

Helical-scan digital composite video cassette recording system using 12,65 mm (0,5 in) magnetic tape — Format D-3

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British Standard

ICS 33.160.40

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Committees responsible for this British Standard

The preparation of this British Standard was entrusted to Technical Committee EPL/60, Recording, upon which the following bodies were represented:

- Association of Professional Recording Services Limited
- Audio Engineering Society
- British Broadcasting Corporation
- British Kinematograph, Sound and Television Society
- British Tape Industry Association
- Federation of the Electronics Industry
- ITV Association (ITVA)
- Royal Photographic Society
- Royal Television Society

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National foreword

This British Standard has been prepared by Technical Committee EPL/60 and is the English language version of EN 61327:1995 *Helical-scan digital composite video cassette recording system using 12,65 mm (0,5 in) magnetic tape — Format D-3*, published by the European Committee for Electrotechnical Standardization (CENELEC). It is identical with IEC 1327:1995, published by the International Electrotechnical Commission (IEC).

Cross-references

Publication referred to	Corresponding British Standard
EN 60735:1991 (IEC 735:1991)	BS EN 60735:1992 <i>Methods for measurement of video tape properties</i>
EN 60958:1990 (IEC 958:1989)	BS EN 60958:1995 <i>Specification for digital audio interface</i>
EN 61179:1993 (IEC 1179:1993)	BS EN 61179:1993 <i>Specification for helical-scan digital composite video cassette recording system using 19 mm magnetic tape, format D2 (NTSC, PAL, PAL-M)</i>
HD 507 S1:1988 (IEC 461:1986)	BS 6865:1987 <i>Specification for time and control codes for video tape recorders</i>

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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 120, 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.

ICS 33.160.40

Descriptors: Recording apparatus, digital recording, magnetoscopes, magnetic tapes, cassettes for magnetic tape, characteristics, mechanical properties, dimensions, interfaces, signal processing, video signals, acoustic signals, recording track

English version

Helical-scan digital composite video cassette recording system using 12,65 mm (0,5 in) magnetic tape Format D-3

(IEC 1327:1995)

Système de magnétoscope numérique à
chrominance composite à cassette à balayage
hélicoïdal utilisant la bande magnétique
de 12,65 mm (0,5 in)
Format D-3
(CEI 1327:1995)

Videokassettensystem mit
Schrägspuraufzeichnung digitaler
Composite-Signale auf
Magnetband 12,65 mm (0,5 in)
D3-Format
(IEC 1327:1995)

This European Standard was approved by CENELEC on 1995-09-20. 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.

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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 60B/255/DIS, future edition 1 of IEC 1327, prepared by SC 60B, Video recording, of IEC TC 60, Recording, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61327 on 1995-09-20.

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) 1996-07-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 1996-07-01

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 and Annex ZA are normative and Annex C is informative. Annex ZA has been added by CENELEC.

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Introduction

One video channel and four independent audio channels are recorded in digital form. Each of these channels is designed to be capable of independent editing. The video channel records and reproduces a composite television signal in the 525-line system with a frame frequency of 29,97 Hz and 625-line system with a frame frequency of 25,00 Hz.

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 and object

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

This standard 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-3 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. The requirements given relate to 525-line composite television signals with a frame frequency of 29,97 Hz nominal (hereinafter referred to as "525/60 system") and to 625-line composite television signals 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 461:1986, *Time and control code for video tape recorders*.

IEC 735:1991, *Measuring method for video tape properties*.

IEC 958:1989, *Digital audio interface*.

IEC 1179:1993, *Helical-scan digital composite video cassette recording system using 19 mm magnetic tape, format D-2 (NTSC, PAL, PAL-M)*.

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

ITU-R Recommendation 647-1:1990, *A digital audio interface for broadcasting studios*.

UIT-T Recommendation J.17:1972, *Pre-emphasis used on sound-programme circuits (Fascicle III.4)*.

1.3 Definitions, symbols and abbreviations

For the purpose 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

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, e.g. GF(256)

1.3.3

LSB

- 1) Least significant bit of a word of data.
- 2) Least significant byte of a data item consisting of two or more bytes.

1.3.4

MSB

- 1) Most significant bit of data.
- 2) Most significant byte of data item consisting of two or more bytes.

1.3.5

ScH

colour subcarrier to horizontal sync timing relationship

1.3.6

ECC

error correcting code

2 Technical data

2.1 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: $20\text{ }^{\circ}\text{C} \pm 1\text{ }^{\circ}\text{C}$;
- relative humidity: $(50 \pm 2)\%$;
- barometric pressure: $(96 \pm 10)\text{ kPa}$;
- tape tension: $(0,31 \pm 0,05)\text{ N}$; ^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 would typically be $0,30\text{ N} \pm 0,03\text{ N}$.

2.2 Reference tape

Blank tape to be used for calibration recordings may be purchased from the following manufacturers:

Company

Matsushita Electric Industrial Co., Ltd.

Audio and Video Systems Division

2-15, Matsuba-cho, Kadoma-city,

Osaka 571 Japan.

TEL.: + 81-6-901-1161

FAX.: + 81-6-905-4048

TLX.: + 81-6-529-4690

Part number

VFM0010

2.3 Calibration tape

Manufacturers of video tape recorders designed for this format specification may sell calibration tapes meeting the following requirements.¹⁾

2.3.1 Record locations and dimensions

Tolerances shown in Table 5 or Table 6 should be reduced by 50 %.

¹⁾ This information is given for the 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.

— large L.

3.1.3 Tape length, thickness and play times

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 times of S, M, L cassettes

Tape cassette	Hub diameter mm	Thickness µm	Length m	Play time min
S	30	11/14	325/254	64/50
	50	11/14	204/163	40/32
M	30	11/14	632/481	125/95
	50	11/14	506/405	100/80
L	44	11/14	1 237/935	245/185

3.1.4 Coating face

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

3.1.5 Datum planes

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

3.1.5.2 Datum C need not correspond with a fastener.

3.1.5.3 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.

3.1.5.4 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.

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

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

3.1.6 Window and labels

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

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

3.1.6.3 Labels shall not hide the identification holes of the users or the manufacturers.

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

3.1.7 Identification holes

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

3.1.7.2 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	11 µm tape, 30 mm diameter hub
	0	0	1	11 µm tape, 50 mm diameter hub
	0	1	0	14 µm tape, 30 mm diameter hub
	0	1	1	14 µm tape, 50 mm diameter hub
	1	0	0	undefined/reserved
	1	0	1	undefined/reserved
	1	1	0	undefined/reserved
	1	1	1	undefined/reserved

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.

