SMPTE 279M-2001
Revision of
ANSI/SMPTE 279M-1996

SMPTE STANDARD

for Digital Video Recording — 1/2-in Type D-5 Standard-Definition Component Video and Type HD-D5 High-Definition Video Compressed Data

Table of contents

1 Scope

This standard specifies the content, format, and recording method of the data blocks containing video, audio, and associated data which form the helical records on 12.65-mm (0.5-in) tape in cassettes as specified in ANSI/SMPTE 263M.

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, and also the longitudinal cue audio, and time and control code.

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.

1.1 Standard-definition television operation

The video channel records and reproduces a component video signal of the 525-line, 29.97-Hz 25 or 30 frame rate system (hereafter referred to as the 525/60 system) or of the 625-line, 25-Hz 30 or 60 frame rate system (hereafter referred to as the 625/50 system).

1.2 High-definition television operation

The compressed video data stream, derived from the HD video signal conforming to SMPTE RP 209, is recorded by configuring the incoming data stream to the structure similar to the uncompressed 18-MHz sampled 525/60 component video signal. The recording system defined herein operates in one of the following three modes, depending on the input signal format:

Recording mode	Input signal	SMPTE standard
1	ANSI/SMPTE 125M	ANSI/SMPTE 125M
2	ANSI/SMPTE 267M	ANSI/SMPTE 267
3	SMPTE RP 209	SMPTE 342M

Figures 1 and 2 show block diagrams of the processes involved in the recorder.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

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Approved
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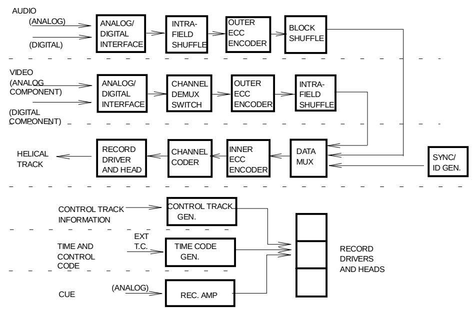


Figure 1 - Record block diagram.

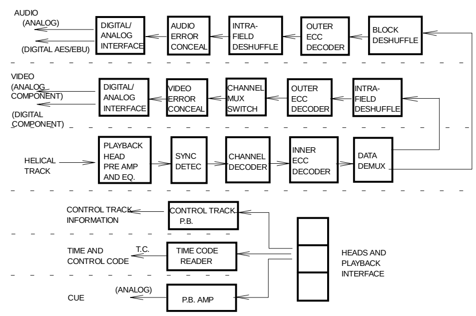


Figure 2 - Playback block diagram.

Figure 1 – Record block diagram

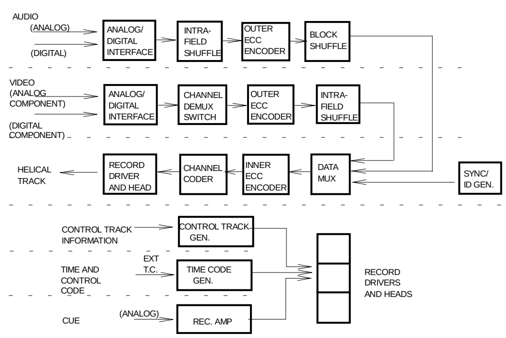


Figure 1 - Record block diagram.

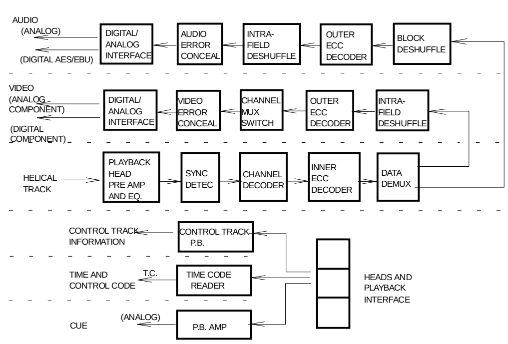


Figure 2 - Playback block diagram.

Figure 2 – Playback block diagram

AES3-1992, Digital Audio Engineering — Serial Transmission Format for Two-Channel Linearly Represented Digital Audio Data

ANSI/SMPTE 125M-1995, Television — Component Video Signal 4:2:2 — Bit-Parallel Digital Interface

ANSI/SMPTE 259M-1997, Television — 10-Bit 4:2:2 Component and $4f_{SC}$ Composite Digital Signals — Serial Digital Interface

ANSI/SMPTE 267M-1995, Television — Bit-Parallel Digital Interface — Component Video Signal 4:2:2 16×9 Aspect Ratio

SMPTE 342M-2000, Television — HD-D5 Compressed Video 1080i and 720p Systems — Encoding Process and Data Format

SMPTE RP 155-1997, Audio Levels for Digital Audio Records on Digital Television Tape Recorders

SMPTE RP 209-2000, Format for Transmission of HD-D5 Compressed Video and Audio Data over 360 Mb/s Serial Digital Interface

IEC 60461 (1986-09), Time and Control Code for Video Tape Recorders

IEC 60958 (1989-02), Digital Audio Interface

ITU-R BT.470-6 (11/98), Conventional Television Systems

ITU-R BT.601-5 (10/95), Studio Encoding Parameters of Digital Television for Standard 4:3 and Wide-Screen 16:9 Aspect Ratios

ITU-R BS.647-2 (03/92), A Digital Audio Interface for Broadcasting Studios

3 Environment and test conditions

3.1 Environment

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

- Temperature 20°C ± 1°C
- Relative humidity (50 ± 2)%
- Barometric pressure from 86 kPa to 106 kPa
- Tape conditioning not less than 24 h
- Center tape tension 0.31 N ± 0.05 N (see annex A)

3.2 Reference tape

Blank tape for reference recordings should be available from any source meeting the tape characteristics as portrayed by this standard.

3.3 Calibration tapes

The calibration tapes meeting the requirements of 3.3.1 and clause 4 should be available from manufacturers who produce DTTRs and players in accordance with this standard.

3.3.1 Record locations and dimensions

Tolerances shown in tables 1 and 2 will be reduced by 50%.

3.3.2 Calibration signals

Two sets of signals shall be recorded on the calibration tape:

a) Video: 100% color bars

Audio: 1-kHz tone at 20 dB below full scale on each audio channel

Cue: 1- kHz tone at reference level; 10-kHz tone at reference level

b) A signal of constant frequency (i.e., one-half the Nyquist frequency) shall be recorded only on the tracks of field 0, segment 0 for the purpose of mechanical alignment. The recording level should conform to that in 6.6.3.

4 Video tape

4.1 Base

The base material shall be polyester or equivalent.

4.2 Width

The tape width shall be 12.650 mm ± 0.008 mm. The tape, covered with glass, shall be measured without tension at a minimum of five different positions along the tape using a calibrated comparator having an accuracy of 0.001 mm (1 µm). The tape width is defined as the average of the five readings.

Table 1 – Record location and dimensions (525/60 system)

	Dimensions	Nominal	Tolerance
A	Time and control code track lower edge	0	Basic
B	Time and control code track upper edge	0.450	± 0.050
C	Control track lower edge	0.900	± 0.050
D	Control track upper edge	1.300	± 0.050
E	Program area lower edge	1.629	Derived
F	Program area width	10.020	Derived
G	Cue audio track lower edge	11.950	± 0.050
H	Cue audio track upper edge	12.550	± 0.050
I	Helical track pitch	0.0200	Ref
K0	Video sector 0 length	55.458	Derived
K1	Video sector 1 length	55.391	Derived
L	Helical track total length	116.397	Derived
M	Audio sector length	0.936	Derived
P1	Control track reference pulse to program reference point (see figure 4)	180.549	± 0.050
P2	Cue/time and control code signal, start of code word, to program reference point (see figure 4)	183.400	± 0.100
X1	Location of start of video sector V0	0	± 0.050
X2	Location of start of audio sector A1[1)]	55.752	± 0.050
X3	Location of start of audio sector A2[1)]	57.049	± 0.050
X4	Location of start of audio sector A3[1)]	58.345	± 0.050
X5	Location of start of audio sector A4[1)]	59.642	± 0.050
X6	Location of start of video sector V1[1)]	60.938	± 0.050
Y	Program reference point	1.640	Basic
θ	Track angle	4.9384°	Basic
α_0	Azimuth angle (track 0)	–20.038°	± 0.150°
α_1	Azimuth angle (track 1)	19.962°	± 0.150°

NOTES

1 Measurements shall be made under the conditions specified in 3.1. The measurements shall be corrected to account for actual tape speed (see figures B.1 and B.2).

2 All dimensions are in millimeters.

[1)] Audio channel numbers vary.

Table 2 – Record location and dimensions (625/50 system)

	Dimensions	Nominal	Tolerance
A	Time and control code track lower edge	0	Basic
B	Time and control code track upper edge	0.450	± 0.050
C	Control track lower edge	0.900	± 0.050
D	Control track upper edge	1.300	± 0.050
E	Program area lower edge	1.716	Derived
F	Program area width	9.940	Derived
G	Cue audio track lower edge	11.950	± 0.050
H	Cue audio track upper edge	12.550	± 0.050
I	Helical track pitch	0.0180	Ref
K0	Video sector 0 length	55.066	Derived
K1	Video sector 1 length	54.993	Derived
L	Helical track total length	115.558	Derived
M	Audio sector length	0.936	Derived
P1	Control track reference pulse to program reference point (see figure 4)	179.606	± 0.050
P2	Cue/time and control code signal, start of code word, to program reference point (see figure 4)	182.995	± 0.100
X1	Location of start of video sector V0	0	± 0.050
X2	Location of start of audio sector A1[1)]	55.344	± 0.050
X3	Location of start of audio sector A2[1)]	56.631	± 0.050
X4	Location of start of audio sector A3[1)]	57.918	± 0.050
X5	Location of start of audio sector A4[1)]	59.205	± 0.050
X6	Location of start of video sector V1[1)]	60.492	± 0.050
Y	Program reference point	1.728	Basic
θ	Track angle	4.9345°	Basic
α_0	Azimuth angle (track 0)	–20.035°	± 0.150°
α_1	Azimuth angle (track 1)	19.965°	± 0.150°

NOTES

1 Measurements shall be made under the conditions specified in 3.1. The measurements shall be corrected to account for actual tape speed (see figures B.1 and B.2).

2 All dimensions are in millimeters.

[1)] Audio channel numbers vary.

4.3 Width fluctuation

Tape width fluctuation shall not exceed 5 µm peak to peak. Measurement of tape width fluctuation shall be taken over a tape length of 900 mm. 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.

4.4 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 (referred to as 11 µm); the second tape thickness shall be 13.0 µm to 14.0 µm (referred to as 14 µm).

4.5 Transmissivity

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

4.6 Offset yield strength

The offset yield strength shall be greater than 9 N for 11-µm tape and 10 N for 14-µm tape. The force required to produce 0.2% elongation of a 1000-mm test sample with a pull rate of 10-mm per minute 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 at the point of intersection of the line and the stress-strain curve.

4.7 Magnetic coating

The magnetic layer of the tape shall consist of a coating of metal particles or equivalent.

4.8 Coating coercivity

The coating coercivity shall be a class 1800 (144000 A/m) with an applied field of 400000 A/m (5000 Oe) as measured by a 50-Hz or 60-Hz B-H meter or vibrating sample magnetometer (VSM).

4.9 Particle orientation

The metal particles shall be longitudinally oriented.

5 Helical recording

5.1 Tape speed

The tape speed shall be 167.228 mm/s. The tolerance shall be ± 0.2%.

5.2 Record location and dimensions

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

5.2.2 Record location and dimensions for continuous recording shall be as specified in figures 3 and 4 and tables 1 (525/60 system) and 2 (625/50 system). In recording, sector locations on each helical track shall be contained within the tolerance specified in figure 3 and tables 1 (525/60 system) and 2 (625/50 system).

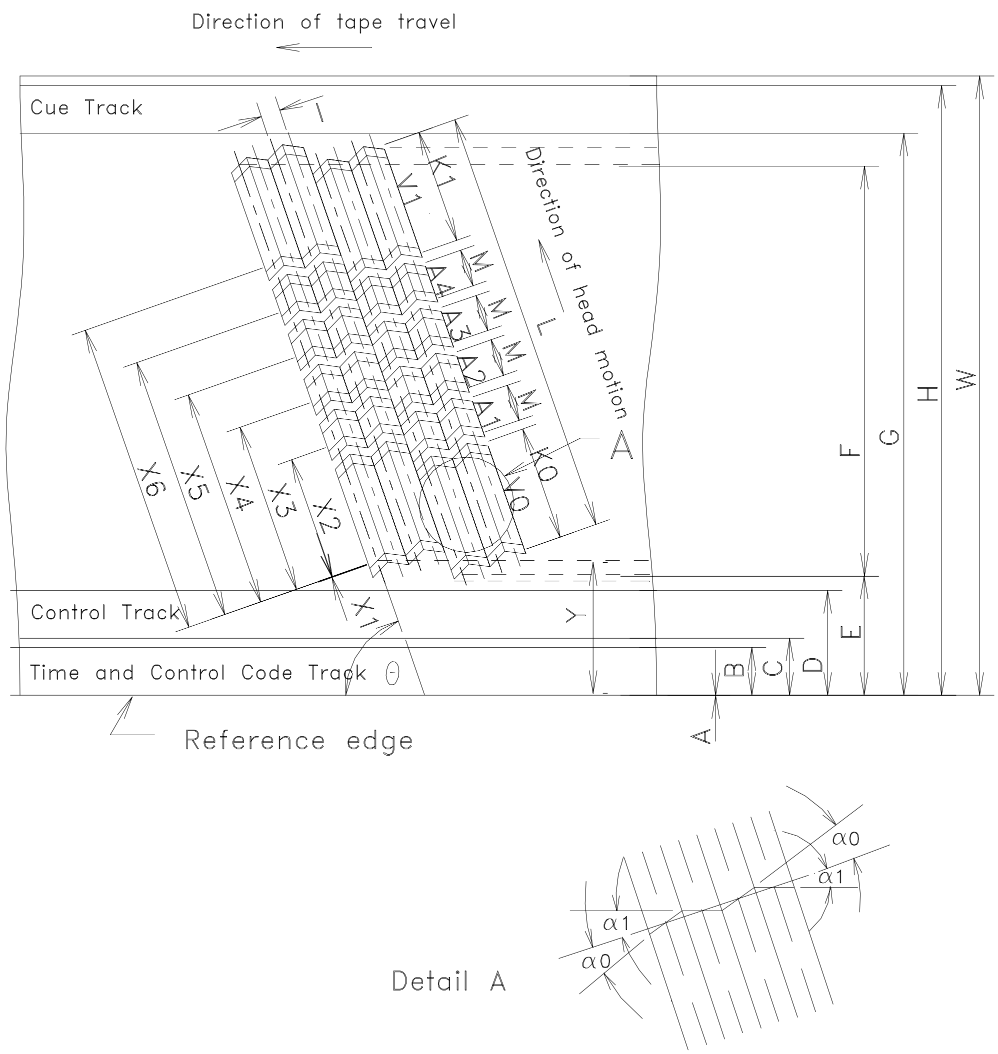
5.2.3 The reference edge of the tape for record location dimensions specified in this standard shall be the lower edge as shown in figure 3. The magnetic coating, with the direction of tape travel as shown in figure 3, is on the side facing the observer (measuring techniques are shown in annex B).

5.2.4 As indicated in figure 3, 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).

5.2.5 In insert editing, this standard provides a guard band of 2 mm (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.

5.3 Helical track record tolerance zones

The lower edges of any eight consecutive tracks starting at the first track in each video frame shall be contained within the pattern of the eight tolerance zones established in figure 5. Each zone is defined by two parallel lines which are inclined with respect to the tape reference edge at an angle of 4.9384° basic (525/60 system) or 4.9345° basic (625/50 system).



NOTES
1 A1, A2, A3 and A4 are audio sectors.
2 V0 and V1 are video sectors.
3 Tape viewed from magnetic coating side.
4 Dimension X1 to X6 are determined by the program reference point as defined in figure 4.

NOTES

1 A1, A2, A3, and A4 are audio sectors.
2 V0 and V1 are video sectors.
3 The tape is viewed from the magnetic coating side.
4 Dimensions X1 to X6 are determined by the program reference point as defined in figure 4.

