = 3)$$

where $A(0) = 0$

$$A(1) = 26$$

$$A(2) = 23$$

$$A(3) = 19$$

Let Sp_{lo} be the sample number within an outer code block,

$Sp_{lo} = 40 * V_{blk} + Spla$ (525/60 system);

$Sp_{lo} = 30 * V_{blk} + Spla$ (625/50 system);

$Sp_{lo} = 0, 1, \dots, 119$.

7.6 Video randomization

Video randomization is equivalent to exclusive OR operation between the byte of the outer code data stream and each bit of the random data stream (i.e. each bit of the outer code byte is ex-ORed with the same bit of random data). This process begins with the LSB of the first byte of the outer code data stream and the second bit of the random data after the random data was set to value $M0$, as shown below:

$$M0 = 128 + (L \bmod 128)$$

7.7 Outer error protection

Eight rows of each video field data array contain the error correction check data associated with each column of 8-bit byte.

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: left-most term is the most significant, and the oldest in time computationally.

Code Generator Polynomial in GF(256):

$$G(x) = (x + 1)(x + a)(x + a^2)(x + a^3)(x + a^4)(x + a^5)(x + a^6)(x + a^7),$$

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

Check characters are $K_7, K_6, K_5, K_4, K_3, K_2, K_1, K_0$, in

$$K_7x^7 + K_6x^6 + K_5x^5 + K_4x^4 + K_3x^3 + K_2x^2 + K_1x + K_0,$$

obtained as the remainder after dividing

$$x^8D(x) \text{ by } G(x),$$

where $D(x)$ is the polynomial given by

$$D(x) = B_{119}x^{119} + B_{118}x^{118} + \dots + B_2x^2 + B_1x + B_0.$$

Equation of full code is given by

$$B_{119}x^{127} + B_{118}x^{126} + B_{117}x^{125} \dots + B_1x^9 + B_0x^8 + K_7x^7 + K_6x^6 + K_5x^5 + K_4x^4 + K_3x^3 + K_2x^2 + K_1x + K_0.$$

7.8 Field data array

The columns and rows for each field are shown below;

	Columns/field	Rows/field
525/60 system	1 020	128
625/50 system	1 216	128

The field data array is shown in Figure 64 and Figure 65.

Column shuffling is the relocation of the column of the field data array.

In each channel, the location Splo in outer code block Oc is placed in the field memory array at the locations (Row, Col) where:

Row = Splo
Col = 4 * (116 * L mod 255) + B (Oc)(525/60 system)
Coll = 4 * (81 * L mod 304) + B (Oc)(625/50 system)

where

B (0) = 1
B (1) = 2
B (2) = 0
B (3) = 3

7.9 Order of transmission to inner coding

The field memory array data is written to tape first by ascending column order, then by ascending row order. Video data byte and outer check byte shall be divided into three segments (525/60 system) or 4 segments (625/50 system) respectively. The outer check bytes are written to tape first and followed by data bytes.

Let Seg be the segment number within a video field,

Seg = 0, 1, 2 (525/60 system);
Seg = 0, 1, 2, 3 (625/50 system).

Let Fld be the field number within a colour frame,

Fld = 0, 1, 2, 3 (525/60 system);
Fld = 0, 1, 2, 3 . . 6, 7 (625/50 system).

The start point address number Xin of the field memory array is as follows:

For the outer check bytes,

Xin = 1 440 + 32 * Seg (525/60 system);
Xin = 1 920 + 32 * Seg (625/50 system).

For the outer data bytes,

Xin = 480 * Seg mod 1 440 (525/60 system);
Xin = (480 * Seg + 480 * Fld) mod 1 920 (625/50 system).

The relation between Xin and Row or Col of the field memory is

Xin = 12 * Row + int (Col/85) (525/60 system);
Xin = 16 * Row + int (Col/76) (625/50 system).

8 Audio processing

8.1 Introduction

Audio in each of the 4 channels is processed independently and identically into a product block for each channel of dimension 85×3 columns by 8 rows (525/60 system) or 76×4 columns by 8 rows (625/50 system). The audio samples of each channel are shuffled in a field before the addition of error correction data in the vertical (row) direction. Error correction in the horizontal (column) dimension is common with video data.

Auxiliary words are multiplexed with the audio data in the product block to provide housekeeping in the interface and in processing. Figure 66 (525/60 system) and Figure 67 (625/50 system) show the audio data block field array.

8.2 Source coding

Audio records that meet the requirements of IEC 60958 are formed independently for each of 4 audio channels, from audio and ancillary data at the input interface. This data includes audio data, channel status data (C), user data (U) and validity data (V). Parity bits are discarded. The remaining bit positions in the audio data words are reserved (R) for future use. Block sync marks for ancillary data are also processed. ITU-T Recommendation J.17 pre-emphasis is not recognized.

Source data is defined as follows:

a) Audio data

- sampling frequency: 48 kHz $\pm$ 3 parts in 10^6 , synchronous with video;
- word length: 20 bits;
- coding: 2's complement linear PCM.

b) Channel status data

- bits rate: 48 kbits/s (nominal);
- word rate: 6 kbytes/s;
- word length: 8 bits;
- block length: 192 bits, 24 words;
- coding: see IEC 60958.

c) User data

- bit rate: 1 bit associated with each audio word;
- coding: undefined.

d) Validity data

- bit rate: 1 bit associated with each audio word;
- coding: 0 = sample valid;
1 = sample defective.

e) Parity bit

- bit rate: 1 bit associated with each audio word;
- coding: even parity of associated word including audio, status, user and validity data.