3.1.7.3 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.

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

3.1.7.5 The colour of the user plugs shall be red.

3.1.8 Leader/trailer tape

3.1.8.1 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	—

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

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

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

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

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

3.1.9 Reels

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

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

3.1.9.3 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 N.

3.1.9.4 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 ± 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 ± 0,3
M	3,5 ± 0,3
L	4,0 ± 0,3

3.1.10 Lid

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

3.1.10.1.1 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.

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

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

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

3.1.10.3 The outer door when open 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 $93^\circ \pm 2^\circ$, as specified in Figure 41.

3.1.10.4 When the cassette is removed from the recorder/player, the lid shall lock automatically.

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

3.1.10.6 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.

3.2 Video tape specification

3.2.1 Base

The base material shall be polyester or equivalent.

3.2.2 Width

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

The tape, covered with glass, is measured without tension at a minimum of five different positions along the tape using a calibrated comparator having an accuracy of $1/1\,000 \text{ mm} = 1 \mu\text{m}$. The tape width is defined as the average of the five readings.

3.2.3 Width fluctuation

Tape width fluctuation shall not exceed $5 \mu\text{m}$ peak-to-peak. Measurement of tape width fluctuation shall be over a tape length of 900 mm at the beginning of tape winding. 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.

3.2.4 Reference edge straightness

The reference edge straightness maximum deviation is $6 \mu\text{m}$ peak-to-peak. Edge straightness fluctuation is measured at the edge of a moving tape guided by three guides having contact on the same edge and having a distance of 85 mm from the first to second guide and 85 mm from the second to third guide. Edge measurements are averaged over 10 mm lengths and are made 5 mm from the midpoint between the first and second guide, towards the first guide.

3.2.5 Tape thickness

The thickness of the tape (including all coatings) shall be, respectively, $10,2 \mu\text{m}$ to $11,0 \mu\text{m}$ and $13,0 \mu\text{m}$ to $14,0 \mu\text{m}$.

3.2.6 Transmissivity

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

3.2.7 Offset yield strength

The offset yield strength shall be greater than 9 N for $11 \mu\text{m}$ tape and 10 N for $14 \mu\text{m}$ tape. The force to produce 0,2 % tangential elongation of a 1 000 mm test sample with a pull rate of a 10 mm/min shall be used to confirm the offset yield strength. The line beginning at 0,2 % elongation parallel to the initial tangential slope is drawn and then read the point of intersection of the line and the stress-strain curve.

3.2.8 Magnetic coating

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

3.2.9 Coating coercivity

The coating coercivity shall be a class 1 600 Oe ($127\,300 \text{ A/m}$), with an applied field of $397\,800 \text{ A/m}$ as measured by a 50 Hz or 60 Hz B-H meter or vibrating sample magnetometer (VSM).

3.2.10 Particle orientation

The metal particles shall be longitudinally oriented or equivalent.

4 Helical recordings

4.1 Tape speed

The tape speed is 83,880 mm/s. The tape speed tolerance is $\pm 0,2\%$.

4.2 Erase head and record location and dimensions

4.2.1 Erase head

The format requires full width erase for continuous recording and flying erase for insert editing.

4.2.2 Record location and dimensions

Record location and dimensions for continuous recording shall be as specified in Figure 42 and Figure 43, and Table 12 (525/60 systems) or Table 13 (625/50 systems). In recording, sector locations on each helical track shall be contained within the tolerance specified in Table 12 or Table 13 and Figure 42.

4.2.3 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.

Measuring techniques are shown in Annex A.

4.2.4 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 such 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).

4.2.5 Flying erase heads

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 B.1 of Annex B.

4.3 Helical track record tolerance zones

The lower edges of any four consecutive tracks starting at the first track in each video frame shall be contained within the pattern of the four tolerance zones established in Figure 44 (525/60 system) or Figure 45 (625/50 system).

Each zone is defined by two parallel lines which are inclined at an angle of 4,919 2° (525/60 system) or 4,917 3° (625/50 system) basic, 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 0 mm basic (625/50 system). The width of zones 1, 3 and 4 shall be 0,006 mm basic for both systems. The width of zone 2 shall be 0,004 mm basic for both systems. These zones are established to contain track angle errors, track straightness errors and vertical head offset tolerance.

Measuring techniques are shown in Annex A.

4.4 Relative positions of recorded signals

4.4.1 Relative positions of the longitudinal tracks

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

4.4.2 Helical/control track relationship

The spatial relationship between the cue track record, time and control code record, control track record and helical tracks are specified in Figure 42 and Figure 43.

4.4.3 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 the distance Y from the reference edge and the centre line of the first track in each video field (segment 0, track 0).

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 X_1 . The locations are shown in Figure 42 and Figure 43, dimensions X_1 and Y are given in Table 12 (525/60 system) or Table 13 (625/50 system). The relationship between sectors and contents of each sector is specified in 5.3 to 5.5.

4.5 Gap azimuth

4.5.1 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.

4.5.2 Helical track

The azimuth of the head gaps used for the helical track recording shall be inclined at angles α_0 and α_1 as specified in Table 12 (525/60 system) or Table 13 (625/50 system) perpendicular to the helical track record. 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 track direction when viewed from the side of the tape containing the magnetic record.

4.6 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 two head pairs mounted at 180° from each other. Figure 46 (525/60 system) or Figure 47 (625/50 system) shows a possible mechanical configuration of the scanner and Table 14 (525/60 system) or Table 15 (625/50 system) shows the corresponding mechanical parameters. Figure 48 (525/60 system) or Figure 49 (625/50 system) shows 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 described in 4.2.1, 4.2.5 and Figure 46 (525/60 system) or Figure 47 (625/50 system).

5 Programme track data arrangement

5.1 Introduction

Each television field is recorded on six tracks.

The helical tracks contain digital data from the video channel and four audio channels. The audio data is contained in four recorded sectors per track, two at the beginning of the track and two at the end of the track. The video data is recorded in a sector in the middle part of each track. An edit gap between sectors accommodates timing errors during editing. Figure 50 shows the arrangement of video and audio sectors on the tape for 525/60 system and Figure 51 shows the arrangement of video and audio sectors on the tape for 625/50 system.

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.

5.2 Labelling convention

The least significant bit is written on the left and is 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. An_h subscript indicates hexadecimal value.