Figure 3 – Location and dimensions of recorded tracks

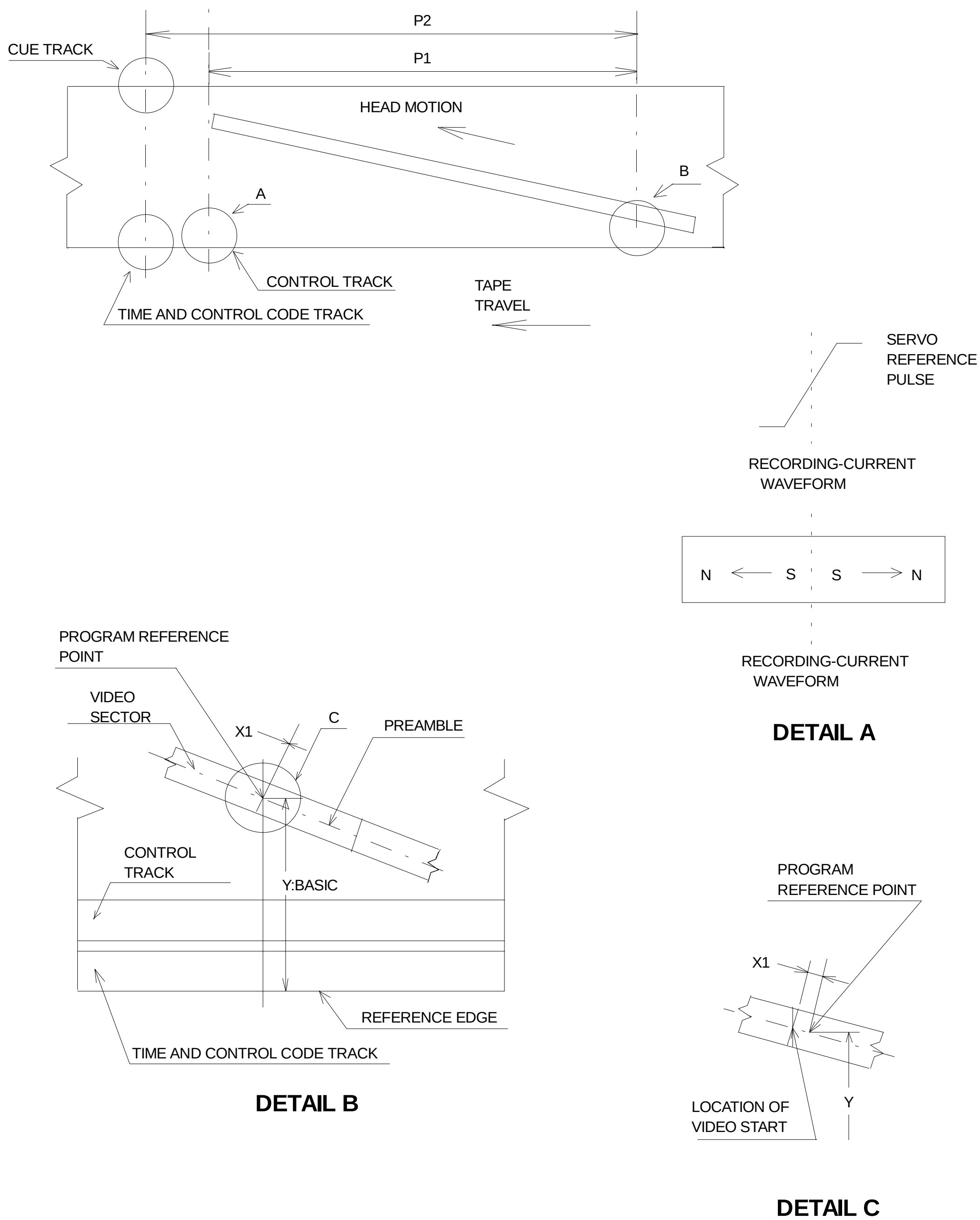
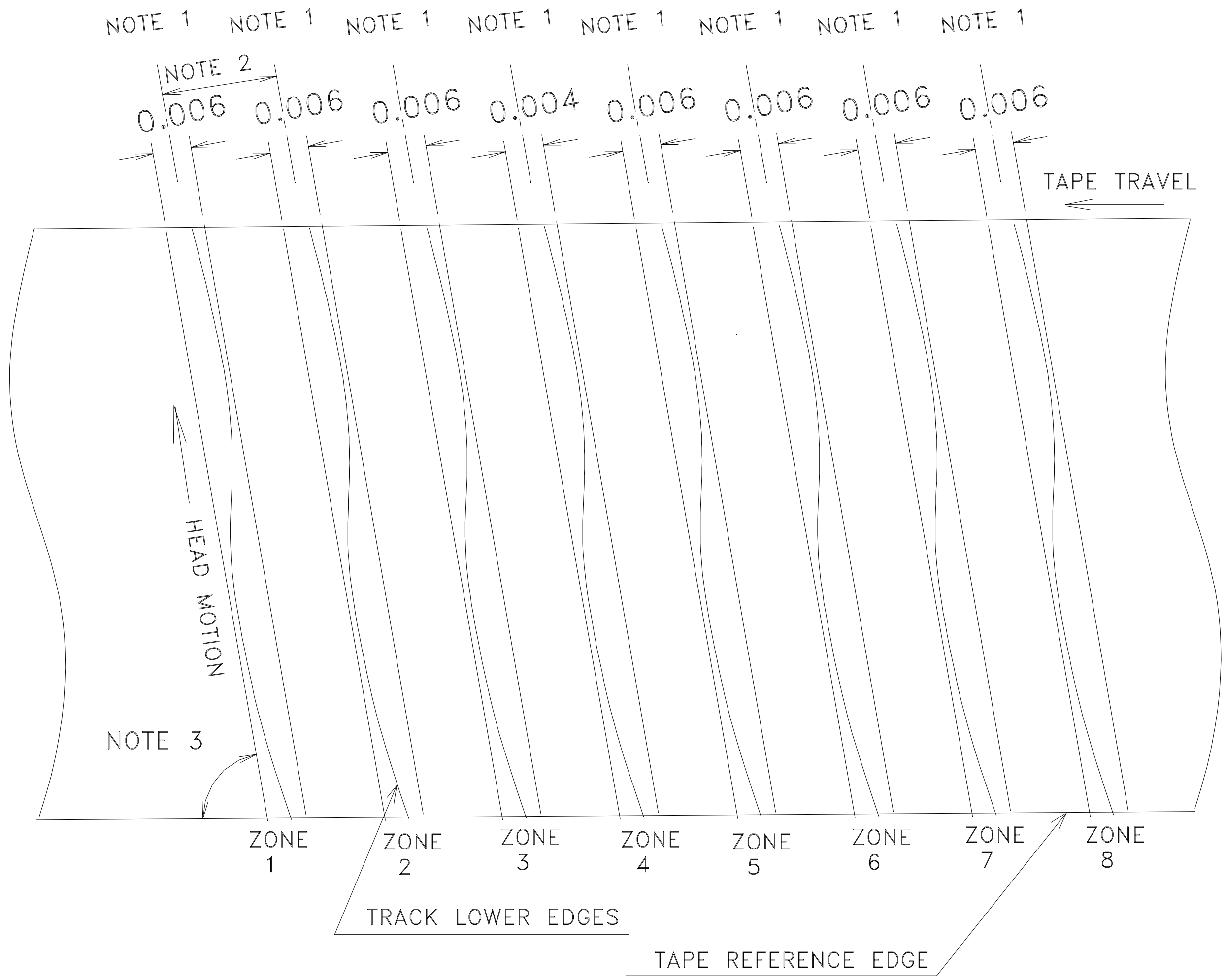


Figure 4 – Location of cue and time and control code track record



NOTES

1 Tolerance zone centerlines.
2 0.0200 (525/60 system); 0.0180 (625/50 system).
3 4.9384° (525/60 system); 4.9345° (625/50 system).
4 All dimensions are in millimeters.

Figure 5 – Location and dimensions of tolerance zones of helical track record

The centerlines of all zones shall be spaced apart 0.0200 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 (measuring technique is shown in annex B).

5.4 Relative positions of recorded information

5.4.1 Relative positions of longitudinal tracks

Audio, video, control track, time and control code, and cue track with information intended to be time coincident shall be positioned as shown in figures 3 and 4.

5.4.2 Program area reference point

The program 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 centerline of the first track in each video field (segment 0, track 0). (See figures 3 and 4.)

The end of the preamble and start of the video sector are located at the program area reference point, and the tolerance is dimension X1. The locations are shown in figures 3 and 4; dimensions X1 and Y are in tables 1 and 2. The relationship between sectors and contents of each sector are specified in clause 6.

5.5 Gap azimuth

5.5.1 Cue track, control track and time 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.

5.5.2 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 tables 1 and 2, 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 a line perpendicular to the helical track direction when viewed from the side of the tape containing the magnetic record.

5.6 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.

One 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 are recorded by two groups of four heads mounted 180° apart. Figures 6 (525/60 system) and 7 (625/50 system) show one possible mechanical configuration of the scanner, and table 3 shows the corresponding mechanical parameters. Figures 8 (525/60 system) and 9 (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 described in 5.2.1 and figures 6 and 7.

6 Program track data

6.1 Introduction

Each television 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 four audio channels. Each track contains a video sector followed by four audio sectors corresponding to four audio channels and followed by a second video sector, recorded in that order. An edit gap between sectors accommodates timing errors during editing. Figure 10 shows the arrangement of video and audio sectors on the tape.

6.2 Labeling convention

The least significant bit is written on the left and first recorded to tape.

The lowest numbered byte is shown at the left/top and is the first encountered in the input data stream.

Byte values are expressed in hexadecimal notation unless otherwise noted. An h subscript indicates a hexadecimal value.

6.3 Sector details

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.

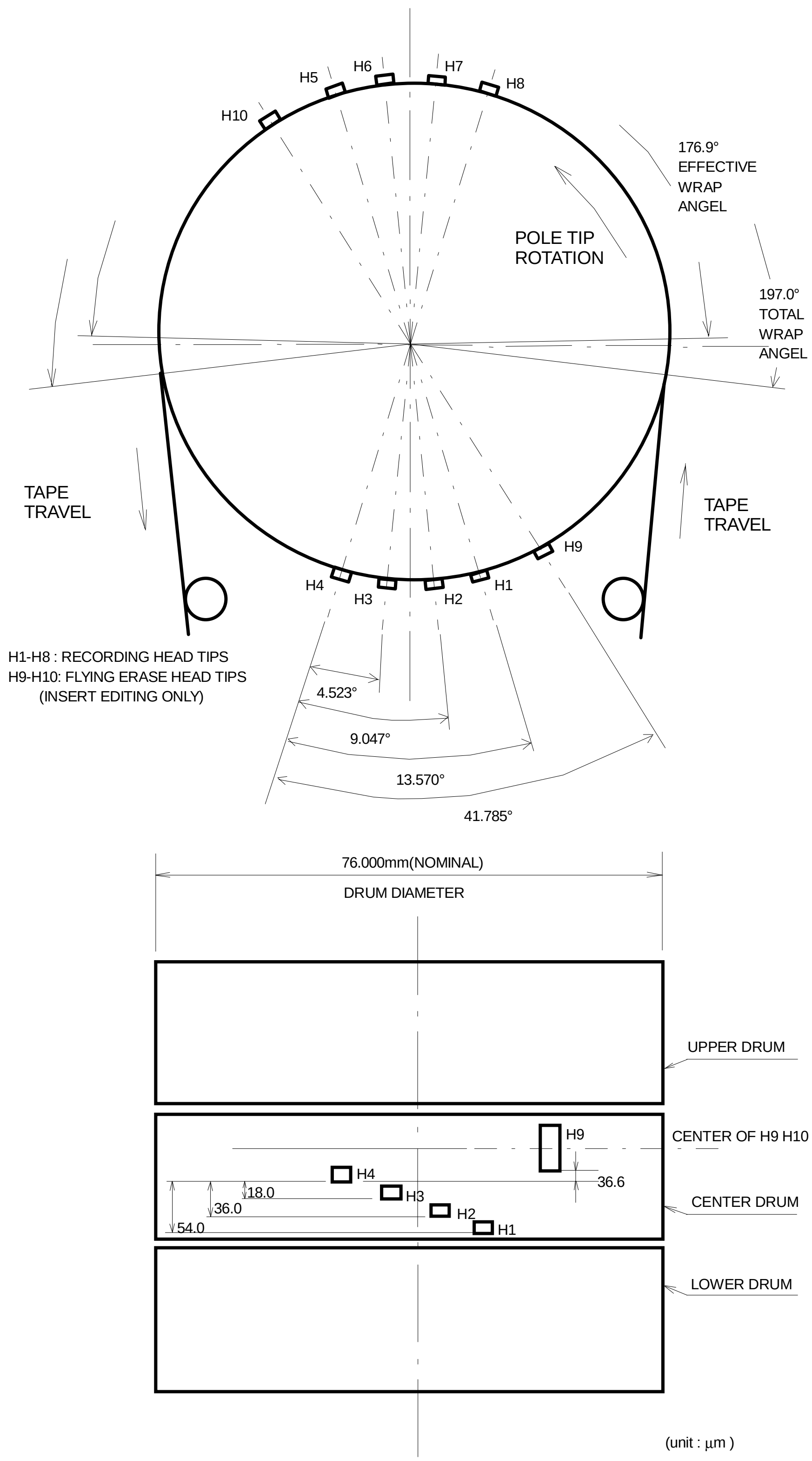


Figure 6 – A possible scanner configuration (525/60 system)

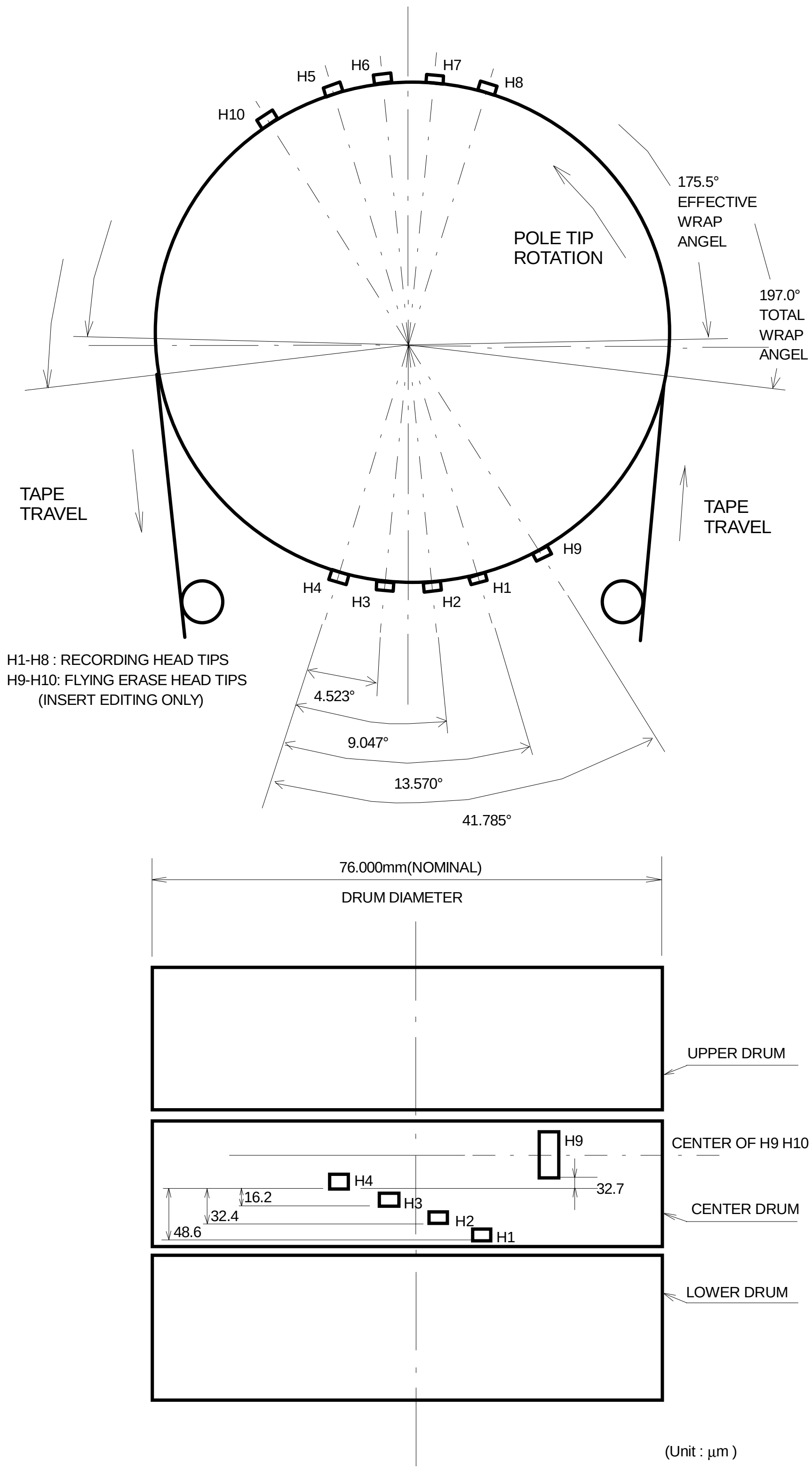
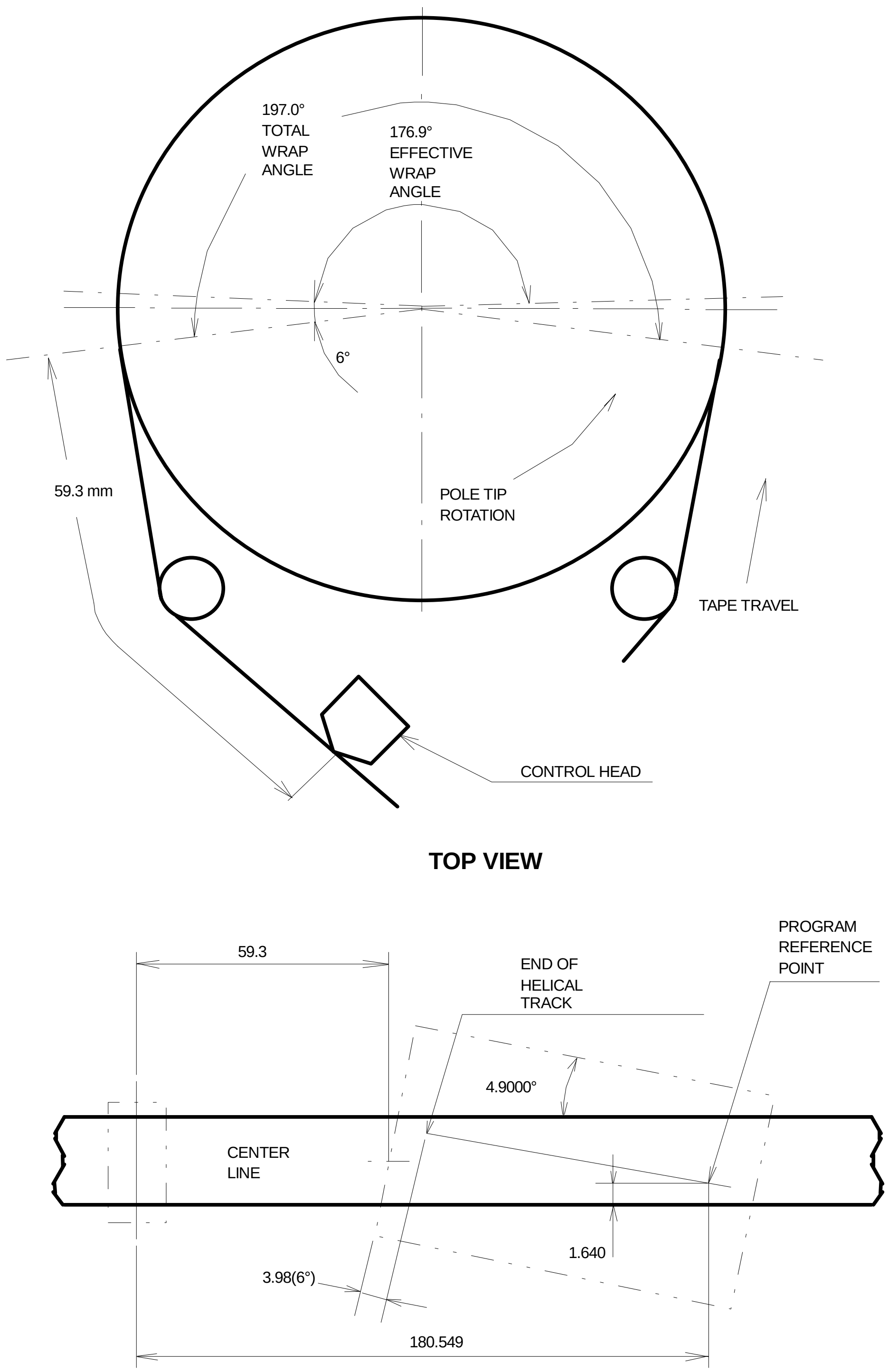
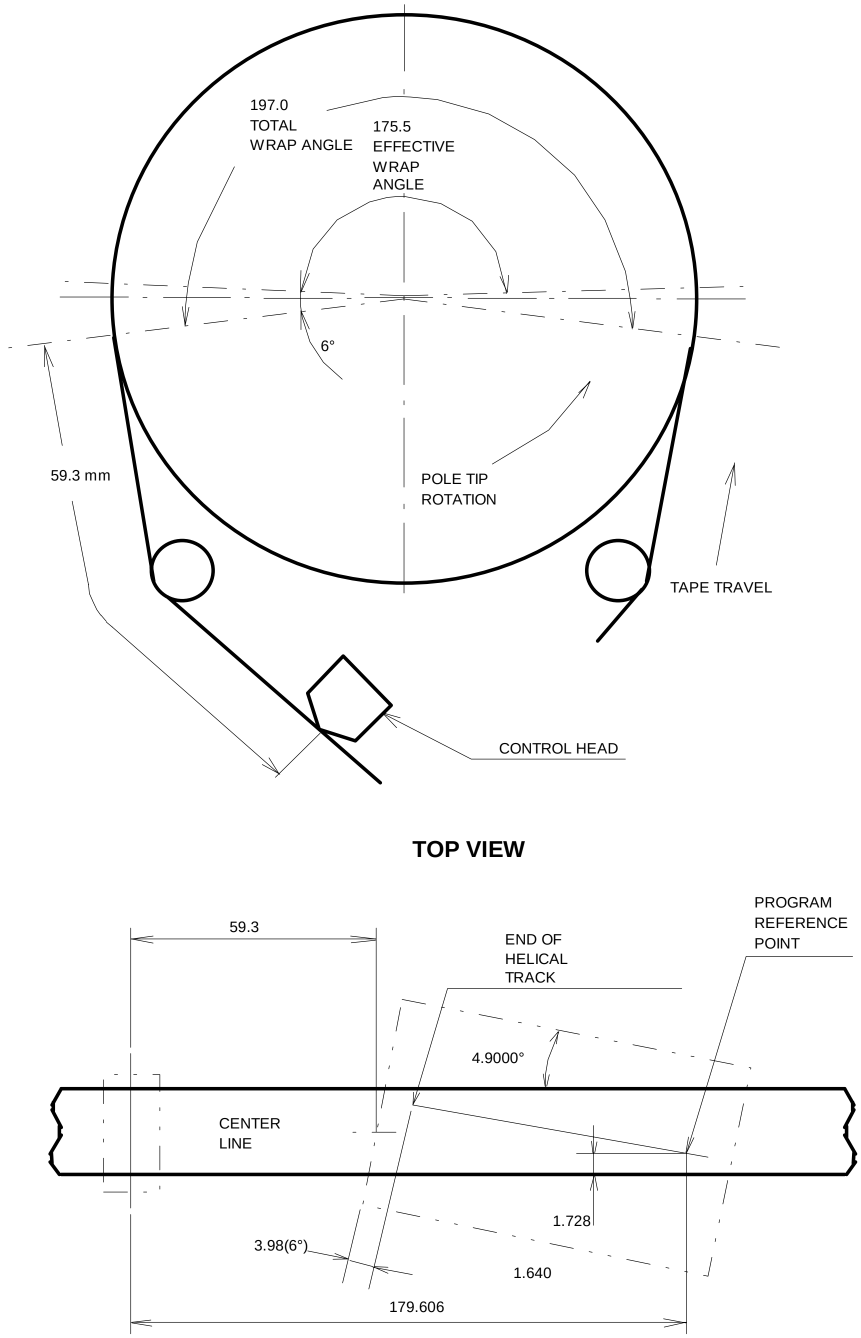