NOTE 1 Bytes 0 and 1 of AES status data are selected only for special processing in the DVTR. The contents of bytes 0 and 1 are shown in Table 13 and Table 14, respectively.

NOTE 2 Bytes 22 and 23 of AES status data contain protection and validity information for bytes 0–21 and may be used in some source decoders.

8.3 Source processing

8.3.1 Introduction

Audio data is processed in fields. Each field contains 801 or 800 audio samples (525/60 system) or 960 audio samples (625/50 system) for an audio channel with associated status, user, and validity data.

In addition, a number of control and user words are added to the data.

8.3.2 Relative audio-video timing

An audio field begins with the audio sample acquired 128 samples (± 20 sample periods) before the first pre-equalizing pulse of the vertical interval of the input video signal.

8.3.3 Audio data in fields

Audio data in fields is processed into an audio block of $85 \times 3 \times 16$ bytes (525/60 system) or $76 \times 4 \times 16$ bytes (625/50 system), each corresponding to six audio sectors (525/60 system) or 8 audio sectors (625/50 system) on tape. The data portion of the block is $85 \times 3 \times 8$ bytes (525/60 system) or $76 \times 4 \times 8$ bytes (625/50 system), and the outer error check bytes portion of the block is also $85 \times 3 \times 8$ bytes (525/60 system) or $76 \times 4 \times 8$ bytes (625/50 system).

Audio data words: 801 or 800 words (525/60 system) or 960 words (625/50 system) with associated C, U, V, R bits (20 bits total per word).

Auxiliary data words: total 15 words (20 bits per word) (525/60 system),
total 32 words (8 bits per word) (625/50 system).

8.3.4 Intra-field shuffling

The audio data for each channel in each field is shuffled. The intra-field shuffling process operates identically for all fields.

Let Col be the column number within an audio field:

Col = 0, 1, . . . , 101 (525/60 system);

Col = 0, 1, . . . , 123 (625/50 system).

Let Row be row number within an audio field:

Row = 0, 1, . . . , 15.

Row 8 to 15 contain the error correction data.

Let Oblk be the data block number:

Oblk = $3 \times \text{Row} + \text{int}(\text{Col}/34)$ (525/60 system);

Oblk = $4 \times \text{Row} + \text{int}(\text{Col}/31)$ (625/50 system).

The data block array is shown in Figure 68 (525/60 system) or Figure 69 (625/50 system). Then sample number Smp within an audio field is obtained according to the following formula:

$\text{Smp} = 24 \times (\text{Col} \bmod 34) + \text{int}(\text{Oblk}/8) + 3 \times (\text{Oblk} \bmod 8)$ (525/60 system).

$\text{Smp} = 32 \times (\text{Col} \bmod 31) + \text{int}(\text{Oblk}/9) + 4 \times (\text{Oblk} \bmod 9) - 3 \times \text{int}[(\text{Oblk} \bmod 9) + \text{int}(\text{Oblk}/9)]/8$.

When Smp is larger than 800, Smp = 801, 802, . . . , 815 are replaced by AUX 0, AUX 1, . . . , AUX 14 respectively for 525/60 system.

When Smp is larger than 959, Smp = 960, 961, . . . , 991 are replaced by AUX 0, AUX 1, . . . , AUX 14 respectively for 625/50 system.

Figure 68 (525/60 system) and Figure 69 (625/50 system) show the layout of the shuffled samples in a field array. Outer ECC codes are situated in row = 8 to 15.

8.3.5 Block shuffling

The block shuffling process operates after the intra-field shuffling identically for all fields.

Let N be the recording order of the data block in an audio sector:

N = 0, 1, 2, 3.

Let Seg be the segment number:

Seg = 0, 1, 2 (525/60 system);

Seg = 0, 1, 2, 3 (625/50 system).

Let Tr be the track number,

Tr = 0, 1, 2, 3.

Then the data block Oblk within a field array is mapped according to the following formula:

$$\text{Oblk} = N' + \text{Tr}' + 8 \times \text{Seg} + 2 \times (12 - \text{Tr}') \times (N' \bmod 2) \text{ (525/60 system);}$$

$$\text{Oblk} = N' + \text{Tr}' + 8 \times \text{Seg} + 2 \times (16 - \text{Tr}') \times (N' \bmod 2) \text{ (625/50 system),}$$

where

$$N' = N + 4 \times \text{int}(\text{Tr}/2);$$

$$\text{Tr}' = \text{Tr} \bmod 2.$$

Figure 70 shows the data block arrangement of an audio channel for 525/60 system in three pairs of sectors. Figure 71 shows the data block arrangement of an audio channel for 625/50 system in 4 pairs of sectors.

8.3.6 Audio data word processing

Input data is formed into words of 20 bits in the sequence:

- a) Assignment of the 20-bits to audio and associated data is controlled by user input (see Table 15).

Table 15 — Audio data word mode

Word mode	Bit				
	0	1	2	3	4–19
0 (000)	C	U	V	R	Audio 0–15
1 (001)	C	U	V	Audio 0 (LSB)	Audio 1–16
2 (010)	C	V	Audio 0 (LSB)	Audio 1	Audio 2–17
3 (011)	C	U	Audio 0 (LSB)	Audio 1	Audio 2–17
4 (100)	C	Audio 0 (LSB)	Audio 1	Audio 2	Audio 3–18
5 (101)	V	Audio 0 (LSB)	Audio 1	Audio 2	Audio 3–18
6 (110)	U	Audio 0 (LSB)	Audio 1	Audio 2	Audio 3–18
7 (111)	Audio 0 (LSB)	Audio 1	Audio 2	Audio 3	Audio 4–19

NOTE 1 C = channel status bit, U = user bit, V = validity bit, R = reserved bit.