5.3 Sector details

5.3.1 Sync block

The sync block format is common for 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 (outer check bytes are considered data) plus eight inner check bytes. The inner code block protects the two bytes of the identification pattern together with 85 data bytes. Figure 52 (525/60 system) or Figure 53 (625/50 system) shows the sync block format.

5.3.2 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

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

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

5.3.3 Identification pattern

The first byte and the bit 0 of the second byte of the identification pattern identify a particular sync block of a helical track. The bits 1–7 of the second byte of the identification pattern identifies a particular track. Figure 54 (525/60 system) or Figure 55 (625/50 system) shows 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 56 (525/60 system) or Figure 57 (625/50 system) shows the sequence of sync block numbers.

The sector ID (bits 1–7 of the byte 3) identifies a particular sector. The (V/A) bit distinguishes between audio and video sectors. For 525/60 system, the segment count is modulo 3. 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 625/50 system, the segment is modulo 4. The field count for video sectors is modulo 8 ($F2 = 0$ in byte 3). The field count for audio sectors is modulo 4 (for $F1$ and $F2$ in byte 3) is used for the identification of the eight field sequence.

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

for 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
for 625/50 system	$F0$	$F1$	$F2$
— field 1	0	0	0

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

For 525/60 system, the field address F0 and F1 (bits 4 and 5 of the byte 3) for audio sync blocks shall identify the four fields over the five field sequences. When audio sectors are edited, the four 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

For 625/50 system, no field sequence is required.

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

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

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

The first term is the most significant and the first to enter the division computation. The polynomial generator noted above is pre-set to 80_h at the first byte of the identification pattern and continues to cycle until the end of the sync block.

5.3.4 Data field

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

a) Length: one inner code block. The inner code block contains 95 bytes (525/60 system) or 86 bytes (625/50 system) consisting of two identification pattern bytes and 85 data bytes (525/60 system) or 76 data bytes (625/50 system), herein outer ECC check bytes are considered data, plus eight inner ECC check bytes.

b) Arrangement: see Figure 52 (525/60 system) or Figure 53 (625/50 system).

c) Interleaving: none.

d) Protection: inner ECC code.

Type: Reed Solomon

Galois field: 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, “oldest” in time computationally, and first written to tape.

Code Generator Polynomial in GF(256) is:

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

where a is given by 02_h 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 $x^8D(x)$ by $G(x)$,

where

for 525/60 system

$$D(x) = ID_0x^{86} + ID_1x^{85} + B_{84}x^{84} + \dots + B_2x^2 + B_1x + B_0$$

for 625/50 system

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

The polynomial of full code is:

for 525/60 system

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

for 625/50 system

$$ID_0x^{85} + ID_1x^{84} + B_{75}x^{83} + B_{74}x^{82} + \dots + B_1x^9 + B_0x^8 + K_7x^7 + K_6x^6 + \dots + K_2x^2 + K_1x + K_0$$

e) Randomization: all data and error correction check characters are randomized before being channel coded. The randomization is equivalent to the randomization as defined in item e) of 5.3.3.

5.3.5 Sector preamble

All sectors are preceded by a preamble consisting of a clock run-up sequence, a sync pattern (2 bytes), an identification pattern (2 bytes) and a 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.

5.3.5.1 Track preamble

This preamble precedes the first sector of every track. The run-up sequence is 50 bytes long and shall contain the pattern 2C_h.

- a) Length: 58 bytes
- b) Arrangement: see Figure 58a
- c) Run-up pattern: 2C_h

LSB				MSB			
0	0	1	1	0	1	0	0

- d) Fill pattern: 00_h
- e) Protection: none
- f) Randomization: only the identification pattern (2 bytes) and fill pattern (4 bytes) are randomized before being channel coded. The randomization is equivalent to the randomization as defined in item e) of 4.3.3.

5.3.5.2 In-track preamble

An in-track preamble precedes every sector except the first sector of a track. The run-up sequence is 20 bytes long and shall contain the pattern 2C_h.

- a) Length: 28 bytes
- b) Arrangement: see Figure 58b
- c) Run-up pattern: 2C_h

LSB				MSB			
0	0	1	1	0	1	0	0

- d) Fill pattern: 00_h
- e) Protection: none
- f) Randomization: only the identification pattern (2 bytes) and fill pattern (4 bytes) are randomized before being channel coded.

The randomization is equivalent to the randomization as defined in 5.3.3 e).

5.3.6 Sector postamble

All sectors are followed by a postamble containing a sync pattern (2 bytes) and identification pattern (two bytes).

When a sector is edited, the postamble shall be recorded.

- a) Length: four bytes
- b) Arrangement: see Figure 58c

- c) Protection: none
- d) Randomization: only the identification pattern (2 bytes) is randomized before being channel coded. The randomization is equivalent to the randomization as defined in item e) of **5.3.3**.

5.4 Edit gaps

The space between sectors on a track, exclusive of postamble and preamble, is nominally 162 bytes long (525/60 system) or 144 bytes long (625/50 system), and is used to accommodate timing errors during editing. In an original recording the edit gap shall contain the pattern $2C_h$.

During an edit, the edit gap may be partially rewritten with $2C_h$, provided that the preamble and postamble of adjacent unedited sectors are not overwritten.

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

5.5 Channel coding

5.5.1 Coding rules

The channel code shall be 8-14 modulation code which is defined by the following code rules.

The following steps are taken for selecting the current 14-bit code.

- 1) Select a 14-bit code satisfying the following conditions of a) and b) from Table 9 and Table 10:
 - a) The number of consecutive identical bits at the joint portion with the preceding 14-bit code is two to seven.
 - b) The absolute value of the DSV at the end of the code (hereinafter called end DSV) is equal to or less than two.
- 2) When two or more 14-bit codes are selected at step 1), choose a 14-bit code that gives the smallest absolute value of the end DSV.
- 3) When two or more 14-bit codes are chosen in step 2), select a 14-bit code by calculating the DSV for each bit of the code (called bit DSV hereinafter), determining 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.
- 4) When two or more 14-bit codes are found in step 3), 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.
- 5) When two or more codes are found in step 4), 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.
- 6) When any codes selected at step 4) do not satisfy step 5), or two or more modulation codes satisfy step 5), select a 14-bit code satisfying the condition that the consecutive identical bits in that code is equal to or less than six.
- 7) When any codes selected at step 4) do not satisfy step 5) and step 6), or when any codes selected at step 5) do not satisfy step 6), or when two or more codes are found at step 6), the following two steps of a) and b) are taken:
 - a) When the end DSV of the code is -2 , select from Table 18 a code of higher priority (corresponding to the smallest number in Table 18). Likewise, when the end DSV of the code is $+2$, select from Table 19 a code of higher priority (corresponding to the smallest number in Table 19).
 - b) When two or more codes belonging to the equal highest priority are found in step a), select all of them temporarily. When the end DSV is zero, select a code satisfying the last six bits which is neither "111111" nor "000000".
- 8) When any codes selected at step 4) do not satisfy steps 5), 6) and 7), or when any codes selected at step 5) do not satisfy step 6) and step 7), or when any codes selected at step 6) do not satisfy step 7), or when two or more codes are further found at step 7), select a code with the bit DSV whose maximum absolute value is smallest.
- 9) When two or more codes are found at step 8), select a 14-bit code with the bit DSV whose minimum absolute value appears earliest in the bit string of the code.