Figure 7 – A possible scanner configuration (625/50 system)



NOTE – Unwrapped; viewed magnetic coating side.

Figure 8 – A possible longitudinal head location and tape wrap (525/60 system)



NOTE - Unwrapped, viewed magnetic coating side.

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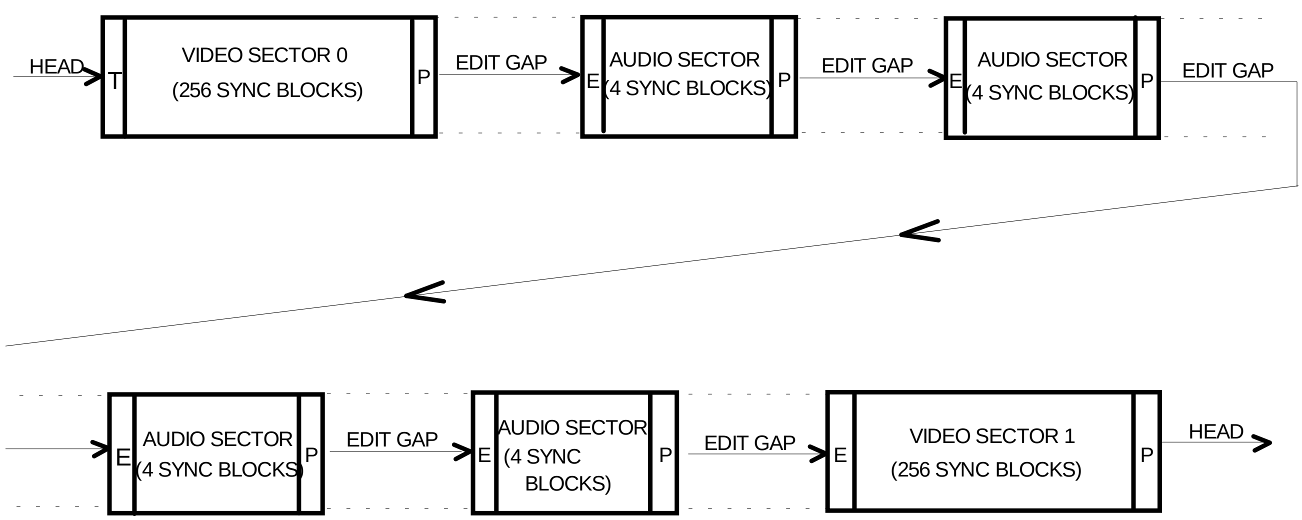
NOTE – Unwrapped; viewed magnetic coating side.

Figure 9 – A possible longitudinal head location and tape wrap (625/50 system)

Table 3 – Parameters for a possible scanner design

Parameters		525/60 system	625/50 system
Scanner rotation speed (rps)		90/1.001	100
Number of tracks per rotation		8	
Drum diameter (mm)		76.000	
Center span tension (N)		0.31	
Helix angle (degrees)		4.9000	
Effective wrap angle (degrees)		176.9	175.5
Scanner circumferential speed (m/s)		21.5	23.9
H1, H3 overwrap head entrance (degrees)		14.1	15.5
H1, H3 overwrap head exit (degrees)		6	
Angular relationship (degrees)	H1 – H4:	13.570	
	H2 – H4:	9.047	
	H3 – H4:	4.523	
	H5 – H8:	13.570	
	H6 – H8:	9.047	
	H7 – H8:	4.523	
	H4 – H8:	180.000	
Vertical displacement (mm)	H1 – H4:	0.054	0.0486
	H2 – H4:	0.036	0.0324
	H3 – H4:	0.018	0.0162
	H5 – H8:	0.054	0.0486
	H6 – H8:	0.036	0.0234
	H7 – H8:	0.018	0.0162
Maximum tip projection (μm)		42.0	
Record head track width (μm)		20	18



NOTES
1 T = track preamble (58 bytes).
2 E = in-track preamble.
3 P = postamble (4 bytes).
4 Sync block: 97 bytes (525/60 system); 88 bytes (625/50 system).
5 Edit gap: 162 bytes nominal (525/60 system); 144 bytes nominal (625/50 system).

Figure 10 – Sector arrangement on helical track

6.3.1 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 block contains an identification pattern (2 bytes) and 85 (525/60 system) or 76 (625/50 system) data bytes of video, audio, or outer check bytes followed by 8 inner check bytes.

The inner code block contains the two bytes of the identification pattern together with 85 data bytes (525/60 system) or 76 data bytes (625/50 system). Figures 11 (525/60 system) and 12 (625/50 system) show the sync block format.

6.3.2 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.

6.3.3 Identification pattern

As illustrated in figures 13 (525/60 system) and 14 (625/50 system), the first two bytes of each inner block are used for identificaton of sync block, television field, segment (group of helical tracks scanned simultaneously), sector (portion of a track), and helical track. Bits 1 to 6 of the second byte (byte 3 of sync block) of the identification pattern identify the track. Bit 7 of the second byte (byte 3) identifies a sector on the helical track (see figures 15 and 16).

a) Length: 16 bits (2 bytes).

b) Arrangement: The sync block number (byte 2 and bit 0 of byte 3) follows a coded sequence along the track. Figure 17 shows the sequence of the sync block numbers.

The sector ID (bits 1-7 of 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 (VF_2 = 0 in byte 3). The field count for audio sectors is modulo 4 (for AF_0 and AF_1 in byte 3) and AF_2 (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 (AF_2 = 0).

c) Video field identification: The field address VF_0, VF_1, VF_2 (bits 4, 5, and 6 of byte 3) for video sync blocks shall identify the field sequence as shown below. In the case of composite signal input, the field address shall identify the four-field color sequences (525/60 system) or eight-field color sequences (625/50 system), as defined in ITU-R BT.470-6 and have the values as shown below:

525/60 system:

Component signal input	Composite signal input	VF_0	VF_1	VF_2
Field 1	Color frame A, field I	0	0	0
Field 2	Color frame A, field II	1	0	0
Field 1	Color frame B, field III	0	1	0
Field 2	Color frame B, field IV	1	1	0

NOTE – Composite recording requires detection of a color field sequence while for component recording this is not required. If a component recorder (as for example D-5) in its implementation allows a recording of composite signals as well, it is necessary to detect and maintain proper color field sequence during editing sessions. Such a relationship between odd/even fields of a component recording and color fields of a composite recording therefore must be defined as shown in 6.3.3.

625/50 system:

Component signal input	Composite signal input	VF_0	VF1	VF_2
Field 1	Color field I	0	0	0
Field 2	Color field II	1	0	0
Field 1	Color field III	0	1	0
Field 2	Color field IV	1	1	0
Field 1	Color field V	0	0	1
Field 2	Color field VI	1	0	1
Field 1	Color field VII	0	1	1
Field 2	Color field VIII	1	1	1

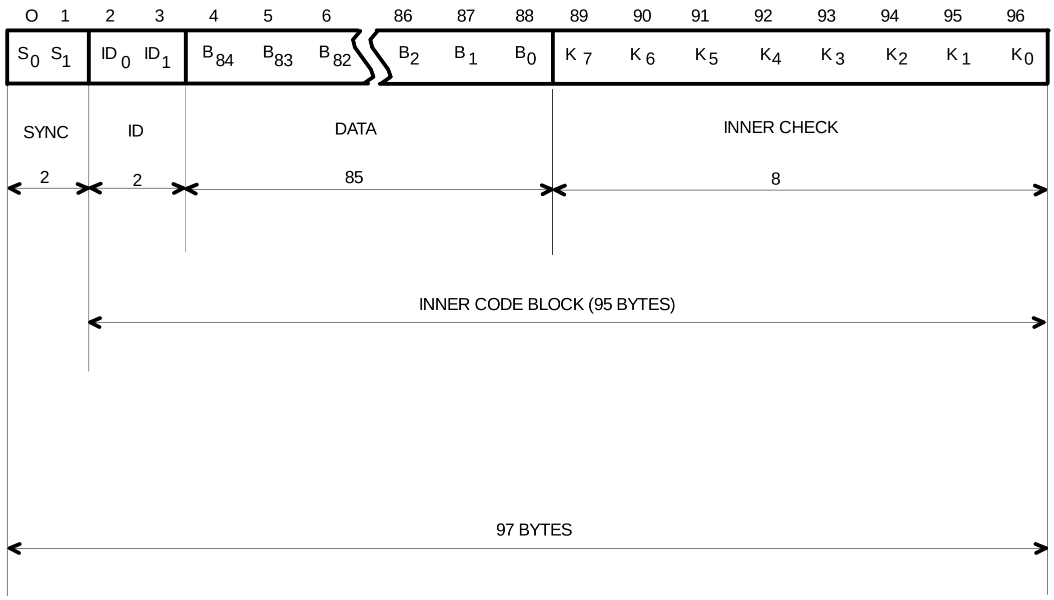


Figure 11 – Sync block format (525/60 system)

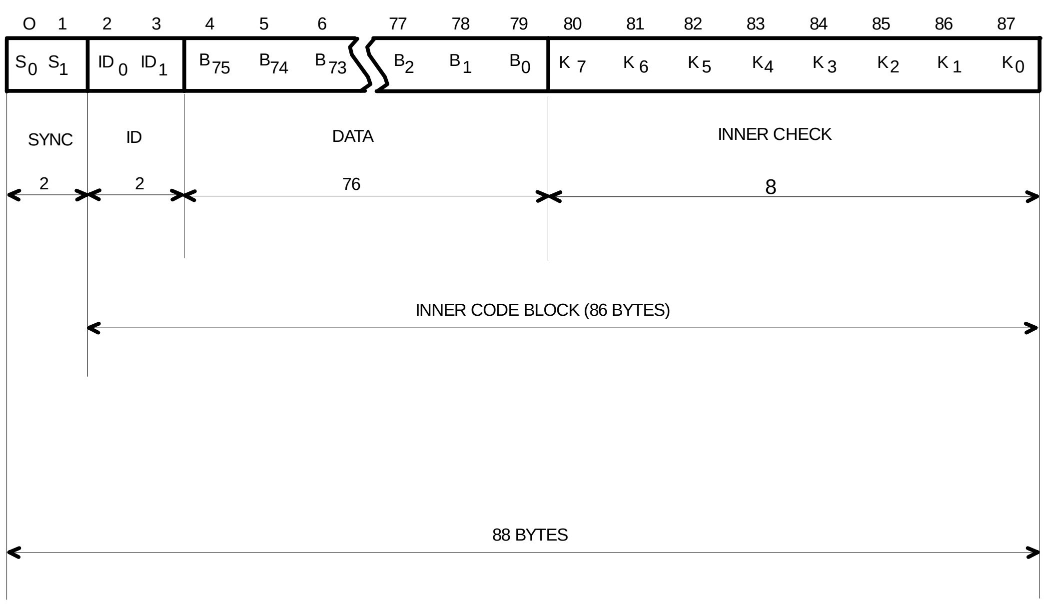
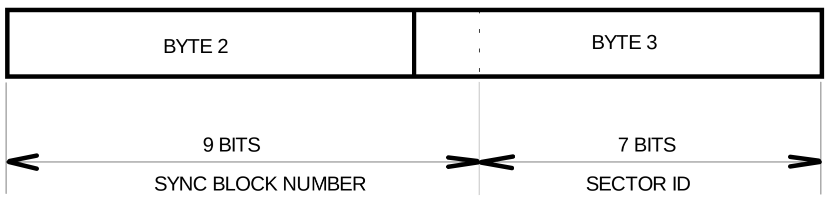
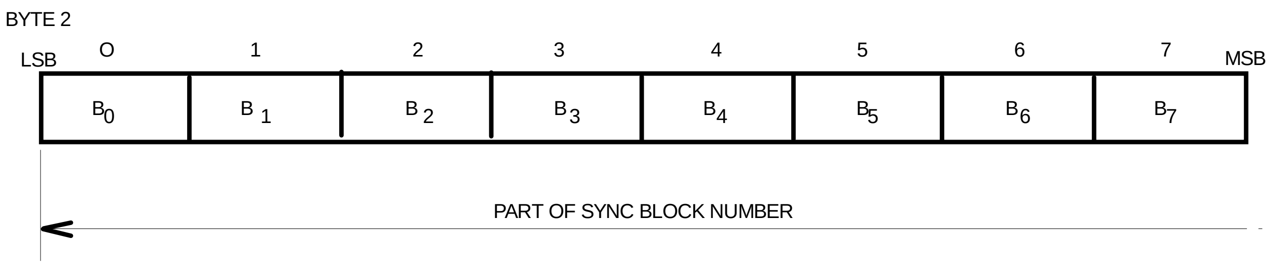


Figure 12 – Sync block format (625/50 system)