NOTE 2 Example, Audio 1 represents bit 1 of audio sample.

NOTE 3 Audio data will be rounded from the 20-bit length of the interface word (auxiliary data truncated) to the length above with the elimination of the least significant bit(s).

NOTE 4 Modes 0, 3, and 7 are the recommended modes for general use.

The most significant bit of the audio word is bit 19 and unused bits of lower significance are removed. The auxiliary word LNGH (4 bits) signals the word mode selected.

b) Each group of 20-bit words is divided into 8-bit bytes as shown in Figure 72 (525/60 system) or Figure 73 (625/50 system), and arranged alternately by the MSB and the LSB of the first word of the word group.

c) Each group is distributed into the product block in accordance with Figure 68 (525/60 system) or Figure 69 (625/50 system).

d) Sample number 800 may be unoccupied for 525/60 system. Every fifth field shall contain 800 samples. All other fields shall contain 801 samples.

The 5-field sequence of the number of audio samples begins at an arbitrarily chosen field. Continuity of the 5-field sequence shall be preserved throughout the recording, including editing.

The 5-field sequence is indicated by the value of the auxiliary word FNCT, as defined in 8.4.5. Furthermore, every fifth field of 800 samples is identified by the field address F2 for audio sync blocks, as defined in 4.3.3.

8.4 Auxiliary words

Auxiliary words are generated at the input interface from incoming data or user selection and serve to signal this information to the output interface. Auxiliary words are five words of 4 bits (525/60 system) or 4 words of 4 bits (625/50 system), plus one word of 8 bits as defined in Figure 74 (525/60 system) and Figure 75 (625/50 system). The word EFLG is written 4 times in each audio block. Figure 72 (525/60 system) and Figure 73 (625/50 system) show the format of the auxiliary words in the audio data block.

8.4.1 Channel use (CHAN)

This word is composed of 4 bits and specifies the usage of the 2 input channels in an interface data stream. CHAN is derived from channel status byte 1. CHAN is inserted in bits 4-7 of AUX 3 (525/60 system) or bits 4-7 of AUX 2 (625/50).

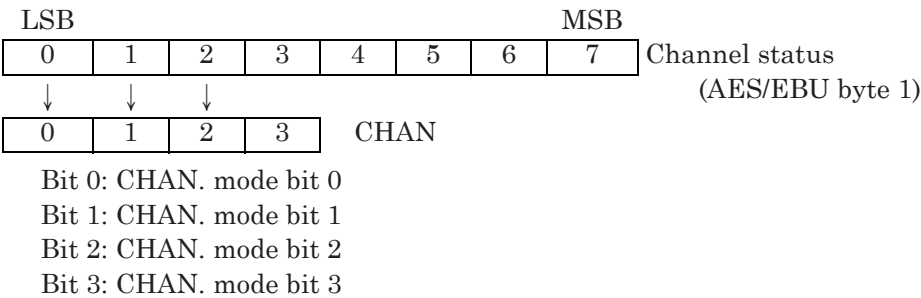


Table 16 — Channel use control word

Mode	CHAN bit 0 1 2 3	Value
0	0 0 0 0	2 channel-default
1	0 0 0 1	2 channel
2	0 0 1 0	single channel
3	0 0 1 1	primary/secondary 2 channel
4	0 1 0 0	stereophonic
5	0 1 0 1	undefined
	through	
F	1 1 1 1	undefined

8.4.2 Pre-emphasis (PREF)

This word is composed of 4 bits and specifies the usage of pre-emphasis in the audio coding. PREF is derived from channel status byte 0. PREF is inserted in bits 4-7 of AUX 0.

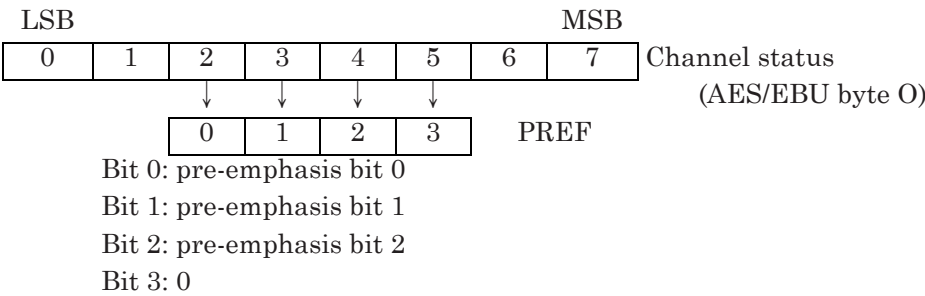


Table 17 — Pre-emphasis control word

Mode	PREF bit 0 1 2	Value
0	0 0 0	Pre-emphasis off – (default)
1	0 0 1	Reserved
2	0 1 0	Reserved
3	0 1 1	Reserved
4	1 0 0	Pre-emphasis off
5	1 0 1	Reserved
6	1 1 0	50/15 µs (CD type)
7	1 1 1	Reserved

8.4.3 Audio data word mode (LNGH)

This word is composed of 4 bits and specifies the audio word length and the usage of the ancillary bits status, user and validity. LNGH is derived from user control inputs and inserted in bits 4–7 of AUX 1.