10) When two or more codes are further found at step 9), select a 14-bit code whose bit will be reserved earliest after the joint portion with the preceding code.

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 waveform, 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 9 and Table 10 are in hexadecimal notation.

5.5.2 Data rate and wavelength

The recorder data rate (for the scanner configuration defined in 4.6) and the shortest recorded wavelength are given in Table 5, provided for reference only:

Table 5 — Data rate and wavelength

Parameter	525/60 system	625/50 system
Total average data rate	125,2 Mb/s	151,7 Mb/s
Instantaneous channel data rate	63,3 Mb/s	76,7 Mb/s
Shortest recorded wavelength	0,77 µm	0,71 µm

5.6 Magnetization

5.6.1 Polarity

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

5.6.2 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.

5.6.3 Record level

The level of the record head current applied to the head should be optimized for the 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 equivalent results.

6 Video interface

6.1 Encoding parameters

The digital composite video signal is encoded according to IEC 1179.

The input video signal is sampled at $4 f_{sc}$ and uniformly quantized 8 or 10 bits per sample. Only 8 bits per sample are recorded on tape, although 10 bits per sample may be present at the digital parallel interface.

6.2 Parallel digital signal interface

The principal mode of interface is analogue. If a parallel digital video interface is used, it should conform to IEC 1179.

7 Audio interface

7.1 Encoding parameters

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

7.1.1 Sampling

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

for 525/60 system

$$48 \text{ kHz} = F_H \times 1\,144/375$$

for 625/50 system

$$48 \text{ kHz} = F_H \times 384/125$$

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

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

7.1.2 Reference level

The recommended recorded audio levels should be – 20 dB below the system maximum.

7.2 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 IEC 958.

8 Video processing

8.1 Recorded and non-recorded data

8.1.1 Recorded samples of digital active line and lines of the television frame

768 samples per line (525/60 system) or 948 samples per line (625/50 system) are recorded, centred about the active picture. The relationship between video signals in the analogue and digital domains together with the address numbers of the digitized samples for zero degrees ScH phase of the incoming signal is shown in IEC 1179.

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 is shown in Table 6.

The first recorded sample of each field is the – I sample (525/60 system) or U-V sample (625/50 system).

When the first recorded line of each field is not used for user data area, all the samples shall be set to $3C_h$.

Table 6 — First recorded sample

525/60 system				
Colour frame A	field I	Sample number	0	of line 9
Colour frame A	field II	Sample number	0	of line 271
Colour frame B	field III	Sample number	2	of line 9
Colour frame B	field IV	Sample number	2	of line 271
625/50 system				
	Field 1	Sample number	1 133	of line 8
	Field 2	Sample number	0	of line 320
	Field 3	Sample number	1 133	of line 7
	Field 4	Sample number	1 133	of line 321
	Field 5	Sample number	0	of line 8
	Field 6	Sample number	1 133	of line 320
	Field 7	Sample number	0	of line 7
	Field 8	Sample number	0	of line 321

8.1.2 Non-recorded data

- a) Information received during the line blanking and nine line vertical intervals is not recorded on tape. The appropriate blanking, sync and burst data is recreated for output during playback.

- b) The digital horizontal blanking interval is defined in IEC 1179.

8.1.3 Source pre-coding

No source pre-coding is applied to the input video data.

8.2 Channel distribution of samples

The samples are distributed between two channels in a checkerboard pattern, which alternates from line to line.

Figure 59 (525/60 system) or Figure 60 (625/50 system) shows the distribution of samples. In Figure 59 the channel number (0 or 1) coincides with the track number as defined in Figure 61 (525/60 system) and in Figure 60 the channel number (0 or 1) coincides with the track number as defined in Figure 62 (625/50 system).

8.3 Shuffling

8.3.1 Introduction

The video data for each channel is shuffled before being written to tape. The shuffling distance is over all the television lines within a video field. The outer check bytes are not shuffled, but are recorded at the beginning of the video sectors on tape.

The shuffling algorithm may be considered as a combination of an intra-line shuffle process preceding the outer ECC coder, and a field data memory array shuffle process following the outer ECC coder.

Each television line contains three outer code blocks per channel. The samples within each outer code block are spaced six samples horizontally within the television line, although they appear in a permuted order within the outer block.

The horizontal sample number of the first sample in each outer block is given by an algebraic function which depends on the line number and outer block number within a line. The horizontal sample number increment between consecutive samples within an outer block is a constant which generates a permutation of every six samples within a television line.

The field data array shuffle is a permutation of the columns, which results in each inner ECC code block containing one sample from each television line within a field. In addition, when data is recorded on tape, the data for track 1 is read from the field memory array with a field memory array off-set relative to the data for track 0. Moreover, when data is recorded on tape, the start address of the field memory is off-set within a colour frame.

8.3.2 Algebraic definition

The shuffling process operates identically for all video fields.

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

$$L = 0, 1, \dots, 254 \quad (525/60 \text{ system})$$

$$L = 0, 1, \dots, 303 \quad (625/50 \text{ system})$$

Let h be the horizontal sample location within line L :

$$h = 0, 1, \dots, 767 \quad (525/60 \text{ system})$$

$$h = 0, 1, \dots, 947 \quad (625/50 \text{ system})$$

Let ih be the horizontal sample index following the channel distribution process described in 8.2:

$$ih = \text{int}(h/2), \quad ih = 0, 1, \dots, 383 \quad (525/60 \text{ system})$$

$$ih = 0, 1, \dots, 473 \quad (625/50 \text{ system})$$

where $\text{int}(x)$ means largest integer less than or equal to x .

Let $Oblk$ be the outer block number within line L :

$$Oblk = 0, 1, 2$$

Let $Obyt$ be the sample number within outer block $Oblk$:

$$Obyt = 0, 1, \dots, 127.$$

NOTE Outer code check bytes are not included in the intra-line shuffle process.