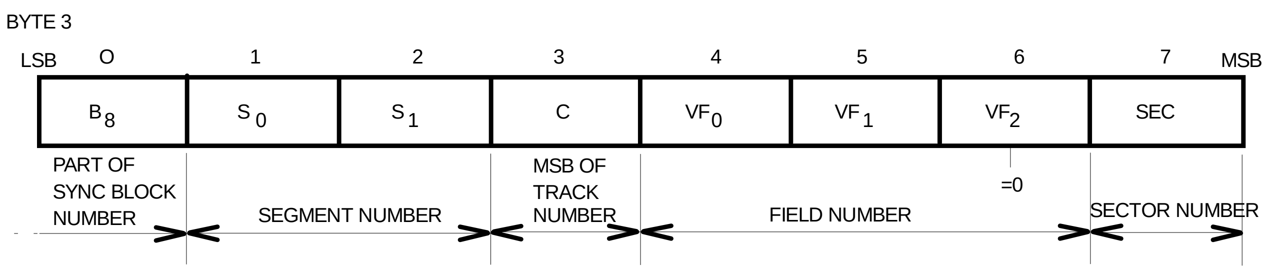
ARRANGEMENT



SYNC BLOCK NUMBER



SECTOR ID FOR VIDEO SYNC BLOCKS



SECTOR ID FOR AUDIO SYNC BLOCKS

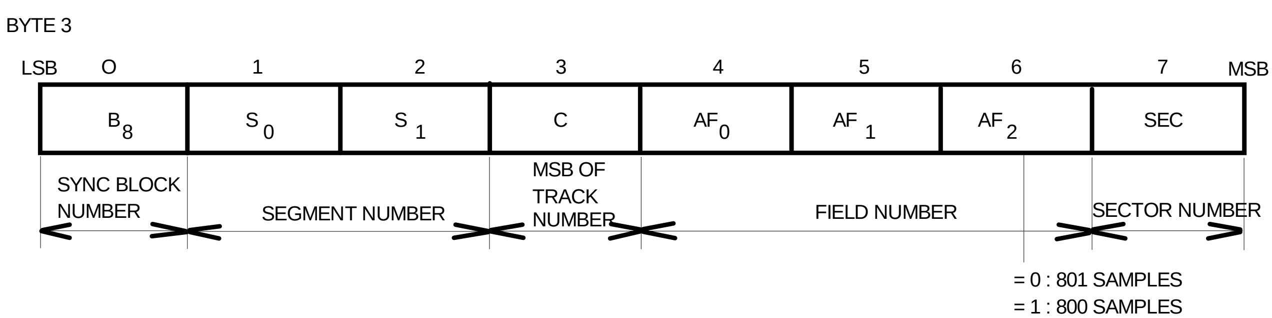
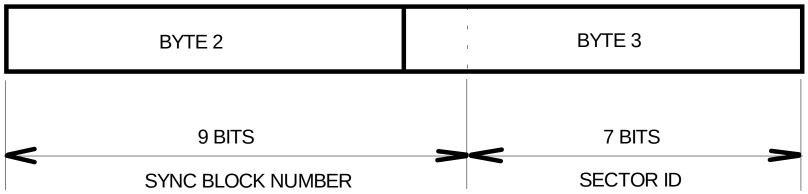


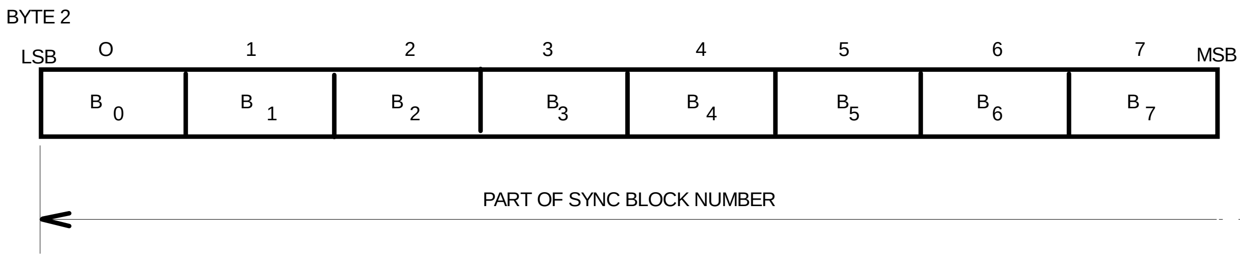
Figure 13 - Sync block identification format. (525/60 system)

Figure 13 – Sync block identification format (525/60 system)

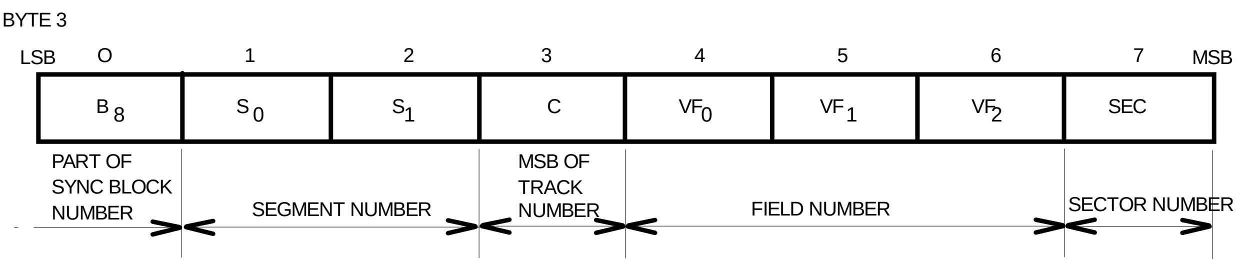
ARRANGEMENT



SYNC BLOCK NUMBER



SECTOR ID FOR VIDEO SYNC BLOCKS



SECTOR ID FOR AUDIO SYNC BLOCKS

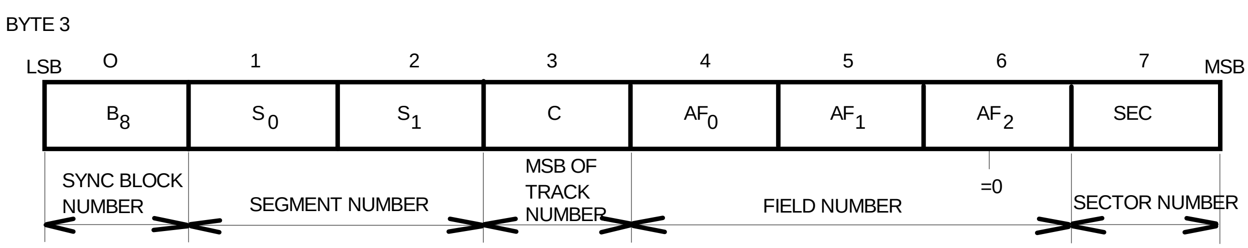
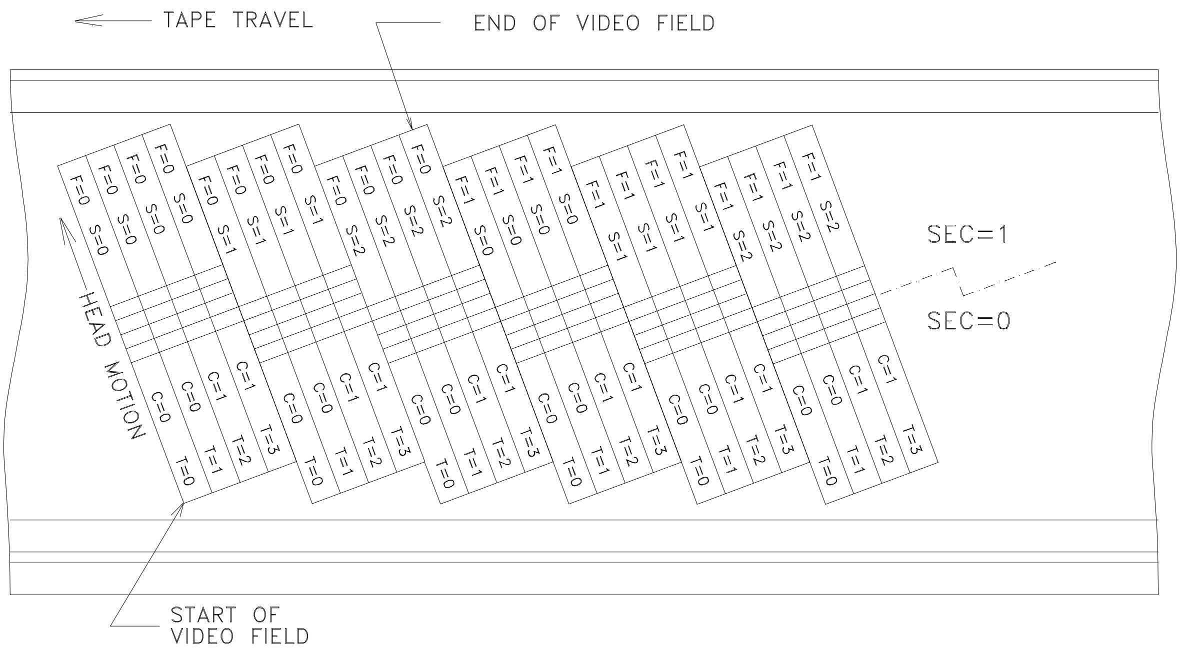


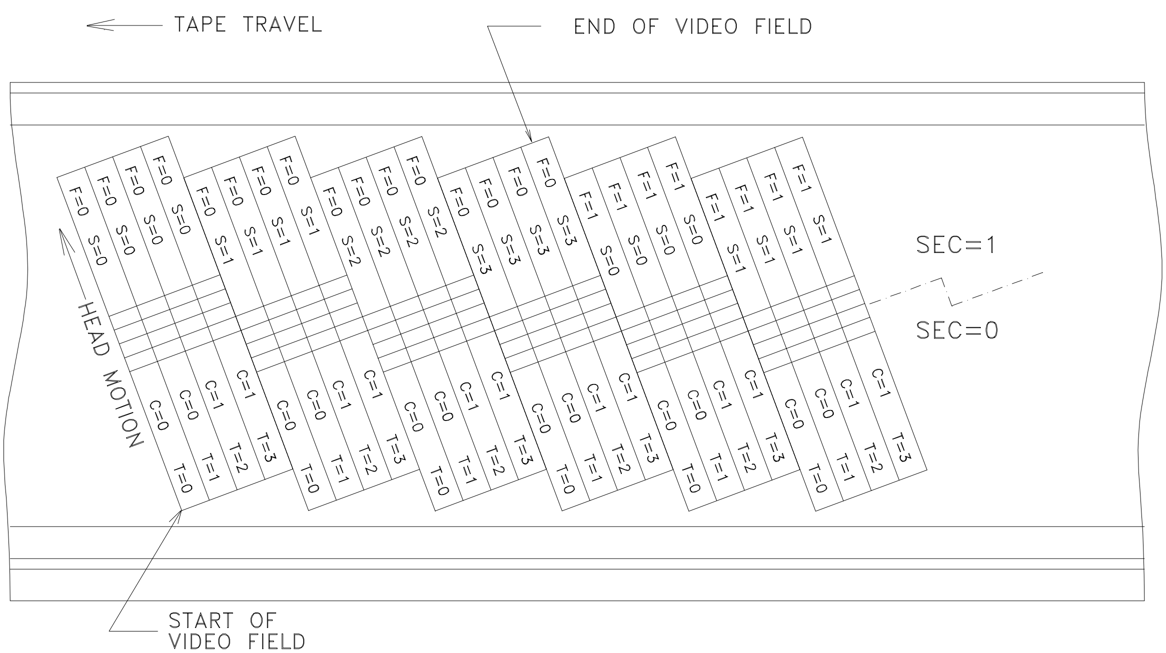
Figure 14 - Sync block identification format. (625/50 system)

Figure 14 – Sync block identification format (625/50 system)



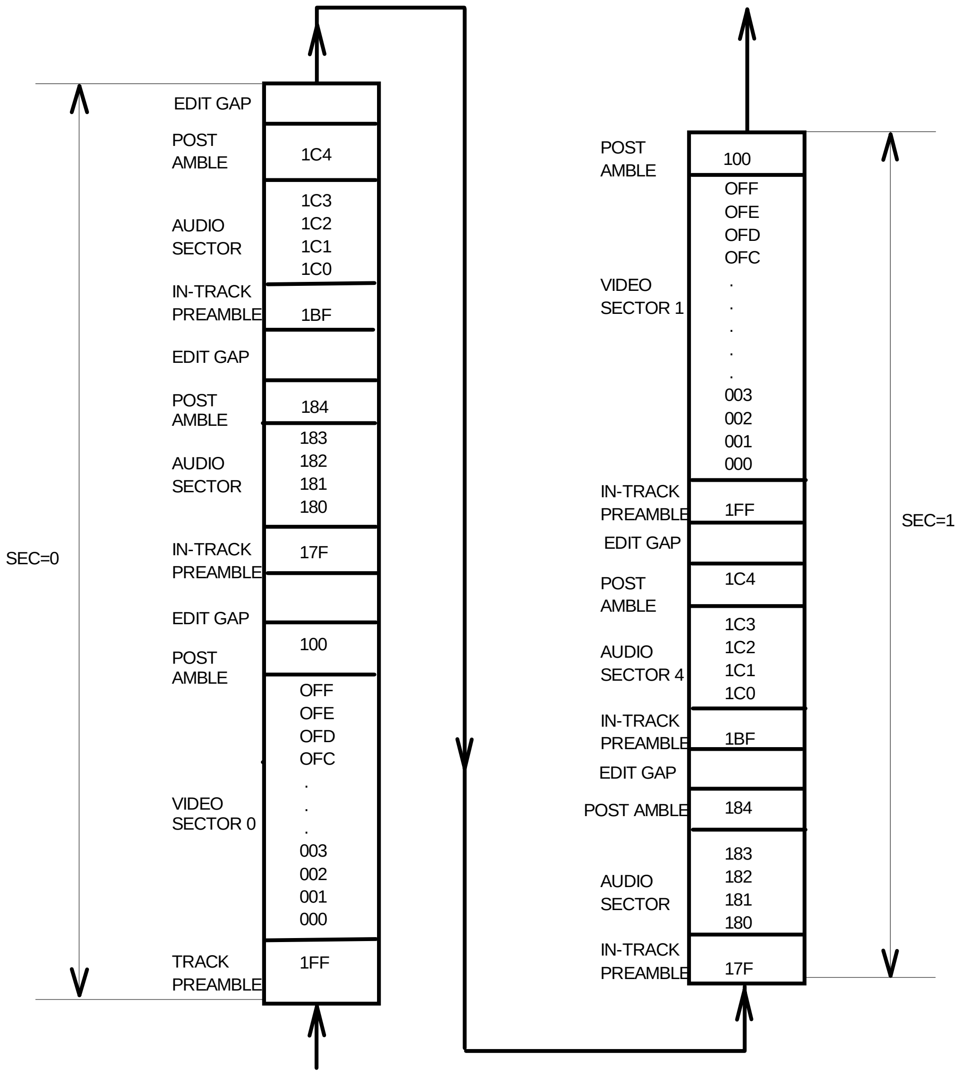
NOTES
1 F = field number (0, 1, 2, 3).
2 S = segment number (0, 1, 2).
3 SEC = sector number; C = MSB of track number (0, 1).
4 T = track number (0, 1, 2, 3). The LSB of the track number is identified by the azimuth angle.
5 Audio sectors are not shown.

Figure 15 – Track, segment and field numbers (525/60 system)



NOTES
1 F = field number (0, 1, 2, 3, . . . 7).
2 S = segment number (0, 1, 2, 3).
3 SEC = sector number; C = MSB of track number (0, 1).
4 T = track number (0, 1, 2, 3). The LSB of the track number is identified by the azimuth angle.
5 Audio sectors are not shown.

Figure 16 – Track, segment and field numbers (625/50 system)



NOTE – Sync block number shown in hexadecimal notation.

Figure 17 – Sync block number

d) Audio field identification: The field addresses AF_0 and AF_1 of the audio sync block (bits 4 and 5 of byte 3) shall identify a four-field sequence as shown below. The sequence shall be identical for the 525/60 system and the 625/50 system. When audio sectors are edited, the four-field sequence shall be maintained.

Field	AF_0	AF_1
m	0	0
m+1	0	1
m+2	1	0
m+3	1	1

For the 525/60 system, the field address AF_2 of the audio sync block (bit 6 of byte 3) shall identify a five-field sequence for the number of audio samples in the current field as shown below. When audio sectors are edited, the five-field sequence shall be maintained (see 10.3.6 d)). For the 625/50 system, the field address AF_2 of the audio sync block (bit 6 of byte 3) shall be set always to 0.

	525/60 system		625/50 system	
Field	AF_2	Number of audio samples	AF_2	Number of audio samples
n	0	801	0	960
n+1	0	801	0	960
n+2	0	801	0	960
n+3	0	801	0	960
n+4	1	800	0	960

e) Protection: The identification pattern is protected by an inner code block.

f) 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 the 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 15_h (525/60 system) or $0C_h$ (625/50 system) at the first byte of the identification pattern and continues to cycle until the end of the sync block.

6.3.4 Data field

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

a) Length: 1 inner code block. For the 525/60 system, the inner code block contains 95 bytes consisting of two 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 two identification pattern bytes, 76 data bytes (outer ECC check bytes are considered data), plus 8 inner ECC check bytes.

b) Arrangement: See figures 11 and 12.

c) Interleaving: None.

d) Protection: Inner ECC code.

Type: Reed-Solomon.

Galois field: GF(256).

Field generator polynomial: $x^8 + x^4 + x^3 + x^2 + 1$, where x^i are place-keeping variables in GF(2), the binary field.

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

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 02_h 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

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

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

Polynomial of full code:

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

$ID_0x^{85} + ID_1x^{84} + B_{75}x^{83} + B_{72}x^{82} + ... + B_1x^9 + B_0x^8 + K_7x^7 + K_6x^6 + ... + K_2x^2 + K_1x + K_0$ (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 6.3.3 f).

6.3.5 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 the run-up sequence, shall be recorded.

6.3.5.1 Track preamble (T)

The track preamble precedes the first sector of every track. The total length of the track preamble is 58 bytes and contains 50 bytes of run-up pattern $2C_h$ which is followed by two bytes of sync pattern, two bytes of identification pattern, and four bytes of fill pattern 00_h.

LSB							MSB
0	0	1	1	0	1	0	0

a) Arrangement: See figure 18 (a).

b) Total length: 58 bytes.

c) Run-up pattern: $2C_h$.

d) Sync pattern: See 6.3.2.

e) Identification pattern: See 6.3.3.

f) Fill pattern: 00_h.

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 6.3.3 f).

6.3.5.2 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 $2C_h$ followed by two bytes of sync pattern, two bytes of identification pattern, and four bytes of fill pattern 00_h.

a) Arrangement: See figure 18 (b).

b) Total length: 28 bytes.

c) Run-up pattern: $2C_h$.

LSB							MSB
0	0	1	1	0	1	0	0

d) Sync pattern: See 6.3.2.

e) Identification pattern: Refer to figures 13 and 14.

f) Fill pattern: 00_h.