LSB		MSB		LNGH
0	1	2	3	

Bit 0: 0

Bit 1: LNGH 1 (LSB)

Bit 2: LNGH 2

Bit 3: LNGH 3 (MSB)

Table 18 — Word mode control word

Mode	LNGH bit 3 2 1	Audio length	Ancillary bits C U V R
0	0 0 0	16 bits	X X X X
1	0 0 1	17 bits	X X X –
2	0 1 0	18 bits	X – X –
3	0 1 1	18 bits	X X – –
4	1 0 0	19 bits	X – –
5	1 0 1	19 bits	– – X –
6	1 1 0	19 bits	– X – –
7	1 1 1	20 bits	– – – –

NOTE X means that the ancillary bit is recorded.

8.4.4 Block sync location (S MARK)

S MARK is an 8-bit-word. S MARK specifies the location of the block sync associated with channel status and user data, as defined in section 6 of ITU-R Recommendation 647. S MARK contains the word count, in the current block, of the first block sync detected, i.e., the word address in the block pointing to the first sample after the block sync mark.

LSB				MSB				S MARK
0	1	2	3	4	5	6	7	

where S MARK is from 00h to BFh inclusive.

S MARK = FFh if no mark is found within the defined range. S MARK is inserted in bits 12–19 of AUX 0 (525/60 system) or bits 0–7 of AUX 4 (625/50 system).

8.4.5 Field number count (FNCT) for 525/60 system

This word is composed of 4 bits and specifies the number of audio samples in the current field. FNCT is inserted in bits 4–7 of AUX 2.

LSB		MSB		FNCT
0	1	2	3	

Bit 0: FNCT 0 (LSB)
Bit 1: FNCT 1
Bit 2: FNCT 2 (MSB)
Bit 3: 0

Table 19 — FNCT mode

Number of samples	FNCT bit 2 1 0
801	0 0 0
801	0 0 1
801	0 1 0
801	0 1 1
800	1 0 0

8.4.6 Edit flag (EFLG)

This word is composed of 4 bits and specifies the field associated with an edit transition. EFLG is inserted in bits 0–3 of AUX 0, AUX 1, AUX 2 and AUX 3.

LSB		MSB		EFLG
0	1	2	3	

EFLG = Dh for the first field of the edit.
EFLG = 7h for the last field of the edit.
EFLG = 0h otherwise.

8.5 Outer error protection

Rows 8 through 15 of the data block, as shown in Figure 66 (525/60 system) or Figure 67 (625/50 system) contain the error check bytes associated with each column.

Type is Reed Solomon.
Galois Field is GF(256).

Field Generator Polynomial is:

$$x^8 + x^4 + x^3 + x^2 + 1,$$

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

Order of use: the far left term is the most significant, last in time computationally, and first written to tape.

Code Generator Polynomial is:

$$G(x) = (x + 1)(x + a)(x + a^2)(x + a^3)(x + a^4)(x + a^5)(x + a^6)(x + a^7),$$

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

Check characters: $K_7, K_6, K_5, K_4, K_3, K_2, K_1, K_0$,

(also identified respectively as $PV_7, PV_6, PV_5, PV_4, PV_3, PV_2, PV_1, PV_0$) in

$$K_7x^7 + K_6x^6 + K_5x^5 + K_4x^4 + K_3x^3 + K_2x^2 + K_1x + K_0$$

obtained as the remainder after dividing the polynomial $x^8D(x)$ by $G(x)$, where $D(x)$ is the polynomial given by:

$$D(x) = B_7x^7 + B_6x^6 + B_5x^5 + \dots + B_1x + B_0.$$

Polynomial of full code is

$$B_7x^{15} + B_6x^{14} + B_5x^{13} + \dots + B_1x^9 + B_0x^8 + K_7x^7 + K_6x^6 + \dots + K_2x^2 + K_1x + K_0.$$

Outer-code check characters in each column of the $85 \times 3 \times 8$ blocks (525/60 system) or $76 \times 4 \times 8$ blocks (625/50 system) are calculated using the data order existing prior to the rearrangement into the pattern shown in Figure 68 (525/60 system) or Figure 69 (625/50 system), i.e., in ascending sample order. The check characters K_7 through K_0 are used as the vertical protection characters identified as PV_7 through PV_0 , respectively.

8.6 Inner protection

The inner protection and sync block format are identical to those for video. (See 4.3 and 4.4.)

8.7 Order of transmission to inner coding

Audio data bytes (outer check bytes considered as data) are sent to the inner coder after the block shuffling.

8.8 Channel coding

Channel coding is identical to that for video. (See 4.5.)

8.9 Allocation of audio sectors

The data blocks of an audio channel are arranged on the three pair of six sectors as shown in Figure 70 (525/60 system) or the 4 pair of sectors (8 sectors) as shown in Figure 71 (625/50 system). A pair of sectors from each of the 4 audio channels is recorded according to Figure 76 (525/60 system) or Figure 77 (625/50 system). The audio sectors labelled A1, A2, A3 and A4 correspond to audio input channels 1, 2, 3 and 4, respectively.

For 525/60 system, the allocation of a pair of sectors is 4-field sequence. Field addresses F0, F1 of sector ID for 4 audio sync blocks as defined in 4.3.3 shall identify 4-field sequence and have the value as shown below:

	F0	F1
— Audio field I	0	0
— Audio field II	1	0
— Audio field III	0	1
— Audio field IV	1	1

9 Longitudinal tracks

9.1 Relative timing

9.1.1 Time and control code input

An external record time and control code input that meets the specifications described in IEC 60461, or a time and control code that is internally generated within the recorder, shall be timed for recording as follows.