Then ih within line L is mapped to $Obyt$ according to the following formula:

$$Obyt = \{107 \times \text{int}(ih/3) + 78 \times Oblk + 46 \times L\} \bmod 128 \quad (525/60 \text{ system})$$

$$Obyt = \{59 \times \text{int}(ih/3) + 72 \times Oblk + 82 \times L\} \bmod 158 \quad (625/50 \text{ system})$$

where $Oblk = ih \bmod 3$.

The outer ECC coder places check bytes $K_7, K_6, K_5, K_4, K_3, K_2, K_1$ and K_0 in locations:

$$Obyt = 128, 129, 130, 131, 132, 133, 134 \text{ and } 135 \text{ respectively} \quad (525/60 \text{ system})$$

$$Obyt = 158, 159, 160, 161, 162, 163, 164 \text{ and } 165 \text{ respectively} \quad (625/50 \text{ system})$$

The byte at location $Obyt$ in outer block $Oblk$ is placed in the field memory array at location (Row, Col) where:

$$Row = Obyt$$

and

$$Col = L + 255 \times Oblk \quad (525/60 \text{ system})$$

$$Col = L + 304 \times Oblk \quad (625/50 \text{ system})$$

The field memory array data is written to tape first by column order

$$(0, 1, \dots, 764) \quad (525/60 \text{ system})$$

$$(0, 1, \dots, 911) \quad (625/50 \text{ system})$$

then by ascending row order

$$(0, 1, 2, \dots, 134, 135) \quad (525/60 \text{ system})$$

$$(0, 1, 2, \dots, 164, 165) \quad (625/50 \text{ system})$$

The outer check bytes are written to tape first and then followed by data bytes.

Let Seg be the segment number within a video field:

$$Seg = 0, 1, 2 \quad (525/60 \text{ system})$$

$$Seg = 0, 1, 2, 3 \quad (625/50 \text{ system})$$

Let Fld be the field number within a colour frame:

$$Fld = 0, 1, 2, 3 \quad (525/60 \text{ system})$$

$$Fld = 0, 1, 2, 3 \dots 6, 7 \quad (625/50 \text{ system})$$

Let Tr be the recording track number:

$$Tr = 0, 1.$$

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

For the outer check bytes,

$$Xin = 1\,152 + 24 \times Seg \quad (525/60 \text{ system})$$

$$Xin = 1\,896 + 24 \times Seg \quad (625/50 \text{ system})$$

and for the outer data bytes

$$Xin = (384 \times Seg + 96 \times Fld + 576 \times Tr) \bmod 1\,152 \quad (525/60 \text{ system})$$

$$Xin = (474 \times Seg + 59 \times Fld + 711 \times Tr) \bmod 1\,896 \quad (625/50 \text{ system})$$

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

$$Xin = 9 \times Row + \text{int}(Col/85) \quad (525/60 \text{ system})$$

$$Xin = 12 \times Row + \text{int}(Col/76) \quad (625/50 \text{ system})$$

8.4 Field data array

For 525/60 system, the field data array is dimensioned 765 columns (nine times 85 bytes), and 136 rows (128 video data plus eight outer check bytes). Figure 63 illustrates the field data array.

For 625/50 system, the field data array is dimensioned 912 columns (12 times 76 bytes), and 166 rows (158 video data plus eight outer check bytes). Figure 64 illustrates the field data array.

8.5 Outer error protection

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

Type: Reed Solomon

Galois field: 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, oldest in time computationally, and 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 02_h 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:

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

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

$$D(x) = B_{127}x^{127} + B_{126}x^{126} + \dots + B_2x^2 + B_1x + B_0 \quad (525/60 \text{ system})$$

$$D(x) = B_{157}x^{157} + B_{156}x^{156} + \dots + B_2x^2 + B_1x + B_0 \quad (625/50 \text{ system})$$

Equation of full code is given by:

$$B_{127}x^{135} + B_{126}x^{134} + \dots + B_1x^9 + B_0x^8 + K_7x^7 + K_6x^6 + K_5x^5 + K_4x^4 + K_3x^3 + K_2x^2 + K_1x + K_0 \quad (525/60 \text{ system})$$

$$B_{157}x^{165} + B_{156}x^{164} + \dots + B_1x^9 + B_0x^8 + K_7x^7 + K_6x^6 + K_5x^5 + K_4x^4 + K_3x^3 + K_2x^2 + K_1x + K_0 \quad (625/50 \text{ system})$$

8.6 Order of transmission to inner coding

For 525/60 system, video data bytes (outer check bytes are considered data) shown in Figure 63 are sent to the inner coder first by column (0 through 8 of 85 bytes data block), then by row (0 through 135).

For 625/50 system, video data bytes (outer check bytes are considered data) shown in Figure 64 are sent to the inner coder first by column (0 through 165).

9 Audio processing

9.1 Introduction

Audio in each of the four 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 to provide house keeping in the interface and in processing. Figure 65 (525/60 system) or Figure 66 (625/50 system) shows the audio data block field array.

9.2 Source coding

Audio records that meet the requirements of IEC 958 are formed independently for each of four 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. IUT-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: two's complement linear PCM.

b) Channel status data:

- bits rate: 48 kbit/s (nominal);
- word rate: 6 kByte/s;
- word length: 8 bits;
- block length: 192 bits, 24 words;
- coding: see IEC 958.

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 status data only are selected for special processing in the DVTR. The contents of bytes 0 and 1 are shown in Table 15 and Table 16, respectively.

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

9.3 Source processing

9.3.1 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.

9.3.2 Relative audio-video timing

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

9.3.3 Audio data in fields

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

Audio data words:

801 or 800 words with associated C , U , V , R bits
(20 bits total per word for 525/60 system).

960 words with associated C , U , V , R bits
(20 bits total per word for 625/50 system).

Auxiliary data words:

total 15 words (20 bits per word for 525/60 system)
total 32 words (20 bits per word for 625/50 system).

9.3.4 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:

$Col = 0, 1, \dots, 101$ (525/60 system)

$Col = 0, 1, \dots, 123$ (625/50 system)

Let Row be the row number within an audio field:

$Row = 0, 1, \dots, 15$.

Row 8 to 15 contain the error correction data.

Let $Oblk$ be the data block number:

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

$Oblk = 4 \times Row + \text{int}(Col/34)$ (625/50 system)

The data block array is shown in Figure 67 (525/60 system) or Figure 68 (625/50 system).