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 6.3.3 f).

6.3.6 Sector postamble (P)

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

a) Arrangement: See figure 18c.

b) Total length: 4 bytes.

c) Sync pattern: See 6.3.2.

d) Identification pattern: See 6.3.3.

e) Protection: None.

f) Randomization: Only the identification pattern is randomized before being channel coded. The randomization is equivalent to randomization as defined in 6.3.3 f).

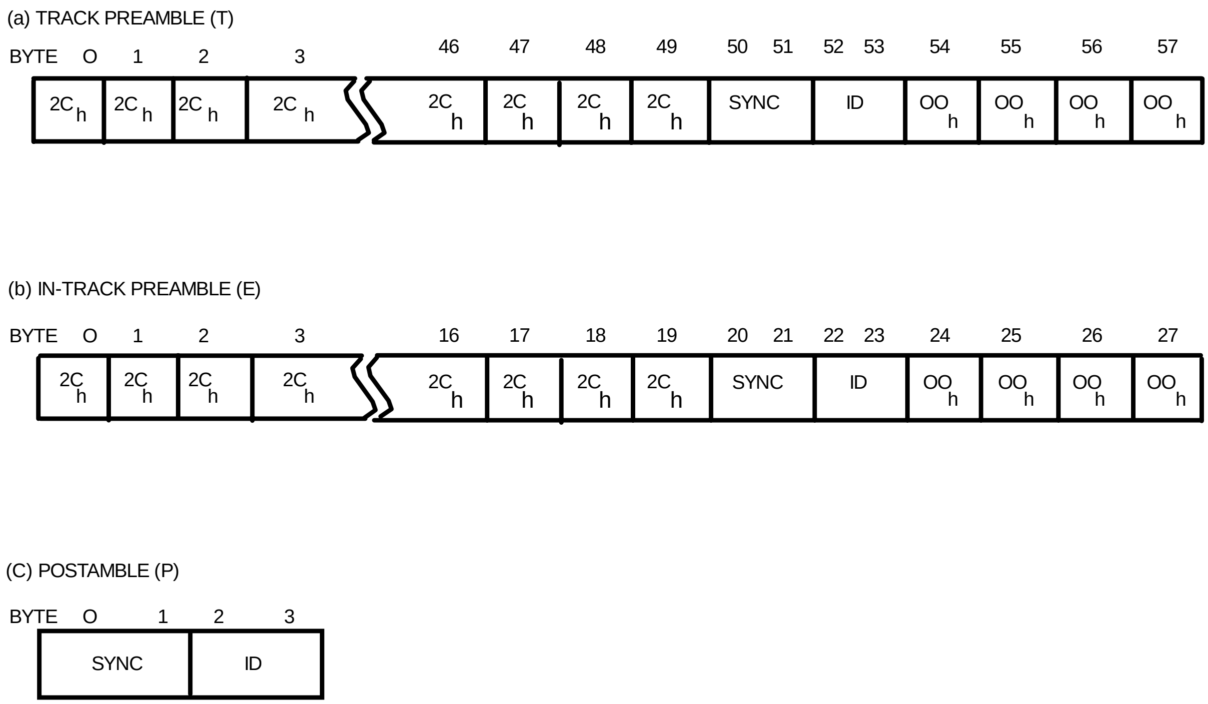


Figure 18 – Sector preamble and postamble

6.4 Edit gaps

The space between the individual sectors of a track, exclusive of preamble and postamble, is nominally 167 bytes long in the 525/60 system and 144 bytes long in the 625/50 system.

The edit gap 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 overwritten with the $2C_h$ code provided that the preamble and/or postamble of the adjacent unedited track sectors are not overwritten.

a) Protection: None.

b) Randomization: None.

6.5 Channel code

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

NOTES

1 DSV is an acronym 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.

2 CDS is an acronym for codeword digital sum and indicates the DSV of one symbol modulation code.

3 Eight-bit data entries in tables 4 and 5 are in hexadecimal notation.

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

1) Select a 14-bit code satisfying the following conditions of (A) and (B) from tables 4 and 5:

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 (called end DSV hereafter) 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 still chosen in step (2), select a 14-bit code by calculating the DSV for each bit of the code (called bit DSV hereafter), 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 further 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 still 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 in 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 number of 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 further found at step (6), the following two steps shall be taken:

a) When the end DSV of the code is –2, select a code of higher priority (corresponding to a smaller number in table 6) according to table 6. Likewise, when the end DSV of the code is +2, select a code of higher priority (corresponding to a smaller number in table 7) according to table 7.

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 except when 111111 or 000000 are in the code.

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 still 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 reversed earliest after the joint portion with the preceding code.

The recorded data rate (for the scanner configuration defined in 5.6) and shortest recorded wavelength are given in table 8, provided for reference only.

6.6 Magnetization

6.6.1 Polarity

Reproduction of the tape record shall be without regard to the polarity of the recorded flux on the helical tracks.

6.6.2 Recorded equalization

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

6.6.3 Record level

The level of the record head current applied to a head with a gap 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.

Table 4 – 4-18 modulation (CDS≥0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
1(A)	00	01111110000001	0	1(B)	00	10000001111110	0
	01	01111100110000	0		01	10000011001111	0
	02	01111100011000	0		02	10000011100111	0
	03	01111100001100	0		03	10000011110011	0
	04	01111100000110	0		04	10000011111001	0
	05	01111100000011	0		05	10000011111100	0
	06	01111001110000	0		06	10000110001111	0
	07	01111001100001	0		07	10000110011110	0
	08	01111000111000	0		08	10000111000111	0
	09	01111000110001	0		09	10000111001110	0
	0A	01111000011100	0		0A	10000111100011	0
	0B	01111000011001	0		0B	10000111100110	0
	0C	01111000001110	0		0C	10000111110001	0
	0D	01111000000111	0		0D	10000111111000	0
	0E	01110011110000	0		0E	10001100001111	0
	0F	01110011100001	0		0F	10001100011110	0
	10	01110011001100	0		10	10001100110011	0
	11	01110011000110	0		11	10001100111001	0
	12	01110011000011	0		12	10001100111100	0
	13	01110001111000	0		13	10001110000111	0
	14	01110001110001	0		14	10001110001110	0
	15	01110001100110	0		15	10001110011001	0
	16	01110001100011	0		16	10001110011100	0
	17	01110000111100	0		17	10001111000011	0
	18	01110000111001	0		18	10001111000110	0
	19	01110000110011	0		19	10001111001100	0
	1A	01110000011110	0		1A	10001111100001	0
	1B	01110000001111	0		1B	10001111110000	0
	1C	01100111110000	0		1C	10011000001111	0
	1D	01100111100001	0		1D	10011000011110	0
	1E	01100111001100	0		1E	10011000110011	0
	1F	01100111000110	0		1F	10011000111001	0
	20	01100111000011	0		20	10011000111100	0
	21	01100110011100	0		21	10011001100011	0
	22	01100110011001	0		22	10011001100110	0
	23	01100110001110	0		23	10011001110001	0
	24	01100110000111	0		24	10011001111000	0
	25	01100011111000	0		25	10011100000111	0
	26	01100011110001	0		26	10011100001110	0
	27	01100011100110	0		27	10011100011001	0
	28	01100011100011	0		28	10011100011100	0
	29	01100011001110	0		29	10011100110001	0
	2A	01100011000111	0		2A	10011100111000	0
	2B	01100001111100	0		2B	10011110000011	0
	2C	01100001111001	0		2C	10011110000110	0
	2D	01100001110011	0		2D	10011110001100	0
	2E	01100001100111	0		2E	10011110011000	0
	2F	01100000111110	0		2F	10011111000001	0
	30	01100000011111	0		30	10011111100000	0
	31	01111111001100	4		31	10000011111110	2
	32	01111111000110	4		32	10000110011111	2
	33	01111111000011	4		33	10000111001111	2
	34	01111110011100	4		34	10000111100111	2
	35	01111110011001	4		35	10000111110011	2
	36	01111110001110	4		36	10000111111001	2
	37	01111110000111	4		37	10000111111100	2
	38	01111100111100	4		38	10001100011111	2

(continued)

Table 4 (continued)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
	39	01111100111001	4		39	10001100111110	2
	3A	01111100110011	4		3A	10001110001111	2
	3B	01111100011110	4		3B	10001110011110	2
	3C	01111100001111	4		3C	10001111000111	2
	3D	01111001111100	4		3D	10001111001110	2
	3E	01111001111001	4		3E	10001111100011	2
	3F	01111001110011	4		3F	10001111100110	2
	40	01111001100111	4		40	10001111110001	2
	41	01111000111110	4		41	10001111111000	2
	42	01111000011111	4		42	10011000011111	2
	43	01110011111100	4		43	10011000111110	2
	44	01110011111001	4		44	10011001100111	2
	45	01110011110011	4		45	10011001110011	2
	46	01110011100111	4		46	10011001111001	2
	47	01110011001111	4		47	10011001111100	2
	48	01110001111110	4		48	10011100001111	2
	49	01110000111111	4		49	10011100011110	2
	4A	01100111111100	4		4A	10011100110011	2
	4B	01100111111001	4		4B	10011100111001	2
	4C	01100111110011	4	1(B)	4C	10011100111100	2
	4D	01100111100111	4		4D	10011110000111	2
	4E	01100111001111	4		4E	10011110001110	2
	4F	01100110011111	4		4F	10011110011001	2
	50	01100011111110	4		50	10011110011100	2
	51	01111111000001	2		51	10011111000011	2
	52	01111110011000	2		52	10011111000110	2
	53	01111110001100	2		53	10011111001100	2
1(A)	54	01111110000110	2		54	10011111100001	2
	55	01111110000011	2		55	10011111110000	2
	56	01111100111000	2		56	10001111001111	4
	57	01111100110001	2		57	10001111100111	4
	58	01111100011100	2		58	10001111110011	4
	59	01111100011001	2		59	10011001111110	4
	5A	01111100001110	2		5A	10011100111110	4
	5B	01111100000111	2		5B	10011110001111	4
	5C	01111001111000	2		5C	10011110011110	4
	5D	01111001110001	2		5D	10011111000111	4
	5E	01111001100110	2		5E	10011111001110	4
	5F	01111001100011	2		5F	10011111100011	4
	60	01111000111100	2		60	10011111100110	4
	61	01111000111001	2		61	11000111100111	4
	62	01111000110011	2		62	11000111110011	4
	63	01111000011110	2		63	11000000111111	2
	64	01111000001111	2		64	11000001111110	2
	65	01110011111000	2		65	11000011001111	2
	66	01110011110001	2		66	11000011100111	2
	67	01110011100110	2		67	11000011110011	2
	68	01110011100011	2		68	11000011111001	2
	69	01110011001110	2	2(B)	69	11000011111100	2
	6A	01110011000111	2		6A	11000110001111	2
	6B	01110001111100	2		6B	11000110011110	2
	6C	01110001111001	2		6C	11000111000111	2
	6D	01110001110011	2		6D	11000111001110	2
	6E	01110001100111	2		6E	11000111100011	2
	6F	01110000111110	2		6F	11000111100110	2
	70	01110000011111	2		70	11000111110001	2

(continued)

Table 4 (continued)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
1(A)	71	01100111111000	2	2(B)	71	11000111111000	2
	72	01100111110001	2		72	11001100001111	2
	73	01100111100110	2		73	11001100011110	2
	74	01100111100011	2		74	11001100110011	2
	75	01100111001110	2		75	11001100111001	2
	76	01100111000111	2		76	11001100111100	2
	77	01100110011110	2		77	11001110000111	2
	78	01100110001111	2		78	11001110001110	2
	79	01100011111100	2		79	11001110011001	2
	7A	01100011111001	2		7A	11001110011100	2
	7B	01100011110011	2		7B	11001111000011	2
	7C	01100011100111	2		7C	11001111000110	2
	7D	01100011001111	2		7D	11001111001100	2
	7E	01100001111110	2		7E	11001111100001	2
	7F	01100000111111	2		7F	11001111110000	2
2(A)	80	00111111100000	0		80	11000000011111	0
	81	00111111000001	0		81	11000000111110	0
	82	00111110011000	0		82	11000001100111	0
	83	00111110001100	0		83	11000001110011	0
	84	00111110000110	0		84	11000001111001	0
	85	00111110000011	0		85	11000001111100	0
	86	00111100111000	0		86	11000011000111	0
	87	00111100110001	0		87	11000011001110	0
	88	00111100011100	0		88	11000011100011	0
	89	00111100011001	0		89	11000011100110	0
	8A	00111100001110	0		8A	11000011110001	0
	8B	00111100000111	0		8B	11000011111000	0
	8C	00111001111000	0		8C	11000110000111	0
	8D	00111001110001	0		8D	11000110001110	0
	8E	00111001100110	0		8E	11000110011001	0
	8F	00111001100011	0		8F	11000110011100	0
	90	00111000111100	0		90	11000111000011	0
	91	00111000111001	0		91	11000111000110	0
	92	00111000110011	0		92	11000111001100	0
	93	00111000011110	0		93	11000111100001	0
	94	00111000001111	0		94	11000111110000	0
	95	00110011111000	0		95	11001100000111	0
	96	00110011110001	0		96	11001100001110	0
	97	00110011100110	0		97	11001100011001	0
	98	00110011100011	0		98	11001100011100	0
	99	00110011001110	0		99	11001100110001	0
	9A	00110011000111	0		9A	11001100111000	0
	9B	00110001111100	0		9B	11001110000011	0
	9C	00110001111001	0		9C	11001110000110	0
	9D	00110001110011	0		9D	11001110001100	0
	9E	00110001100111	0		9E	11001110011000	0
	9F	00110000111110	0		9F	11001111000001	0
	A0	00110000011111	0		A0	11001111100000	0
	A1	00111111100001	2		A1	11001100111110	4
	A2	00111111001100	2		A2	11001110011110	4
	A3	00111111000110	2		A3	11001111000111	4
	A4	00111111000011	2		A4	11001111001110	4
	A5	00111110011100	2		A5	11001111100011	4
	A6	00111110011001	2		A6	11001111100110	4

(continued)

Table 4 (continued)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
	A7	00111110001110	2		A7	11100001111110	4
	A8	00111110000111	2		A8	11100011100111	4
	A9	00111100111100	2		A9	11100011110011	4
	AA	00111100111001	2		AA	11100011111100	4
	AB	00111100110011	2		AB	11100110011110	4
	AC	00111100011110	2		AC	11100111000111	4
	AD	00111100001111	2		AD	11100111001110	4
	AE	00111001111100	2		AE	11100111100011	4
	AF	00111001111001	2		AF	11100111100110	4
	B0	00111001110011	2		B0	11100111111000	4
	B1	00111001100111	2		B1	11100000011111	2
	B2	00111000111110	2		B2	11100000111110	2
	B3	00111000011111	2		B3	11100001100111	2
	B4	00110011111100	2		B4	11100001110011	2
	B5	00110011111001	2		B5	11100001111001	2
2(A)	B6	00110011110011	2		B6	11100001111100	2
	B7	00110011100111	2		B7	11100011000111	2
	B8	00110011001111	2		B8	11100011001110	2
	B9	00110001111110	2		B9	11100011100011	2
	BA	00110000111111	2		BA	11100011100110	2
	BB	00111111100110	4		BB	11100011110001	2
	BC	00111111100011	4		BC	11100011111000	2
	BD	00111111001110	4		BD	11100110000111	2
	BE	00111111000111	4	3(B)	BE	11100110001110	2
	BF	00111110011110	4		BF	11100110011001	2
	C0	00111110001111	4		C0	11100110011100	2
	C1	00111100111110	4		C1	11100111000011	2
	C2	00111100011111	4		C2	11100111000110	2
	C3	00111001111110	4		C3	11100111001100	2
	C4	00111000111111	4		C4	11100111100001	2
	C5	00110011111110	4		C5	11100111110000	2
	C6	00011111110000	0		C6	11100000001111	0
	C7	00011111100001	0		C7	11100000011110	0
	C8	00011111001100	0		C8	11100000110011	0
	C9	00011111000110	0		C9	11100000111001	0
	CA	00011111000011	0		CA	11100000111100	0
	CB	00011110011100	0		CB	11100001100011	0
	CC	00011110011001	0		CC	11100001100110	0
	CD	00011110001110	0		CD	11100001110001	0
	CE	00011110000111	0		CE	11100001111000	0
	CF	00011100111100	0		CF	11100011000011	0
	D0	00011100111001	0		D0	11100011000110	0
	D1	00011100110011	0		D1	11100011001100	0
	D2	00011100011110	0		D2	11100011100001	0
3(A)	D3	00011100001111	0		D3	11100011110000	0
	D4	00011001111100	0		D4	11100110000011	0
	D5	00011001111001	0		D5	11100110000110	0
	D6	00011001110011	0		D6	11100110001100	0
	D7	00011001100111	0		D7	11100110011000	0
	D8	00011000111110	0		D8	11100111000001	0
	D9	00011000011111	0		D9	11100111100000	0
	DA	00011111110001	2		DA	11110001111100	4
	DB	00011111100110	2	4(B)	DB	11110011111000	4
	DC	00011111100011	2		DC	11110000001111	2
	DD	00011111001110	2		DD	11110000011110	2

(continued)