The relationship between the “start of address” of the time and control code and the programme reference point of a track with an even-field address (count) for the video data is defined by Figure 43 and Table 5 (525/60 system) or Table 6 (625/50 system).

9.1.2 Time and control code information

The time and control code information shall refer to the video frame during which it is recorded.

9.1.3 Cue information

Cue information shall be recorded on the tape at a point referenced to the associated video information as defined by dimension P2 of Figure 43, and Table 5 (525/60 system) or Table 6 (625/50 system).

9.1.4 Control track servo pulse

Control track servo pulse record timing is described in 9.2.

9.2 Control track

9.2.1 Method of recording

The control track shall be recorded using the hysteresis (non-bias recording) method.

9.2.2 Servo reference pulse

The control track servo reference pulse, at the time of recording, shall be a series of pulses with a period of $9,122\text{ ms} \pm 6\text{ }\mu\text{s}$ (525/60 system) or $10,000\text{ ms} \pm 6\text{ }\mu\text{s}$ (625/50 system) as shown in Figure 78 and Figure 79, respectively.

9.2.3 Flux polarity

The polarities of the recorded flux shall be as shown in Figure 43.

9.2.4 Flux level

The peak recorded flux level shall be greater than 500 nWb/m of the track width. The recording shall attenuate any previous recording by at least 30 dB.

9.2.5 Pulse width

The recorded pulses shall have periods of $4T$, $5T$ or $6T$ where T equals to $1,1122\text{ ms}$ nominal (525/60 system) or $1,000\text{ ms}$ nominal (625/50 system). The rise and fall times of the record current (10 % to 90 % points) shall be less than $150\text{ }\mu\text{s}$.

9.2.6 Servo reference pulse timing

The servo reference pulses and the data of the programme reference point, when recorded according to Figure 43, shall occur at the same time.

9.2.7 Colour frame pulse

A colour frame sequence at the time of the start of each recording shall be indicated by a pulse rising transition point which follows a sequence of $6T-4T$ duration pulses. The colour frame commences with colour frame A field I. It shall be located at the rising point after the $6T-4T$ duration pulses, coinciding with a segment count and a field count of zero in the video sector identification pattern, as defined in 4.3.3.

9.2.8 Video frame pulse

The first segment of a video frame at the time of the start of each recording shall be indicated by a pulse rising transition point which follows a sequence of $6T-4T$ or $4T-6T$ duration pulses. It shall be located at the rising points after the $6T-4T$ or $4T-6T$ duration pulses, coinciding with a segment count and an even field count of zero in the video sector identification pattern, as defined in 4.3.3.

9.3 Cue record

9.3.1 Method of recording

The signals shall be recorded using the anhysteresis (a.c. bias) method.

9.3.2 Flux level

The recorded reference audio level shall correspond to an r.m.s. magnetic short-circuit flux level of $125\text{ nWb/m} \pm 3\text{ nWb/m}$ of track width at $1\text{ }000\text{ Hz}$.

9.4 Time and control code record

9.4.1 Method of recording

The signals shall be recorded using the anhysteresis (a.c. bias) recording method.

9.4.2 Flux level

The recorded peak-to-peak flux shall correspond to a magnetic short circuit flux level of $250\text{ nWb/m} \pm 20\text{ nWb/m}$ of track width at $1\text{ }000\text{ Hz}$.

The signal recorded on this track shall be in accordance with IEC 60461.

9.4.3 Input signal

The signal recorded on this track shall be in accordance with IEC 60461.