Then sample number Smp within an audio field is obtained according to the following formula:

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

$Smp = 32 \times (Col \bmod 36) + \text{int}(Oblk/9) + 4 \times (Oblk \bmod 9)$ (625/50 system)

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

When Smp is larger than 959, $Smp = 960, 961, \dots, 991$ are replaced by $AUX 0, AUX 1, \dots, AUX 31$ respectively for 625/50 system.

Figure 67 (525/60 system) or Figure 68 (625/50 system) shows the layout of the shuffled samples in a field array.

Outer ECC codes are situated in rows 8 to 15.

9.3.5 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:

$N = 0, 1, \dots, 7$.

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:

$Tr = 0, 1$

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

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

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

Figure 69 shows the data block arrangement of an audio channel for 525/60 system in three pairs of sectors.

Figure 70 shows the data block arrangement of an audio channel for 625/50 system in four pairs of sectors.

9.3.6 Audio data word processing

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

- a) Assignment of the 20-bit word to audio and associated data is controlled by user input as follows:

Table 7 — Audio data word mode

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

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 71 (525/60 system) or Figure 72 (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 67 (525/60 system) or Figure 68 (625/50 system).

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

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

The five-field sequence is indicated by the value of the auxiliary word *FNCT*, as defined in 9.4.5.

Furthermore, every fifth field of 800 samples is identified by the field address F2 for audio sync blocks, as defined in 5.3.3.

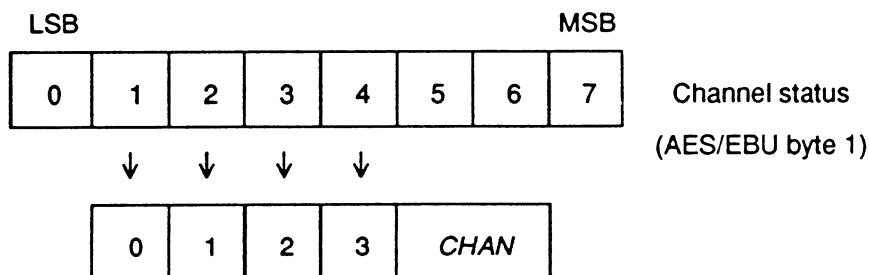
9.4 Auxiliary words

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 four words of 4 bits (625/50 system), plus one word of 8 bits as defined in Figure 73 (525/60 system) or Figure 74 (625/50 system). The word *EFLG* is written four times in each audio block.

Figure 73 (525/60 system) or Figure 74 (625/50 system) shows the format of the auxiliary words in the audio data block.

9.4.1 Channel use (*CHAN*)

This word is 4 bits and specifies the usage of the two input channels in an interface data stream. *CHAN* is derived from channel status byte 1.



Bit 0: channel mode bit 0
 Bit 1: channel mode bit 1
 Bit 2: channel mode bit 2
 Bit 3: channel mode bit 3

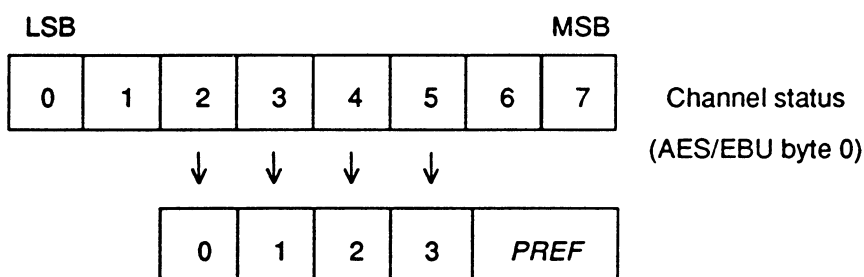
Table 8 — Channel use control word

Mode	CHAN bit				Value
	0	1	2	3	
0	0	0	0	0	Two-channel default
1	0	0	0	1	Two channel
2	0	0	1	0	Single channel
3	0	0	1	1	Primary/secondary two channel
4	0	1	0	0	Stereophonic
5	0	1	0	1	Undefined
	through				
F	1	1	1	1	Undefined

NOTE *CHAN* is inserted in bits 4–7 of *AUX 3* (525/60 system) or *AUX 2* (625/50 system)

9.4.2 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.



Bit 0: pre-emphasis bit 0
 Bit 1: pre-emphasis bit 1
 Bit 2: pre-emphasis bit 2
 Bit 3: 0

Table 9 — Pre-emphasis control word

Mode	PREF bit			Value
	0	1	2	
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

NOTE PREF is inserted in bits 4–7 of AUX 0.

9.4.3 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.

LSB		MSB		
0	1	2	3	<i>LNGH</i>

Bit 0: 0

Bit 1: *LNGH* 1 (LSB)

Bit 2: *LNGH* 2

Bit 3: *LNGH* 3 (MSB)

Table 10 — Word mode control word

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

NOTE 1 × means that the ancillary bit is recorded.

NOTE 2 *LNGH* is inserted in bits 4–7 of AUX 1.

9.4.4 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 IEC 958. *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				
0	1	2	3	4	5	6	7	<i>S MARK</i>

where *S MARK* is from 00_h to BF_h inclusive

S MARK = FF_h 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).

9.4.5 Field number count (*FNCT*) for 525/60 system

This word is composed of 4 bits and specifies the number of audio sample in the current field.

LSB		MSB		
0	1	2	3	<i>FNCT</i>

Bit 0: *FNCT 0* (LSB)

Bit 1: *FNCT 1*

Bit 2: *FNCT 2* (MSB)

Bit 3: 0

Table 11 — *FNCT* mode

Number of samples	<i>FNCT</i> bit		
	2	1	0
801	0	0	0
801	0	0	1
801	0	1	0
801	0	1	1
800	1	0	0

NOTE *FNCT* is inserted in bits 4–7 of *AUX 2*.

9.4.6 Edit flag (*EFLG*)

This word is 4 bits and specifies the field associated with an edit transition.

LSB		MSB		
0	1	2	3	<i>EFLG</i>

for 525/60 system

$EFLG = D_h$ for the first field of the edit

$EFLG = 7_h$ for the last field of the edit

$EFLG = 0_h$ otherwise

for 625/50 system

$EFLG = B_h$ for the first field of the edit

$EFLG = E_h$ for the last field of the edit

$EFLG = 0_h$ otherwise.

EFLG is inserted in bits 0–3 of *AUX 0*, *AUX 1*, *AUX 2*, and *AUX 3*.

9.5 Outer error protection

Rows 8 through 15 of the data block as shown in Figure 65 or Figure 66 contain the error check bytes associated with each column.