Table 4 (concluded)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
3(A)	DE	00011111000111	2	4(B)	DE	11110000110011	2
	DF	00011110011110	2		DF	11110000111001	2
	E0	00011110001111	2		E0	11110000111100	2
	E1	00011100111110	2		E1	11110001100011	2
	E2	00011100011111	2		E2	11110001100110	2
	E3	00011001111110	2		E3	11110001110001	2
	E4	00011000111111	2		E4	11110001111000	2
	E5	00011111110011	4		E5	11110011000011	2
	E6	00011111100111	4		E6	11110011000110	2
	E7	00011111001111	4		E7	11110011001100	2
	E8	00011110011111	4		E8	11110011100001	2
	E9	00011100111111	4		E9	11110011110000	2
4(A)	EA	00001111111000	0		EA	11110000000111	0
	EB	00001111110001	0		EB	11110000001110	0
	EC	00001111100110	0		EC	11110000011001	0
	ED	00001111100011	0		ED	11110000011100	0
	EE	00001111001110	0		EE	11110000110001	0
	EF	00001111000111	0		EF	11110000111000	0
	F0	00001110011110	0		F0	11110001100001	0
	F1	00001110001111	0		F1	11110001110000	0
	F2	00001100111110	0		F2	11110011000001	0
	F3	00001100011111	0		F3	11110011100000	0
	F4	00001111111001	2	5(B)	F4	11111000000111	2
	F5	00001111110011	2		F5	11111000001110	2
	F6	00001111100111	2		F6	11111000011001	2
	F7	00001111001111	2		F7	11111000011100	2
	F8	00001110011111	2		F8	11111000110001	2
	F9	00001100111111	2		F9	11111000111000	2
5(A)	FA	00000111111100	0		FA	11111001100001	2
	FB	00000111111001	0		FB	11111001110000	2
	FC	00000111110011	0		FC	11111000001100	0
	FD	00000111100111	0		FD	11111000011000	0
	FE	00000111001111	0		FE	11111000110000	0
	FF	00000110011111	0		FF	11111001100000	0

Table 5 – 8-14 modulation CDS≤0)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
	00	01111110000001	0		00	10000001111110	0
	01	01111100110000	0		01	10000011001111	0
	02	01111100011000	0		02	10000011100111	0
	03	01111100001100	0		03	10000011110011	0
	04	01111100000110	0		04	10000011111001	0
	05	01111100000011	0		05	10000011111100	0
	06	01111001110000	0		06	10000110001111	0
	07	01111001100001	0		07	10000110011110	0
	08	01111000111000	0		08	10000111000111	0
	09	01111000110001	0		09	10000111001110	0
	0A	01111000011100	0		0A	10000111100011	0
	0B	01111000011001	0		0B	10000111100110	0
	0C	01111000001110	0		0C	10000111110001	0
	0D	01111000000111	0		0D	10000111111000	0
	0E	01110011110000	0		0E	10001100001111	0
	0F	01110011100001	0		0F	10001100011110	0
	10	01110011001100	0		10	10001100110011	0
	11	01110011000110	0		11	10001100111001	0
	12	01110011000011	0		12	10001100111100	0
	13	01110001111000	0		13	10001110000111	0
	14	01110001110001	0		14	10001110001110	0
	15	01110001100110	0		15	10001110011001	0
	16	01110001100011	0		16	10001110011100	0
	17	01110000111100	0		17	10001111000011	0
	18	01110000111001	0		18	10001111000110	0
	19	01110000110011	0		19	10001111001100	0
	1A	01110000011110	0		1A	10001111100001	0
	1B	01110000001111	0		1B	10001111110000	0
1(C)	1C	01100111110000	0	1(D)	1C	10011000001111	0
	1D	01100111100001	0		1D	10011000011110	0
	1E	01100111001100	0		1E	10011000110011	0
	1F	01100111000110	0		1F	10011000111001	0
	20	01100111000011	0		20	10011000111100	0
	21	01100110011100	0		21	10011001100011	0
	22	01100110011001	0		22	10011001100110	0
	23	01100110001110	0		23	10011001110001	0
	24	01100110000111	0		24	10011001111000	0
	25	01100011111000	0		25	10011100000111	0
	26	01100011110001	0		26	10011100001110	0
	27	01100011100110	0		27	10011100011001	0
	28	01100011100011	0		28	10011100011100	0
	29	01100011001110	0		29	10011100110001	0
	2A	01100011000111	0		2A	10011100111000	0
	2B	01100001111100	0		2B	10011110000011	0
	2C	01100001111001	0		2C	10011110000110	0
	2D	01100001110011	0		2D	10011110001100	0
	2E	01100001100111	0		2E	10011110011000	0
	2F	01100000111110	0		2F	10011111000001	0
	30	01100000011111	0		30	10011111100000	0
	31	01111100000001	-2		31	10000000110011	-4
	32	01111001100000	-2		32	10000000111001	-4
	33	01111000110000	-2		33	10000000111100	-4
	34	01111000011000	-2		34	10000001100011	-4
	35	01111000001100	-2		35	10000001100110	-4
	36	01111000000110	-2		36	10000001110001	-4
	37	01111000000011	-2		37	10000001111000	-4
	38	01110011100000	-2		38	10000011000011	-4

(continued)

Table 5 (continued)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
	39	01110011000001	-2		39	10000011000110	-4
	3A	01110001110000	-2		3A	10000011001100	-4
	3B	01110001100001	-2		3B	10000011100001	-4
	3C	01110000111000	-2		3C	10000011110000	-4
	3D	01110000110001	-2		3D	10000110000011	-4
	3E	01110000011100	-2		3E	10000110000110	-4
	3F	01110000011001	-2		3F	10000110001100	-4
	40	01110000001110	-2		40	10000110011000	-4
	41	01110000000111	-2		41	10000111000001	-4
	42	01100111100000	-2		42	10000111100000	-4
	43	01100111000001	-2		43	10001100000011	-4
	44	01100110011000	-2		44	10001100000110	-4
	45	01100110001100	-2		45	10001100001100	-4
	46	01100110000110	-2		46	10001100011000	-4
	47	01100110000011	-2		47	10001100110000	-4
	48	01100011110000	-2		48	10001110000001	-4
	49	01100011100001	-2		49	10001111000000	-4
	4A	01100011001100	-2		4A	10011000000011	-4
	4B	01100011000110	-2		4B	10011000000110	-4
1(C)	4C	01100011000011	-2		4C	10011000001100	-4
	4D	01100001111000	-2		4D	10011000011000	-4
	4E	01100001110001	-2		4E	10011000110000	-4
	4F	01100001100110	-2		4F	10011001100000	-4
	50	01100001100011	-2		50	10011100000001	-4
	51	01100000111100	-2		51	10000000111110	-2
	52	01100000111001	-2	1(D)	52	10000001100111	-2
	53	01100000110011	-2		53	10000001110011	-2
	54	01100000011110	-2		54	10000001111001	-2
	55	01100000001111	-2		55	10000001111100	-2
	56	01110000110000	-4		56	10000011000111	-2
	57	01110000011000	-4		57	10000011001110	-2
	58	01110000001100	-4		58	10000011100011	-2
	59	01100110000001	-4		59	10000011100110	-2
	5A	01100011000001	-4		5A	10000011110001	-2
	5B	01100001110000	-4		5B	10000011111000	-2
	5C	01100001100001	-4		5C	10000110000111	-2
	5D	01100000111000	-4		5D	10000110001110	-2
	5E	01100000110001	-4		5E	10000110011001	-2
	5F	01100000011100	-4		5F	10000110011100	-2
	60	01100000011001	-4		60	10000111000011	-2
	61	00111000011000	-4		61	10000111000110	-2
	62	00111000001100	-4		62	10000111001100	-2
	63	00111111000000	-2		63	10000111100001	-2
	64	00111110000001	-2		64	10000111110000	-2
	65	00111100110000	-2		65	10001100000111	-2
	66	00111100011000	-2		66	10001100001110	-2
	67	00111100001100	-2		67	10001100011001	-2
	68	00111100000110	-2		68	10001100011100	-2
2(C)	69	00111100000011	-2		69	10001100110001	-2
	6A	00111001110000	-2		6A	10001100111000	-2
	6B	00111001100001	-2		6B	10001110000011	-2
	6C	00111000111000	-2		6C	10001110000110	-2
	6D	00111000110001	-2		6D	10001110001100	-2
	6E	00111000011100	-2		6E	10001110011000	-2
	6F	00111000011001	-2		6F	10001111000001	-2
	70	00111000001110	-2		70	10001111100000	-2

(continued)

Table 5 (continued)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
	71	00111000000111	-2		71	10011000000111	-2
	72	00110011110000	-2		72	10011000001110	-2
	73	00110011100001	-2		73	10011000011001	-2
	74	00110011001100	-2		74	10011000011100	-2
	75	00110011000110	-2		75	10011000110001	-2
	76	00110011000011	-2		76	10011000111000	-2
	77	00110001111000	-2	1(D)	77	10011001100001	-2
	78	00110001110001	-2		78	10011001110000	-2
	79	00110001100110	-2		79	10011100000011	-2
	7A	00110001100011	-2		7A	10011100000110	-2
	7B	00110000111100	-2		7B	10011100001100	-2
	7C	00110000111001	-2		7C	10011100011000	-2
	7D	00110000110011	-2		7D	10011100110000	-2
	7E	00110000011110	-2		7E	10011110000001	-2
	7F	00110000001111	-2		7F	10011111000000	-2
	80	00111111100000	0		80	11000000011111	0
	81	00111111000001	0		81	11000000111110	0
	82	00111110011000	0		82	11000001100111	0
	83	00111110001100	0		83	11000001110011	0
	84	00111110000110	0		84	11000001111001	0
	85	00111110000011	0		85	11000001111100	0
	86	00111100111000	0		86	11000011000111	0
	87	00111100110001	0		87	11000011001110	0
	88	00111100011100	0		88	11000011100011	0
	89	00111100011001	0		89	11000011100110	0
2(C)	8A	00111100001110	0		8A	11000011110001	0
	8B	00111100000111	0		8B	11000011111000	0
	8C	00111001111000	0		8C	11000110000111	0
	8D	00111001110001	0		8D	11000110001110	0
	8E	00111001100110	0		8E	11000110011001	0
	8F	00111001100011	0		8F	11000110011100	0
	90	00111000111100	0		90	11000111000011	0
	91	00111000111001	0		91	11000111000110	0
	92	00111000110011	0		92	11000111001100	0
	93	00111000011110	0		93	11000111100001	0
	94	00111000001111	0	2(D)	94	11000111110000	0
	95	00110011111000	0		95	11001100000111	0
	96	00110011110001	0		96	11001100001110	0
	97	00110011100110	0		97	11001100011001	0
	98	00110011100011	0		98	11001100011100	0
	99	00110011001110	0		99	11001100110001	0
	9A	00110011000111	0		9A	11001100111000	0
	9B	00110001111100	0		9B	11001110000011	0
	9C	00110001111001	0		9C	11001110000110	0
	9D	00110001110011	0		9D	11001110001100	0
	9E	00110001100111	0		9E	11001110011000	0
	9F	00110000111110	0		9F	11001111000001	0
	A0	00110000011111	0		A0	11001111100000	0
	A1	00110011000001	-4		A1	11000000011110	-2
	A2	00110001100001	-4		A2	11000000110011	-2
	A3	00110000111000	-4		A3	11000000111001	-2
	A4	00110000110001	-4		A4	11000000111100	-2
	A5	00110000011100	-4		A5	11000001100011	-2
	A6	00110000011001	-4		A6	11000001100110	-2

(continued)

Table 5 (continued)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
3(C)	A7	00011110000001	-4	2(D)	A7	11000001110001	-2
	A8	00011100011000	-4		A8	11000001111000	-2
	A9	00011100001100	-4		A9	11000011000011	-2
	AA	00011100000011	-4		AA	11000011000110	-2
	AB	00011001100001	-4		AB	11000011001100	-2
	AC	00011000111000	-4		AC	11000011100001	-2
	AD	00011000110001	-4		AD	11000011110000	-2
	AE	00011000011100	-4		AE	11000110000011	-2
	AF	00011000011001	-4		AF	11000110000110	-2
	B0	00011000000111	-4		B0	11000110001100	-2
	B1	00011111100000	-2		B1	11000110011000	-2
	B2	00011111000001	-2		B2	11000111000001	-2
	B3	00011110011000	-2		B3	11000111100000	-2
	B4	00011110001100	-2		B4	11001100000011	-2
	B5	00011110000110	-2		B5	11001100000110	-2
	B6	00011110000011	-2		B6	11001100001100	-2
	B7	00011100111000	-2		B7	11001100011000	-2
	B8	00011100110001	-2		B8	11001100110000	-2
	B9	00011100011100	-2		B9	11001110000001	-2
	BA	00011100011001	-2		BA	11001111000000	-2
	BB	00011100001110	-2		BB	11000000011001	-4
	BC	00011100000111	-2		BC	11000000011100	-4
	BD	00011001111000	-2		BD	11000000110001	-4
	BE	00011001110001	-2		BE	11000000111000	-4
	BF	00011001100110	-2		BF	11000001100001	-4
	C0	00011001100011	-2		C0	11000001110000	-4
	C1	00011000111100	-2		C1	11000011000001	-4
	C2	00011000111001	-2		C2	11000011100000	-4
	C3	00011000110011	-2		C3	11000110000001	-4
	C4	00011000011110	-2		C4	11000111000000	-4
	C5	00011000001111	-2		C5	11001100000001	-4
	C6	00011111110000	0	3(D)	C6	11100000001111	0
	C7	00011111100001	0		C7	11100000011110	0
	C8	00011111001100	0		C8	11100000110011	0
	C9	00011111000110	0		C9	11100000111001	0
	CA	00011111000011	0		CA	11100000111100	0
	CB	00011110011100	0		CB	11100001100011	0
	CC	00011110011001	0		CC	11100001100110	0
	CD	00011110001110	0		CD	11100001110001	0
	CE	00011110000111	0		CE	11100001111000	0
	CF	00011100111100	0		CF	11100011000011	0
	D0	00011100111001	0		D0	11100011000110	0
	D1	00011100110011	0		D1	11100011001100	0
	D2	00011100011110	0		D2	11100011100001	0
	D3	00011100001111	0		D3	11100011110000	0
	D4	00011001111100	0		D4	11100110000011	0
	D5	00011001111001	0		D5	11100110000110	0
	D6	00011001110011	0		D6	11100110001100	0
	D7	00011001100111	0		D7	11100110011000	0
	D8	00011000111110	0		D8	11100111000001	0
	D9	00011000011111	0		D9	11100111100000	0
4(C)	DA	00001110000011	-4		DA	11100000001110	-2
	DB	00001100000111	-4		DB	11100000011001	-2
	DC	00001111110000	-2		DC	11100000011100	-2
	DD	00001111100001	-2		DD	11100000110001	-2

(continued)

Table 5 (concluded)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
4(C)	DE	00001111001100	-2	3(D)	DE	11100000111000	-2
	DF	00001111000110	-2		DF	11100001100001	-2
	E0	00001111000011	-2		E0	11100001110000	-2
	E1	00001110011100	-2		E1	11100011000001	-2
	E2	00001110011001	-2		E2	11100011100000	-2
	E3	00001110001110	-2		E3	11100110000001	-2
	E4	00001110000111	-2		E4	11100111000000	-2
	E5	00001100111100	-2		E5	11100000001100	-4
	E6	00001100111001	-2		E6	11100000011000	-4
	E7	00001100110011	-2		E7	11100000110000	-4
	E8	00001100011110	-2		E8	11100001100000	-4
	E9	00001100001111	-2		E9	11100011000000	-4
	EA	00001111111000	0	4(D)	EA	11110000000111	0
	EB	00001111110001	0		EB	11110000001110	0
	EC	00001111100110	0		EC	11110000011001	0
	ED	00001111100011	0		ED	11110000011100	0
	EE	00001111001110	0		EE	11110000110001	0
	EF	00001111000111	0		EF	11110000111000	0
	F0	00001110011110	0		F0	11110001100001	0
	F1	00001110001111	0		F1	11110001110000	0
	F2	00001100111110	0		F2	11110011000001	0
	F3	00001100011111	0		F3	11110011100000	0
5(C)	F4	00000111111000	-2		F4	11110000000110	-2
	F5	00000111110001	-2		F5	11110000001100	-2
	F6	00000111100110	-2		F6	11110000011000	-2
	F7	00000111100011	-2		F7	11110000110000	-2
	F8	00000111001110	-2		F8	11110001100000	-2
	F9	00000111000111	-2		F9	11110011000000	-2
	FA	00000110011110	-2	5(D)	FA	11111000000011	0
	FB	00000110001111	-2		FB	11111000000110	0
	FC	00000111110011	0		FC	11111000001100	0
	FD	00000111100111	0		FD	11111000011000	0
	FE	00000111001111	0		FE	11111000110000	0
	FF	00000110011111	0		FF	11111001100000	0

Table 6 – Priority of modulation code selection (end DSV = –2)

Modulation codes	Priority
x x x x x x x x x x x 0 0 1	4
x x x x x x x x x x 0 0 1 1	1
x x x x x x x x x 0 0 1 1 1	2
x x x x x x x x 0 0 1 1 1 1	3
x x x x x x x 0 0 1 1 1 1 1	8
x x x x x x x x x x x 1 1 0	10
x x x x x x x x x x 1 1 0 0	5
x x x x x x x x x 1 1 0 0 0	6
x x x x x x x x 1 1 0 0 0 0	7
x x x x x x x 1 1 0 0 0 0 0	9
x x x x x x 1 1 0 0 0 0 0 0	11

NOTES
1 “x” is a don’t-care bit.
2 This table shall be used in the case where the DSV at the end of the modulation code is –2.

Table 7 – Priority of modulation code selection (end DSV = +2)

Modulation codes	Priority
x x x x x x x x x x x 1 1 0	4
x x x x x x x x x x 1 1 0 0	1
x x x x x x x x x 1 1 0 0 0	2
x x x x x x x x 1 1 0 0 0 0	3
x x x x x x x 1 1 0 0 0 0 0	8
x x x x x x x x x x x 0 0 1	10
x x x x x x x x x x 0 0 1 1	5
x x x x x x x x x 0 0 1 1 1	6
x x x x x x x x 0 0 1 1 1 1	7
x x x x x x x 0 0 1 1 1 1 1	9
x x x x x x 0 0 1 1 1 1 1 1	11

NOTES
1 “x” is a don’t-care bit.
2 This table shall be used in the case where the DSV at the end of the modulation code is +2.

Table 8 – 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

7 Video interface

The video signal interface shall conform to the following:

525/60 system

Analog interface	ITU-R BT.470
Digital parallel interface	ANSI/SMPTE 125M and ANSI/SMPTE 267M
Digital serial interface	ANSI/SMPTE 259M and SMPTE RP 209

625/50 system

Analog interface	ITU-R BT.470
Digital parallel interface	ITU-R BT.656
Digital serial interface	IEC 61179

8 Audio interface

8.1 Encoding parameters

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

8.1.1 Sampling

a) The sampling frequency is 48.000 kHz and shall be related to the horizontal frequency as follows:

$$48\ \text{kHz} = F_H \times 1144 / 375\ \text{(525/60 system)};$$
$$48\ \text{kHz} = F_H \times 384 / 125\ \text{(625/50 system)}.$$

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

c) The coding is twos complement linear PCM.