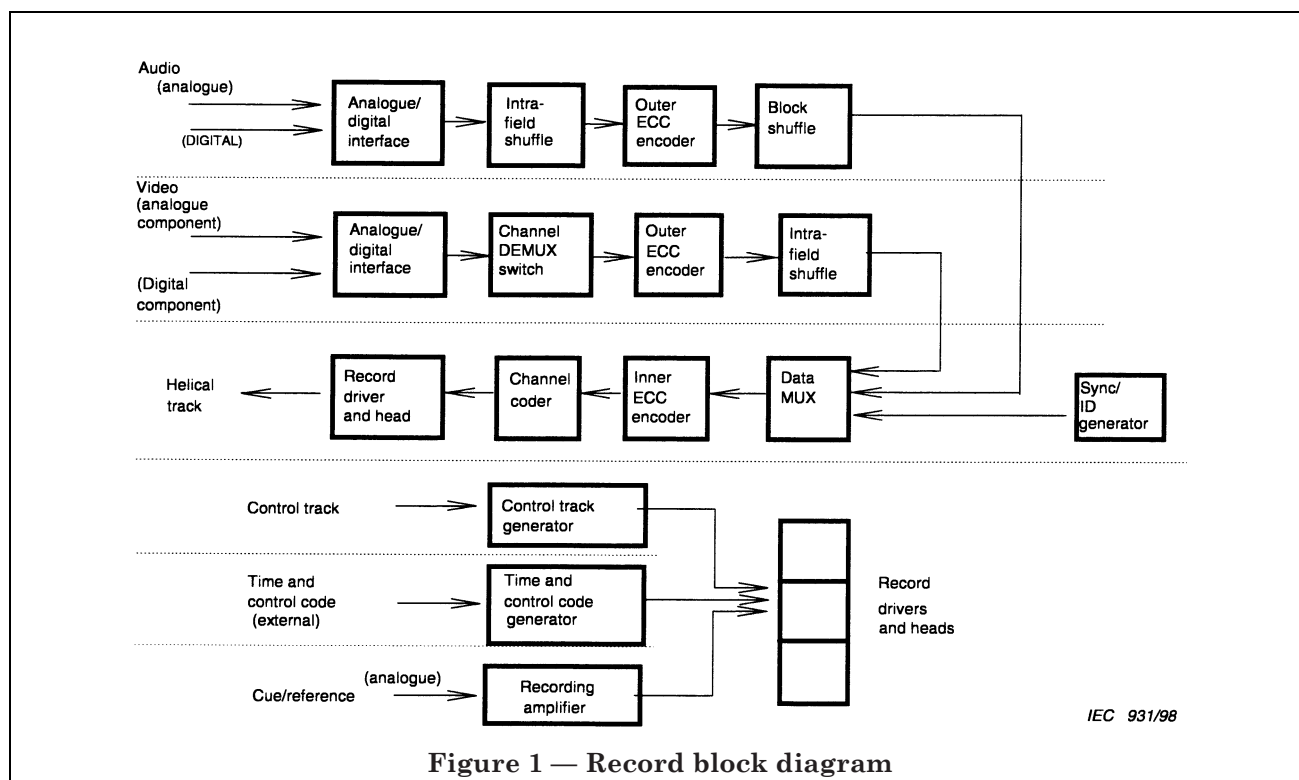


Figure 1 — Record block diagram

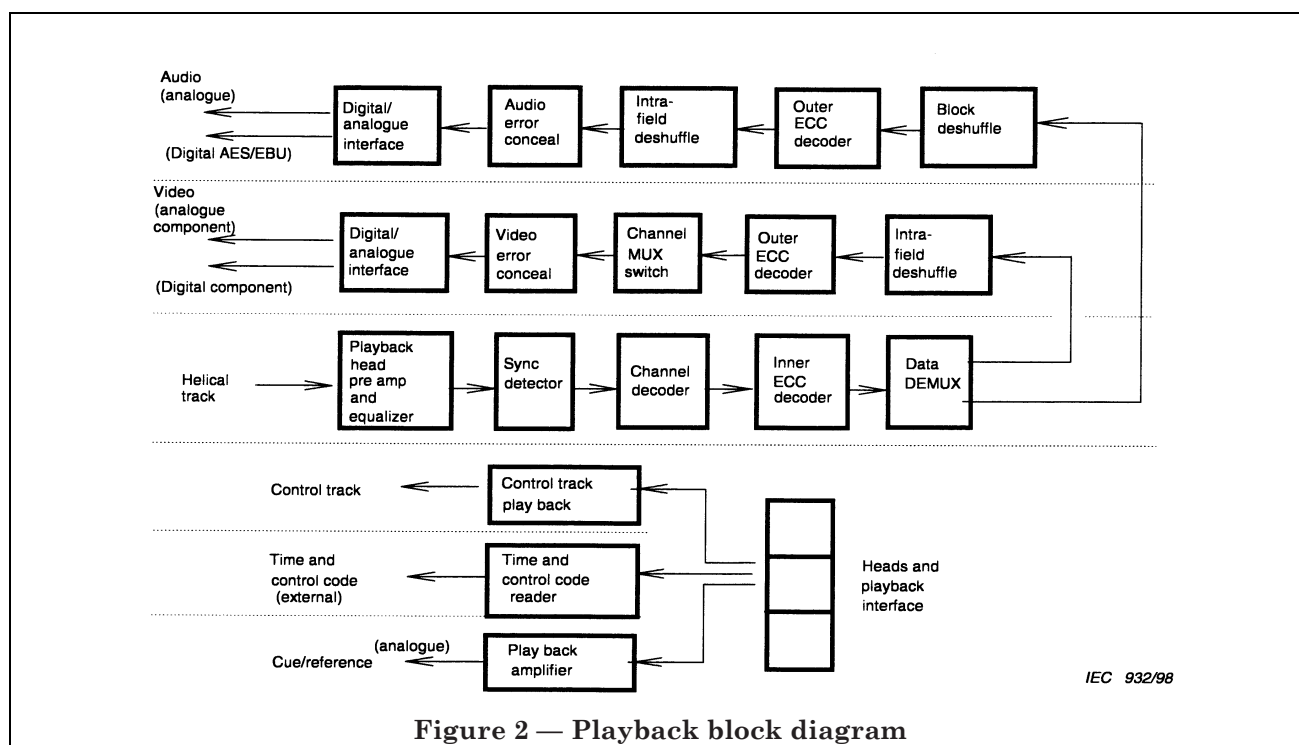
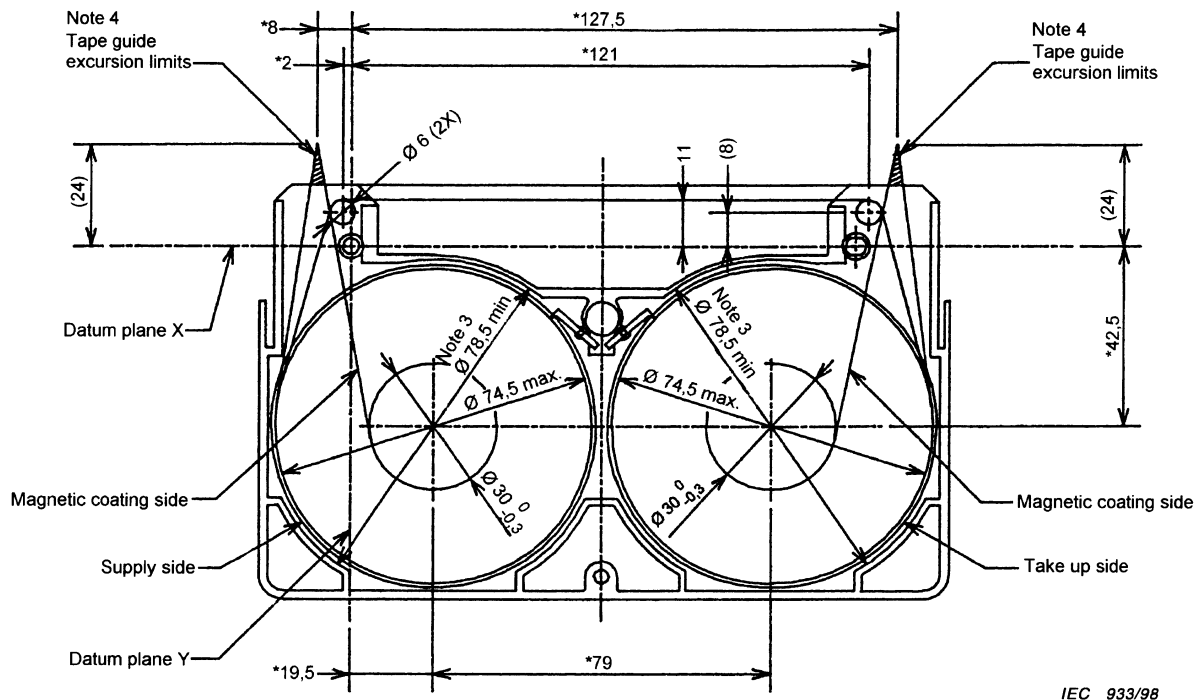