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, last in time computationally and first written to tape.

Code generator polynomial:

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

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

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

$$B_7x^{15} + B_6x^{14} + B_5x^{13} + \dots + B_1x^9 + B_0x^8 + K_7x^7 + K_6x^6 + K_5x^5 + K_4x^4 + K_3x^3 + K_2x^2 + K_1x + K_0$$

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 67 or Figure 68, 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.

9.6 Inner protection

The inner protection and sync block format are identical to that for video. See 5.3 and 5.4.

9.7 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.

9.8 Channel code

Channel code is identical to that for video. See 5.5.

9.9 Allocation of audio sectors

The data blocks of an audio channel are arranged on the three pairs of sectors (six sectors for 525/60 system or eight sectors for 625/50 system) as shown in Figure 69 or Figure 70. A pair of sectors from each of the four audio channels is recorded according to the allocation of Figure 75 (525/60 system) or Figure 76 (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 four-field sequence. Field address F0, F1 of sector ID for four audio sync blocks as defined in 5.3.3 shall identify four-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

10 Longitudinal tracks

10.1 Relative timing

10.1.1 Time and control code input

An external record time and control code input, that meets the specifications described in IEC 461 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).

10.1.2 Time and control code information

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

10.1.3 Cue information

Cue information shall be recorded on the tape at a point referenced to the associated video information as defined by dimension P_2 of Figure 43 and Table 5 (525/60 system) or Table 6 (625/50 system).

10.1.4 Control track servo pulse

Control track servo pulse record timing is described in 10.2.

10.2 Control track

10.2.1 Method of recording

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

10.2.2 Servo reference pulse

The servo reference pulse, at the time of recording, shall be a series of pulses with a period of $11,122 \text{ ms} \pm 6 \text{ } \mu\text{s}$ (525/60 system) or $10,000 \text{ ms} \pm 6 \text{ } \mu\text{s}$ (625/50 system) as shown in Figure 77 (525/60 system) or Figure 78 (625/50 system).

10.2.3 Flux polarity

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

10.2.4 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.

10.2.5 Pulse width

The recorded pulses shall have periods of $4T$, $5T$ or $6T$ where T equals to $1,112 \text{ } \mu\text{s}$ nominal. The rise and fall times of the record current (10 % to 90 % points) shall be less than $150 \text{ } \mu\text{s}$.

10.2.6 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.

10.2.7 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 for 525/60 system or field I for 625/50 system. 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 5.3.3.

10.2.8 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 point 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 5.3.3.

10.3 Cue record

10.3.1 Method of recording

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

10.3.2 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 $1\,000 \text{ Hz}$.

10.4 Time and control code record

10.4.1 Method of recording

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

10.4.2 Flux level

The recorded peak-to-peak flux shall correspond to a magnetic short-circuit flux level of 250 nWb/m ± 20 nWb/m of track width.

10.4.3 Input signal

The signal recorded on this track shall be in accordance with IEC 461.