8.1.2 Reference level

The recommended recorded audio levels should conform to SMPTE RP 155.

8.2 Digital signal interface

The principal mode of interface is analog. The audio signal may also be input and output digitally in a bit-serial form. The bit-serial interface, if present, shall conform to AES3 and IEC 60958 without error checking.

9 Video processing

9.1 Introduction

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

For the noncompressed standard definition video data, recording mode 1 or 2 is used. For HD compressed video data, being the same data volume as the mode 2 video signal (18 MHz sampled), recording mode 3 is used.

By reassembling odd and even samples of the luminance data, two equal-size data blocks are produced. All four data blocks, odd luminance Y_o, even luminance Y_e, color difference C_R, and color difference C_B, are of equal data volume.

Mode 1 operation

Reserved data space equal to 48 samples of 10 bits per sample, provided for all horizontal line data, is required to store video data (see annex E).

Mode 2 operation

The reserved data space is fully utilized in mode 2, to record the increased data volume of 18-MHz sampled video signal, at 8 bits component video signal.

Mode 3 operation

Mode 3 operation is used to record the compressed video data stream by configuring the data into the structure similar to mode 2.

Color-difference samples C_R,C_B, and even-luminance sample Y_e are handled together as one group. Odd luminance samples are handled independently (see figures D.3–D.5).

The total video data are distributed into 12 video blocks (4 channels, each channel with 3 video blocks) for the 525/60 system and 16 video blocks (4 channels, each channel with 4 video blocks) for the 625/50 system.

The data are converted from 10-bit words to 8-bit words (mode 1 only, see figure D.6 and annex E) and randomized. Column shuffling, outer error correction code addition, and interleaving operations are performed.

The ID is multiplexed with the interleaved data and applied to the inner error correction coder. A sync word is added to each code block to form a sync block, the smallest data block. Prior to recording, randomization and 8–14 conversion are performed.

9.2 Recorded data

9.2.1 Recorded samples and lines of the television frame

Video samples and reserve data are recorded in the following manner: In a 525/60 system, 255 consecutive lines and in a 625/50 system, 304 consecutive lines of each field are recorded on tape. Each line contains the following data:

– Mode 1

Y: 720 samples/line of luminance signal (Y) plus reserved area equal to 48 samples

C_B/C_R: 360 samples/line of color-difference signal (C_B/C_R) plus reserved area equal to 24 samples/line, respectively

The first recorded sample of each field shall vary as shown below:

525/60 system

– From field 1, the first recorded sample is number 0 of line 9;

– From field 2, 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.

– Mode 2

Y: 960 samples/line of luminance signal (Y)

C_B/C_R: 480 samples/line of color-difference signal (C_B/C_R), respectively

The first recorded sample of each field shall vary as shown below:

525/60 system

– From field 1, the first recorded sample is number 0 of line 9;

– From field 2, 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.

– Mode 3

Y: HD compressed video data treated as mode 2 Y data

C_B/C_R: HD compressed video data treated as mode 2 C_B/C_R data

Signal format information

Signal format information, as shown in table 9, replaces the first Y and C_B sample (byte 0) and the subsequent three Y samples (bytes 1, 2,3) in the first recorded line of each field.

If the remaining part of the first recorded line is not filled by other data, the rest of the luminance samples of the first line shall be set to 040_h in mode 1 and 10_h in modes 2 and 3, and the rest of the color-difference samples shall be set to 200_h in mode 1 and 80_h in modes 2 and 3.

9.2.2 Nonrecorded data

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

525/60 system

– Field 1, lines 1 through 8;
– Field 2, lines 264 through 270.

Table 9 – Signal format information

Mode	Recorded signal format		Signal format information Byte 0	Byte 1	Byte 2	Byte 3
1	13.5 MHz sampled	525/60	45_h	01_h	01_h	20h
		625/50	41_h	01h	01_h	20h
2	18 MHz sampled	525/60	$4D_h$	01h	01_h	20h
		625/50	49_h	01h	01_h	20h
3	HD compressed video data	1080i/60	21_h	02h	01_h	20h
		720p/60	23_h	01h	01h	20h

NOTE – In mode 1, byte 0 – byte 3 correspond to 8 MSBs of 10-bit word.

625/50 system

– Field 1, from line 624 of the previous field through line 6 of field 1;

– Field 2, from line 311 through line 319 of field 2.

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

9.2.3 Source precoding

No source precoding is applied to the input video data.

9.3 Luminance separation and video reserve data

– Mode 1

Luminance samples are separated into two groups consisting of odd and even samples (Y_o and Y_e). The separated two groups of luminance samples Y_o, Y_e with color-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 four signals (Y_o, Y_e, C_R, C_B) are formatted into four groups of 360 samples each for each line of video data. These 360 samples on each line (see figures 19 and 20) are followed by 24 samples of video reserve data which are set to 000_h and reserved for future use.

– Mode 2

Formatting of the sampled data is identical to that for mode 1 except for the increased samples per line as the result of the higher sampling frequency. The formatted data per line are increased from 360 samples to 480 samples (see figures 21 and 22).

– Mode 3

The HD compressed video data are composed of 5760 DIF blocks and each DIF block is composed of 85 bytes of data, defined in SMPTE 342M. DIF blocks are reconfigured to resemble the mode 2 video data as shown in figure 23. The rule of reconfiguration is described below:

Let S be the data block of C_B, Y_e, C_R, Y_o in figure 23:

S = 0: C_B
S = 1: Y_e
S = 2: C_R
S = 3: Y_o

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

L = 0, 1, . . ., 254

Let H be the horizontal sample location within line L:

H = 0, 1, . . ., 959

$$S = (85 * DN + BN) \bmod 4$$
$$L = (\mathrm{int}((85 * DN + BN) / 4)) \bmod 255$$
$$H = 8 * ((\mathrm{int}(DN/12)) \bmod 120) + 2 * (\mathrm{int}(DN/1440)) + \mathrm{int}(S/3)$$

where DN: DIF block number (DN = 0, 1, . . ., 5759)
BN: Byte location number in DIF block (BN = 0, 1, . . ., 84)

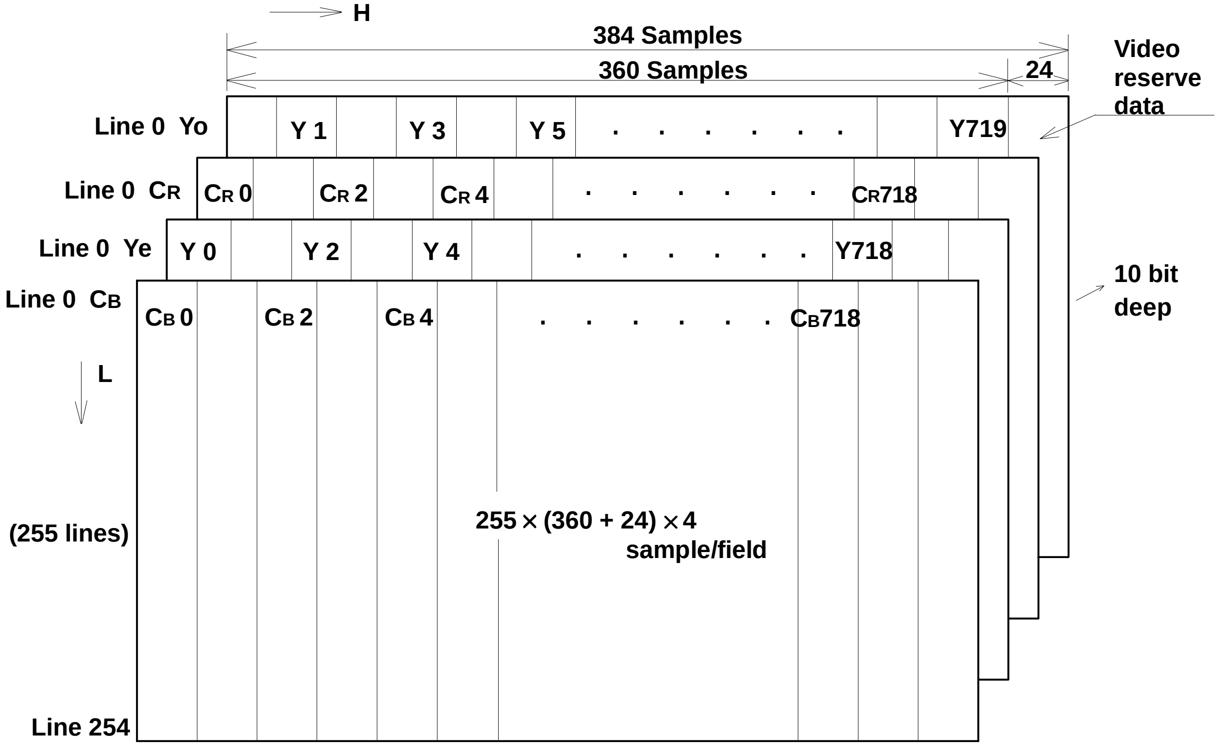


Figure 19 – Separated luminance and color-difference samples in mode 1 (525/60 system)

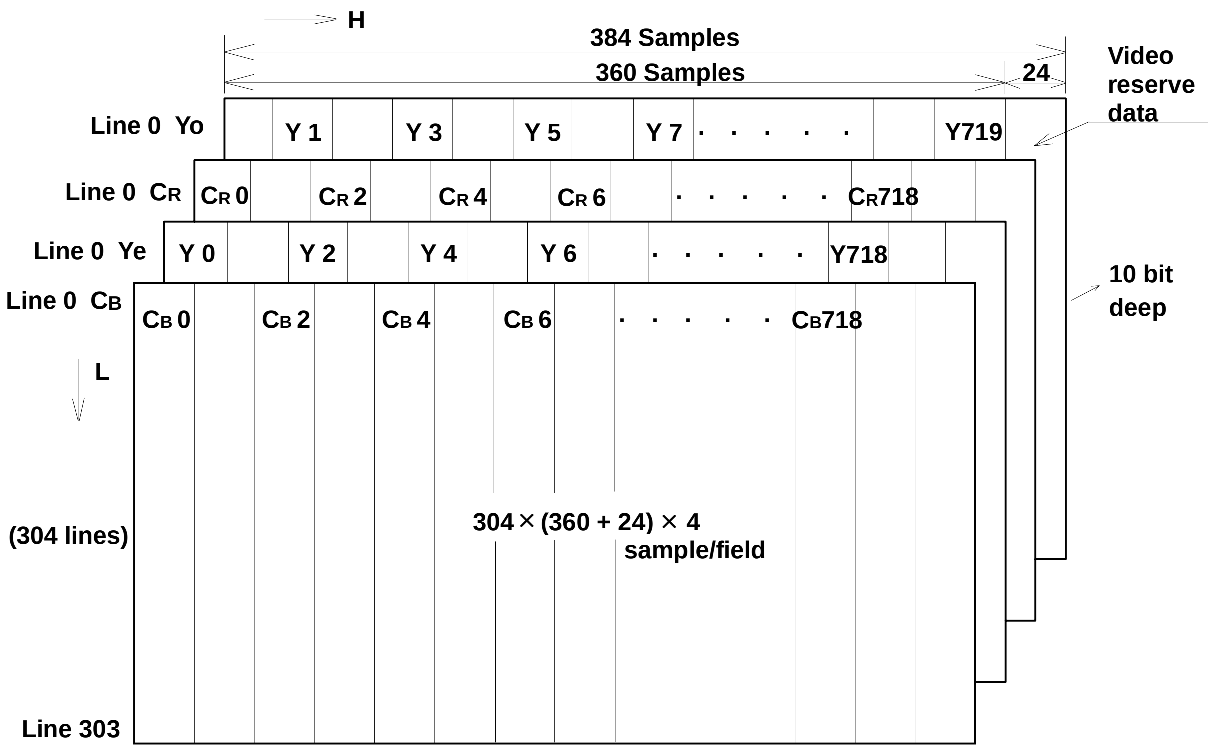


Figure 20 – Separated luminance and color-difference samples in mode 1 (625/50 system)

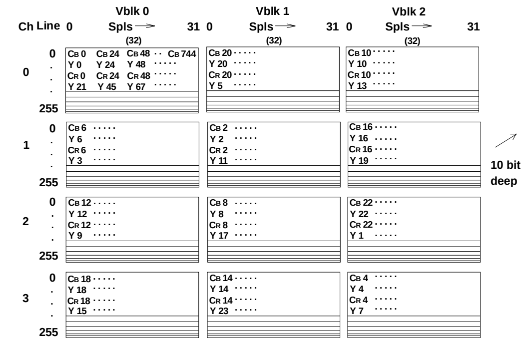


Figure 21 - Channel and video block distribution. (525/60 system)

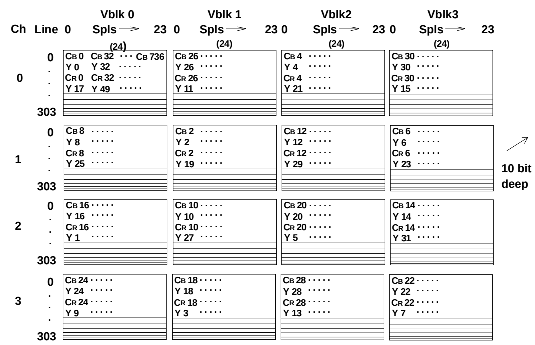


Figure 22 - Channel and video block distribution. (625/50 system)

Figure 21 – Separated luminance and color-difference samples in mode 2 (525/60 system)

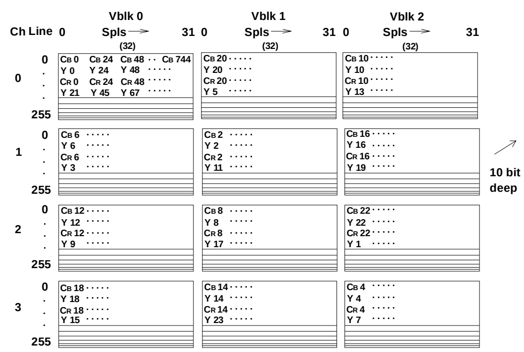


Figure 21 - Channel and video block distribution. (525/60 system)

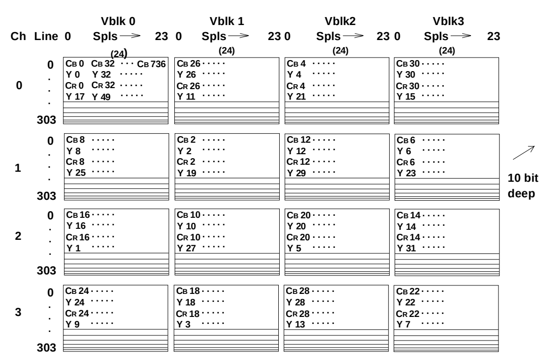


Figure 22 - Channel and video block distribution. (625/50 system)

Figure 22 – Separated luminance and color-difference samples in mode 2 (625/50 system)

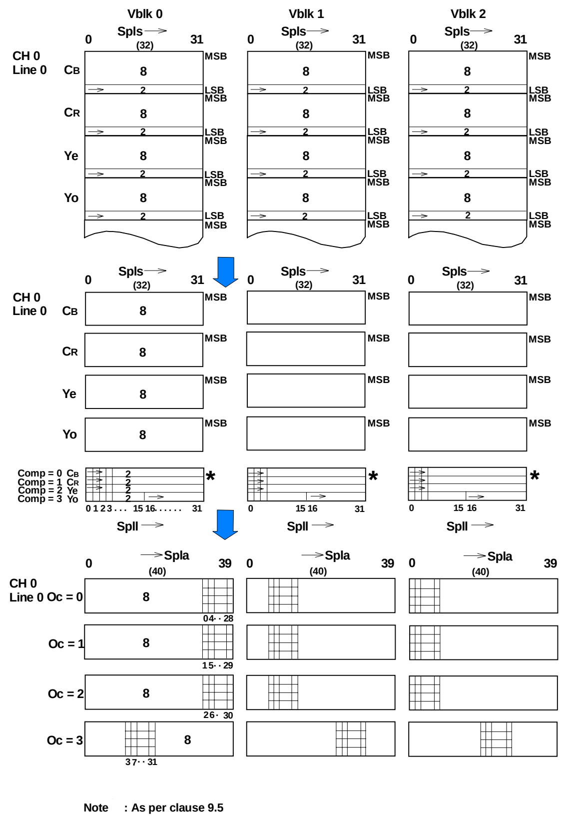


Figure 23 - 10 / 8 bit arrangement (525/60 system).

NOTE – Data compression of the HD video signal is completed within the 1080i video field boundary or the 720p video frame boundary, thus the compressed video data stream has a 60-Hz repetition rate. The data stream, however, does not have any Y, C_B, or C_R distinction or horizontal line structure. The data stream is configured to the structure of the uncompressed 18-MHz sampled component video signal for recording. References to the locations of data bytes in the field, as shown in figure 23 with conventional designations, e.g., Y0, C_B0, C_R0, etc., are for location correlation purposes only.

Figure 23 – Separated luminance and color-difference samples in mode 3

9.4 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 the video field:

L = 0, 1, . . . 254 (525/60 system)
L = 0, 1, . . . 303 (625/50 system)

Let H be the horizontal sample location within line L:

H = 0, 1, . . . 767 (mode 1)
H = 0, 1, . . . 959 (modes 2 and 3)

Samples of Y_e (luminance even samples) and their corresponding color-difference samples, C_R and C_B, are placed together within a given Vblk of a given channel. Samples of Y_o (luminance odd samples) are placed away from Y_e sample groups in a separate Vblk of the same or different channel in mode 1 and mode 2.

The use of an index (I) following each horizontal sample for channel distribution (Ch) and video block distribution (Vblk) is in accordance with figures 24 to 28. The actual index for channel distribution and video block is indicated below.