Figure 2 — Playback block diagram



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Dimensions in millimetres

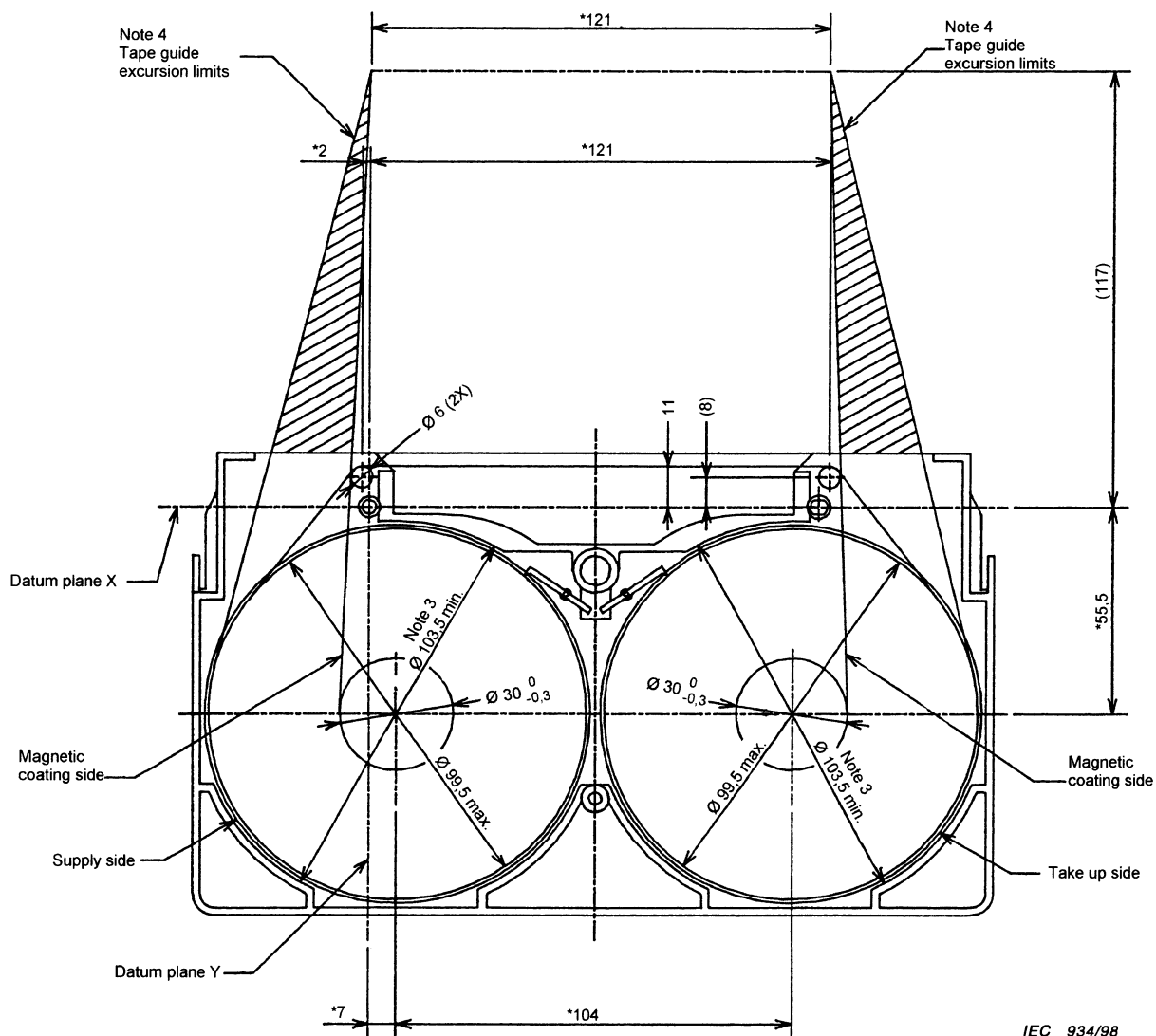
NOTE 1 Dimensions with an asterisk (*) are nominal values specifying the tape path.