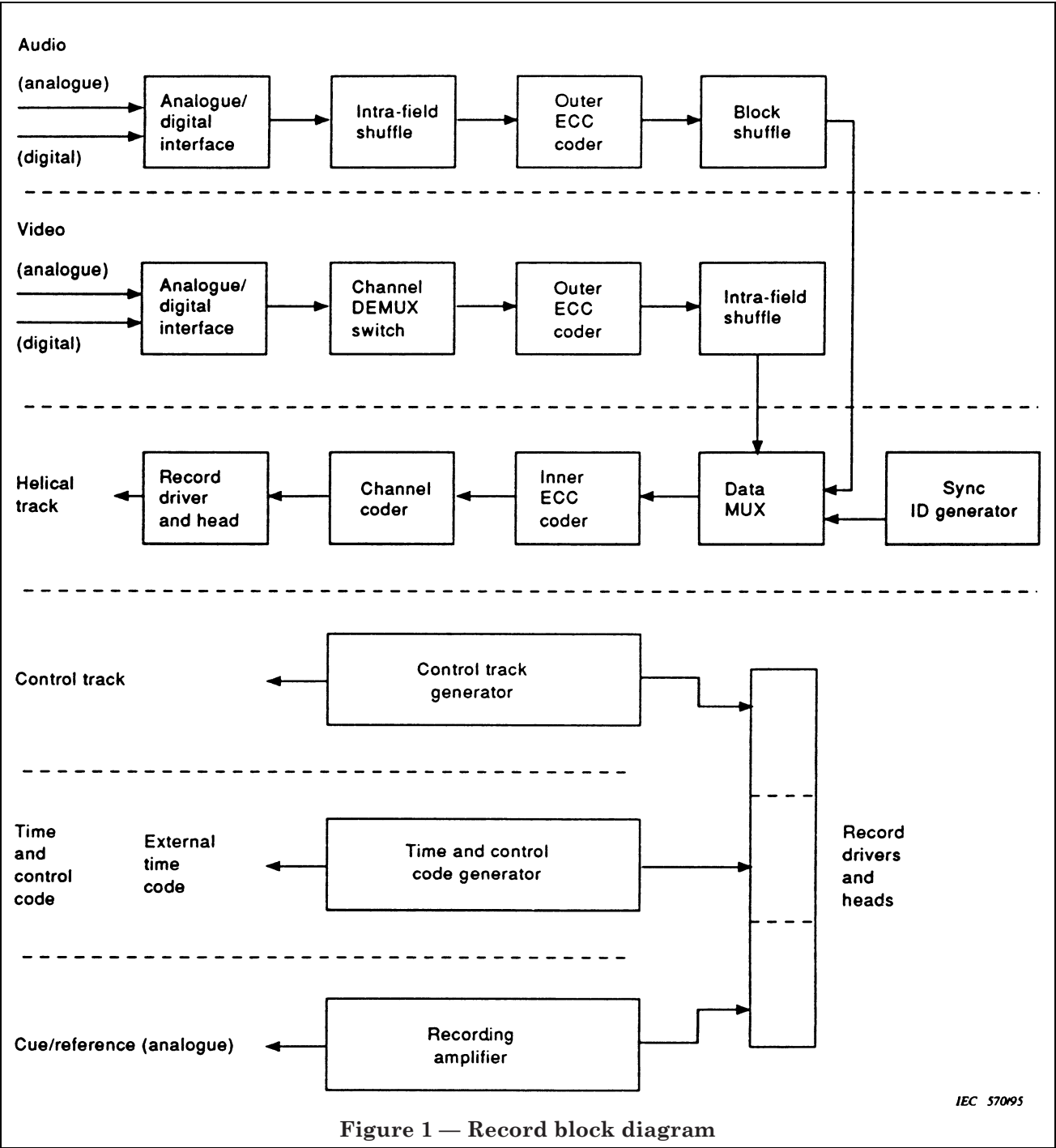
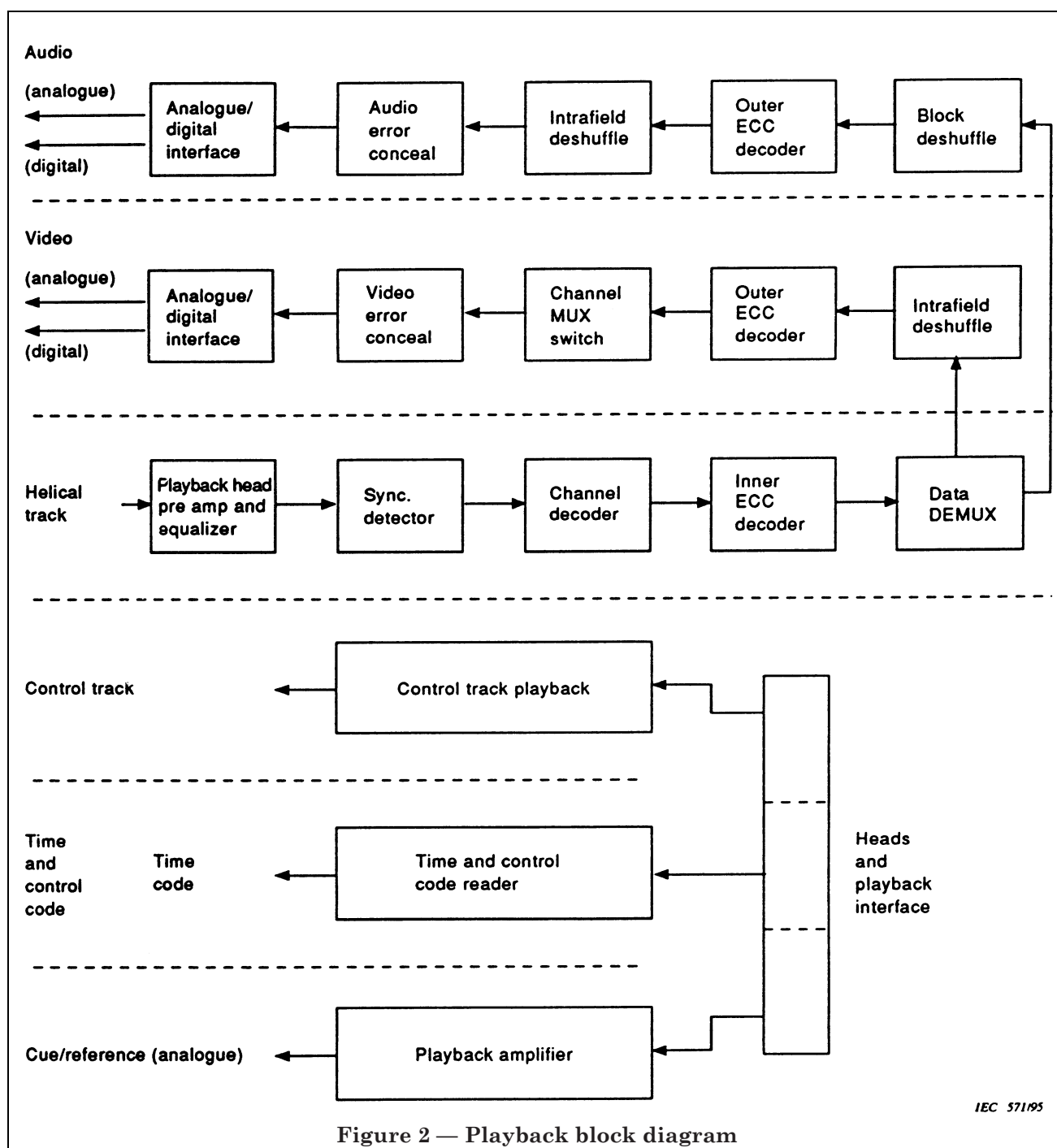
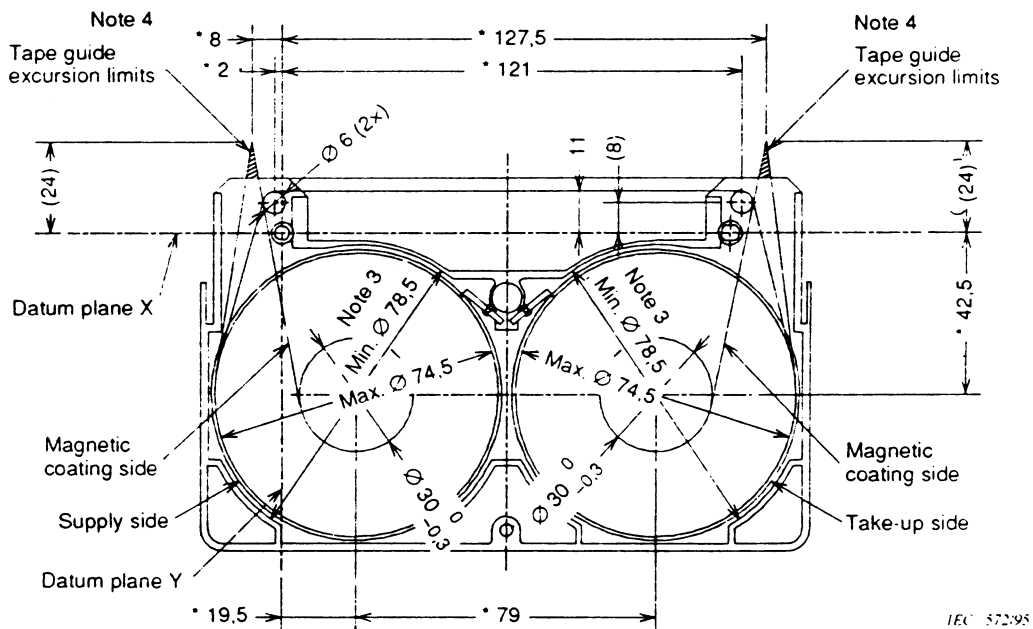


Figure 1 — Record block diagram





Dimensions in millimetres

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

NOTE 2 Dimensions with parenthesis are for reference only.

NOTE 3 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 tape contact with cassette components.

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