NOTE 2 Dimensions in parenthesis are for reference only.

NOTE 3 The diameter specifies the minimum clearance for the reel flange.

NOTE 4 The maximum excursion limits for machine tape guides are to ensure that there is no contact between tape and cassette components.

Figure 3 — Top view, inner structure and tape path of S cassette (for reference only)



Dimensions in millimetres

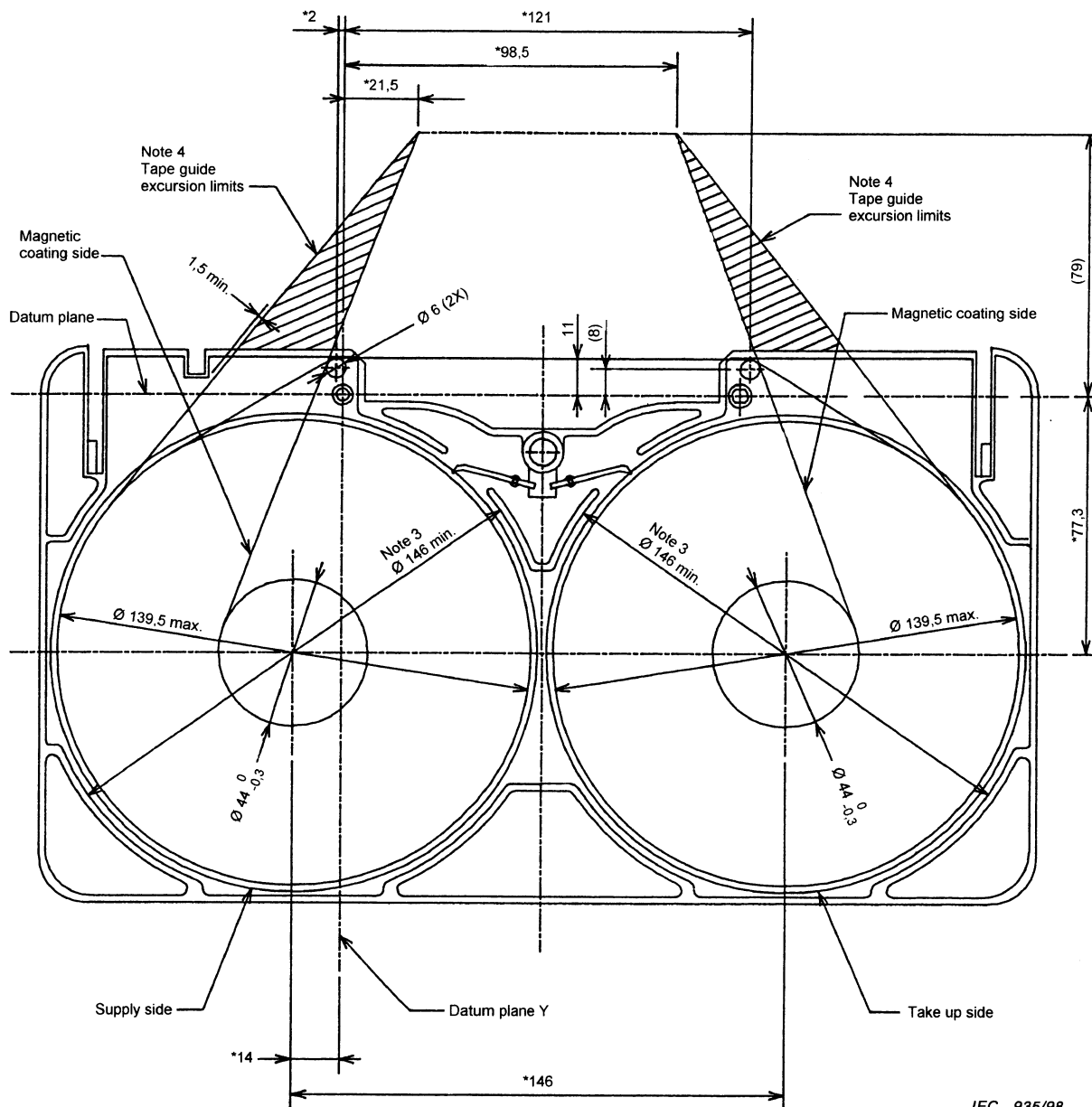
NOTE 1 Dimensions with an asterisk(*) are nominal values specifying the tape path.

NOTE 2 Dimensions in parenthesis are for reference only.

NOTE 3 The diameter specifies the minimum clearance for the reel flange.

NOTE 4 The maximum excursion limits for machine tape guides are to ensure that there is no contact between tape and cassette components.

Figure 4 — Top view, inner structure and tape path of M cassette (for reference only)



IEC 935/98

Dimensions in millimetres

NOTE 1 Dimensions with an asterisk(*) are nominal values specifying the tape path.

NOTE 2 Dimensions in parenthesis are for reference only.

NOTE 3 The diameter specifies the minimum clearance for the reel flange.

NOTE 4 The maximum excursion limits for machine tape guides are to ensure that there is no contact between tape and cassette components.

Figure 5 — Top view, inner structure and tape path of L cassette (for reference only)