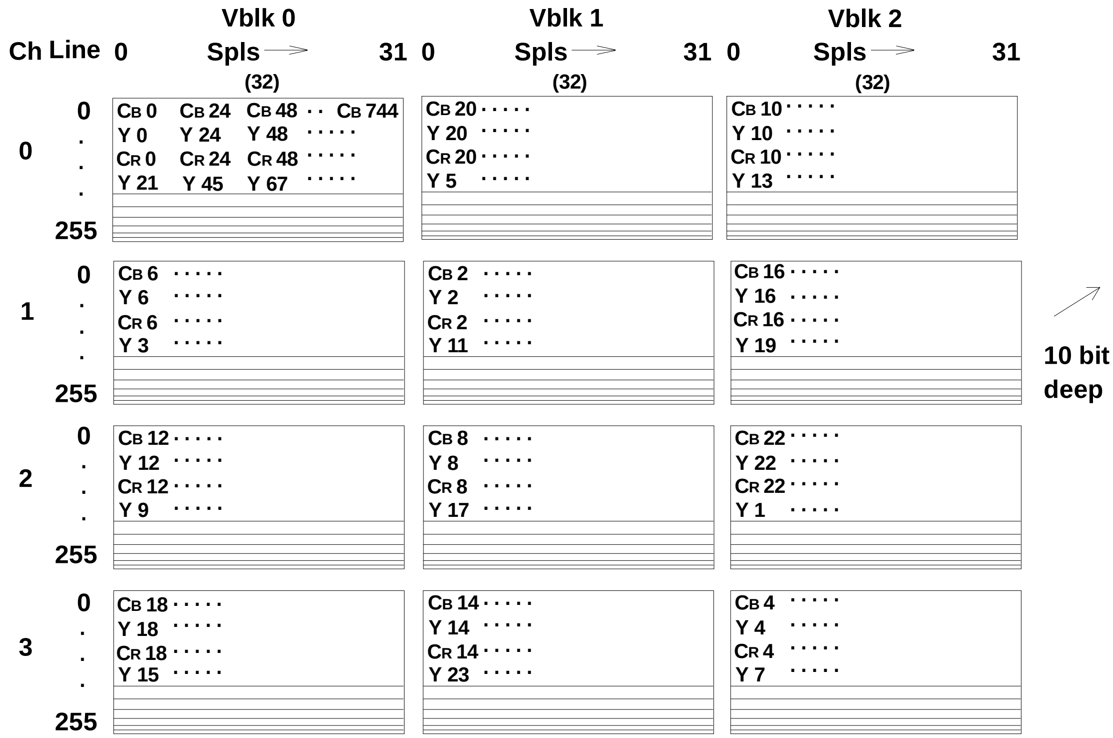


Figure 24 – Channel and video block distribution in mode 1 (525/60 system)

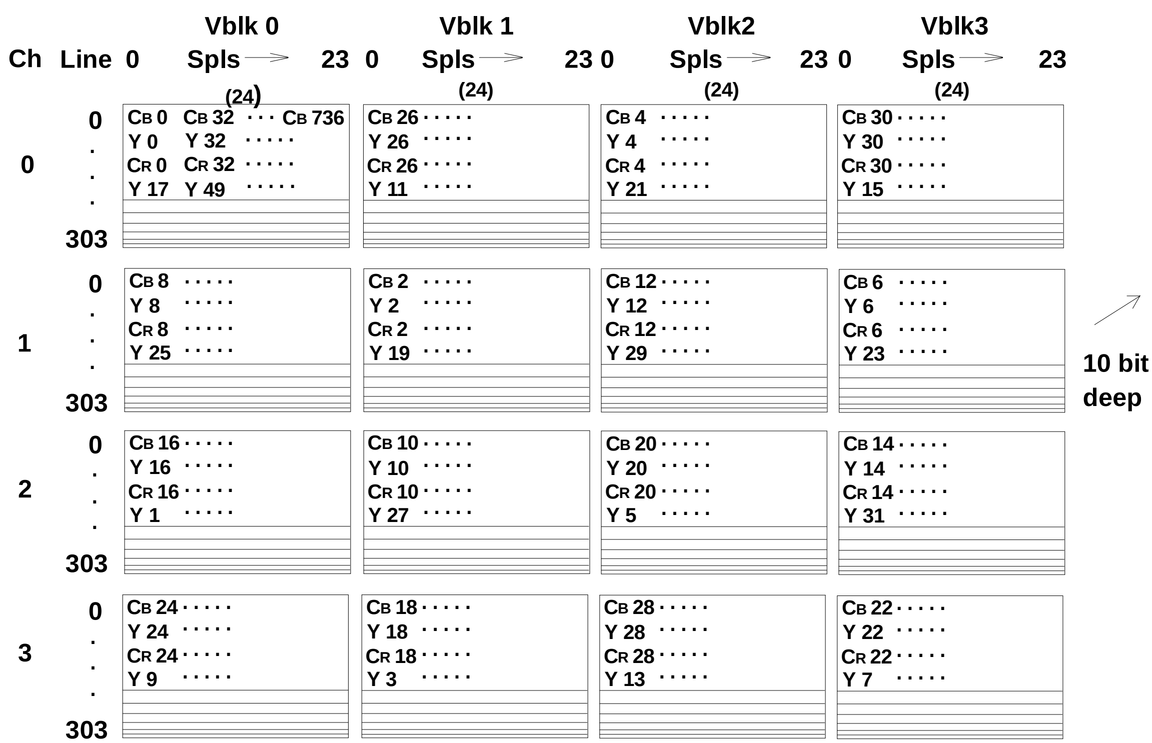


Figure 25 – Channel and video block distribution in mode 1 (625/50 system)

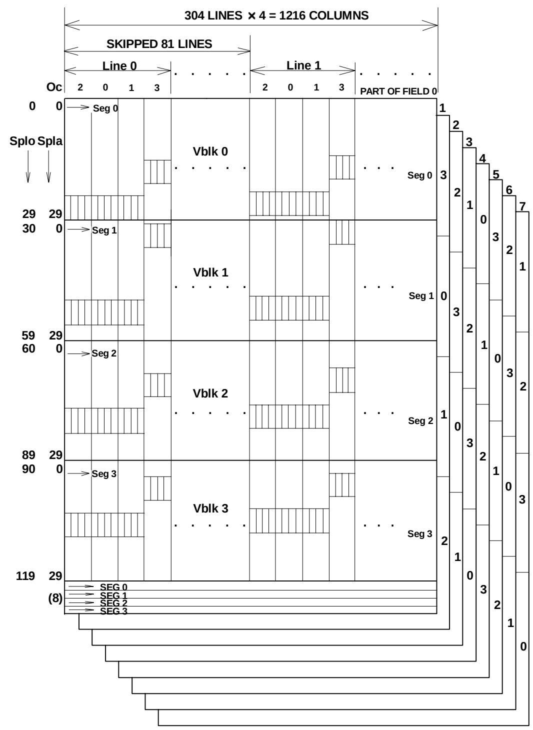


Figure 26 - Field data array (625/50 system).

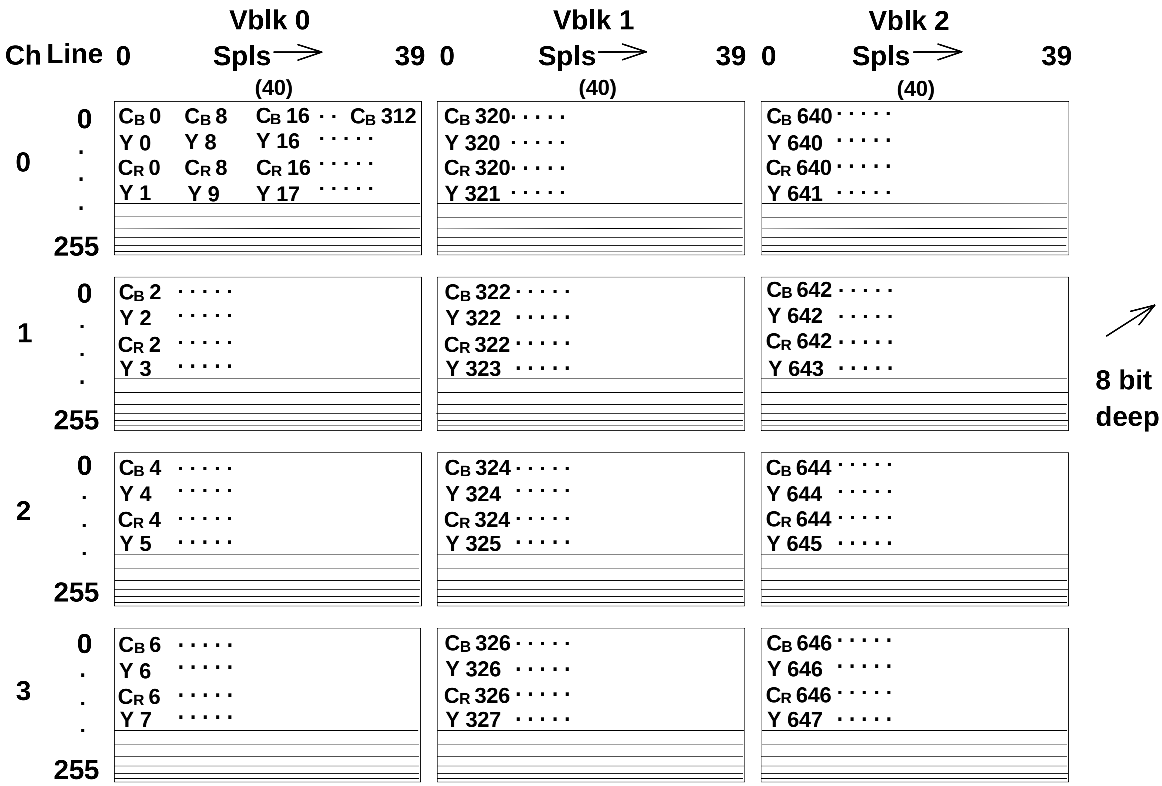
Figure 26 – Channel and video block distribution in mode 2 (525/60 system)

			85 BYTES	85 BYTES	85 BYTES
AUDIO DATA (8 ROWS)	S=0	0	0	1	2
		1	3	4	5
		2	6	7	8
	S=1	3	9	10	11
		4	12	13	14
		5	15	16	17
	S=2	6	18	19	20
		7	21	22	23
OUTER CHECK (8 ROWS)	S=0	8	24	25	26
		9	27	28	29
		10	30	31	32
	S=1	11	33	34	35
		12	36	37	38
		13	39	40	41
	S=2	14	42	43	44
		15	45	46	47

NOTES
1 Numeric table entries are audio sync block numbers.
2 S = Segment number (0, 1, 2).

Figure 27 - Audio data block field array. (525/60 system)

Figure 27 – Channel and video block distribution in mode 2 (625/50 system)



NOTE – See note to figure 23.

Figure 28 – Channel and video block distribution in mode 3

– Mode 1

For 525/60 system:
Ch = {Chi (H mod 6) + int (H/6) + L} mod 4,
Vblk = Vblki (H mod 6)

For 625/50 system:
Ch = {Chi (H mod 8) + int (H/8) + L} mod 4,
Vblk = Vblki (H mod 8)

where Chi and Vblki are constant values as follows:

For 525/60 system

H mod 6	0	1	2	3	4	5
Chi	0	2	1	1	3	0
Vblki	0	2	1	0	2	1

For 625/50 system

H mod 8	0	1	2	3	4	5	6	7
Chi	0	2	1	3	0	2	1	3
Vblki	0	0	1	1	2	2	3	3

Spls means the sample number in the horizontal axis in figures 24 and 25.

Spls = int (H/24) (525/60 system)
Spls = int (H/32) (625/50 system)

where

Spls = 0, 1, 2, . . . 31 (525/60 system)
Spls = 0, 1, 2, . . . 23 (625/50 system)

– Mode 2

For 525/60 system:
Ch = {Chi (H mod 6) + int (H/6) + L} mod 4,
Vblk = Vblki (H mod 6)

For 625/50 system:
Ch = {Chi (H mod 8) + int (H/8) + L} mod 4,
Vblk = Vblki (H mod 8)

where Chi and Vblki are constant values as follows:

For 525/60 system

H mod 6	0	1	2	3	4	5
Chi	0	2	1	1	3	0
Vblki	0	2	1	0	2	1

For 625/50 system

H mod 8	0	1	2	3	4	5	6	7
Chi	0	2	1	3	0	2	1	3
Vblki	0	0	1	1	2	2	3	3

Spls means the sample number in the horizontal axis in figures 26 and 27.

Spls = int (H/24) (525/60 system)
Spls = int (H/32) (625/50 system)

where

Spls = 0, 1, 2, . . . 39 (525/60 system)
Spls = 0, 1, 2, . . . 29 (625/50 system)

– Mode 3

Ch = {int (H/2)} mod 4,
Vblk = int (H/320)

Spls means the sample number in the horizontal axis in figure 28.

Spls = {int (H/8)} mod 40

where

Spls = 0, 1, 2, . . . 39

9.5 Word data arrangement

– Mode 1

Each data word consists of 10 bits. These 10-bit data words shall be separated into two groups where the first group contains eight MSBs of the original 10-bit data word and a second group contains the remaining two LSBs of the original 10-bit data word. The last two LSBs of C_B, C_R, Y_e, Y_o of the same sample are then combined into an 8-bit data word as 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 the combined LSB 2-bit data:

Spll = 0, 1, 2, . . . 31 (525/60 system)
Spll = 0, 1, 2, . . . 23 (625/50 system)

Let Comp be the component signal number as follows:

Comp = 0: C_B signal
Comp = 1: C_R signal
Comp = 2: Y_e signal
Comp = 3: Y_o signal

For 525/60 system:

Spll = Spls (Comp = 0)
Spll = Spls (Comp = 1)
Spll = Spls (Comp = 2)
Spll = (Spls + 16) mod 32 (Comp = 3)

For 625/50 system:

Spll = Spls (Comp = 0)
Spll = Spls (Comp = 1)
Spll = Spls (Comp = 2)
Spll = (Spls + 12) mod 24 (Comp = 3)

The combined LSB 2-bit group shall be relocated as described in figures 29 and 30.

Let Oc be the outer code number within a horizontal video line.

Oc = 0, 1, 2, 3.

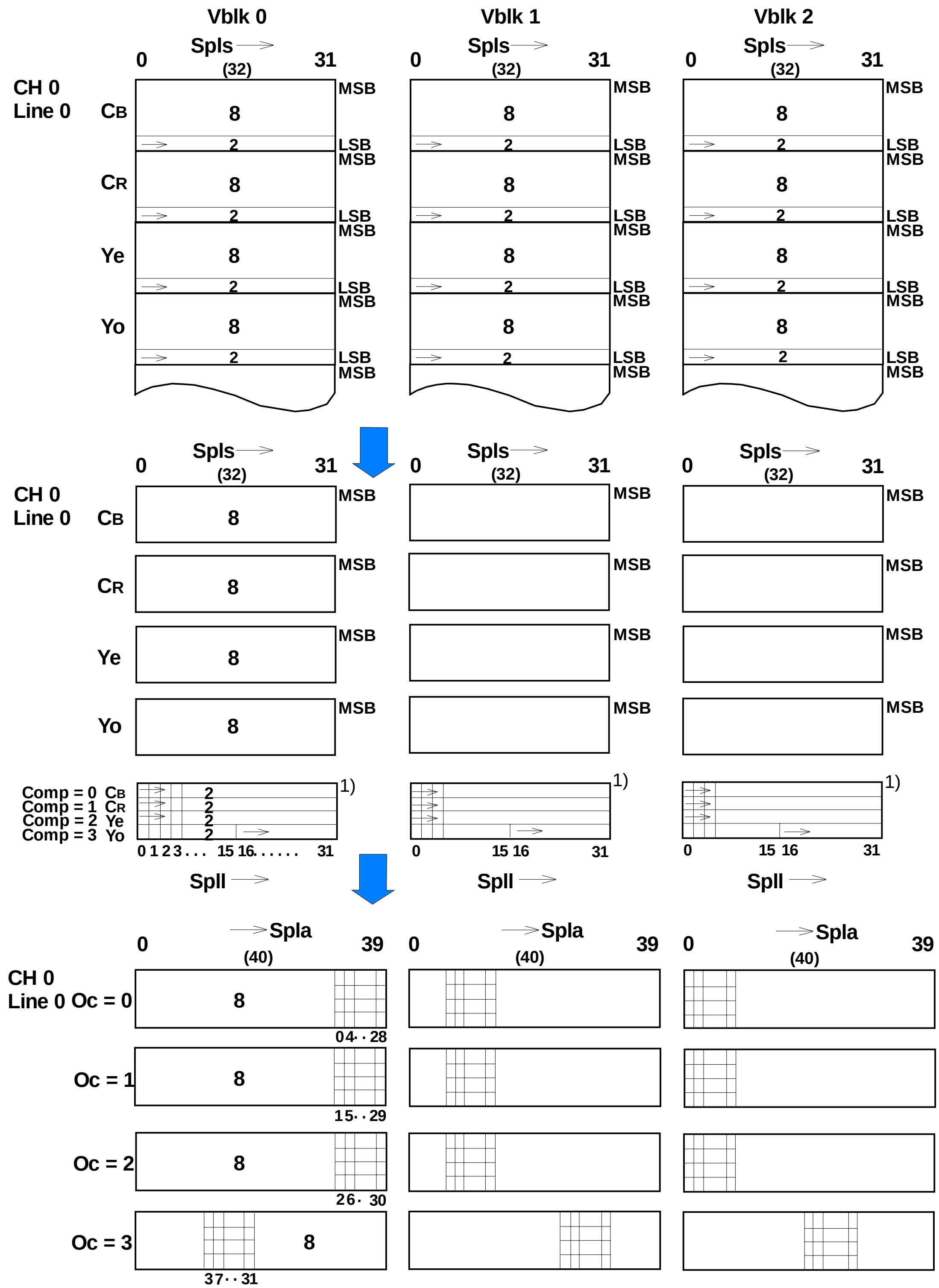
Let Spla be the sample number within a video block of each outer code block.

Spla = 0, 1, . . . 39 (525/60 system)
Spla = 0, 1, . . . 29 (625/50 system)

MSB 8-bit samples:

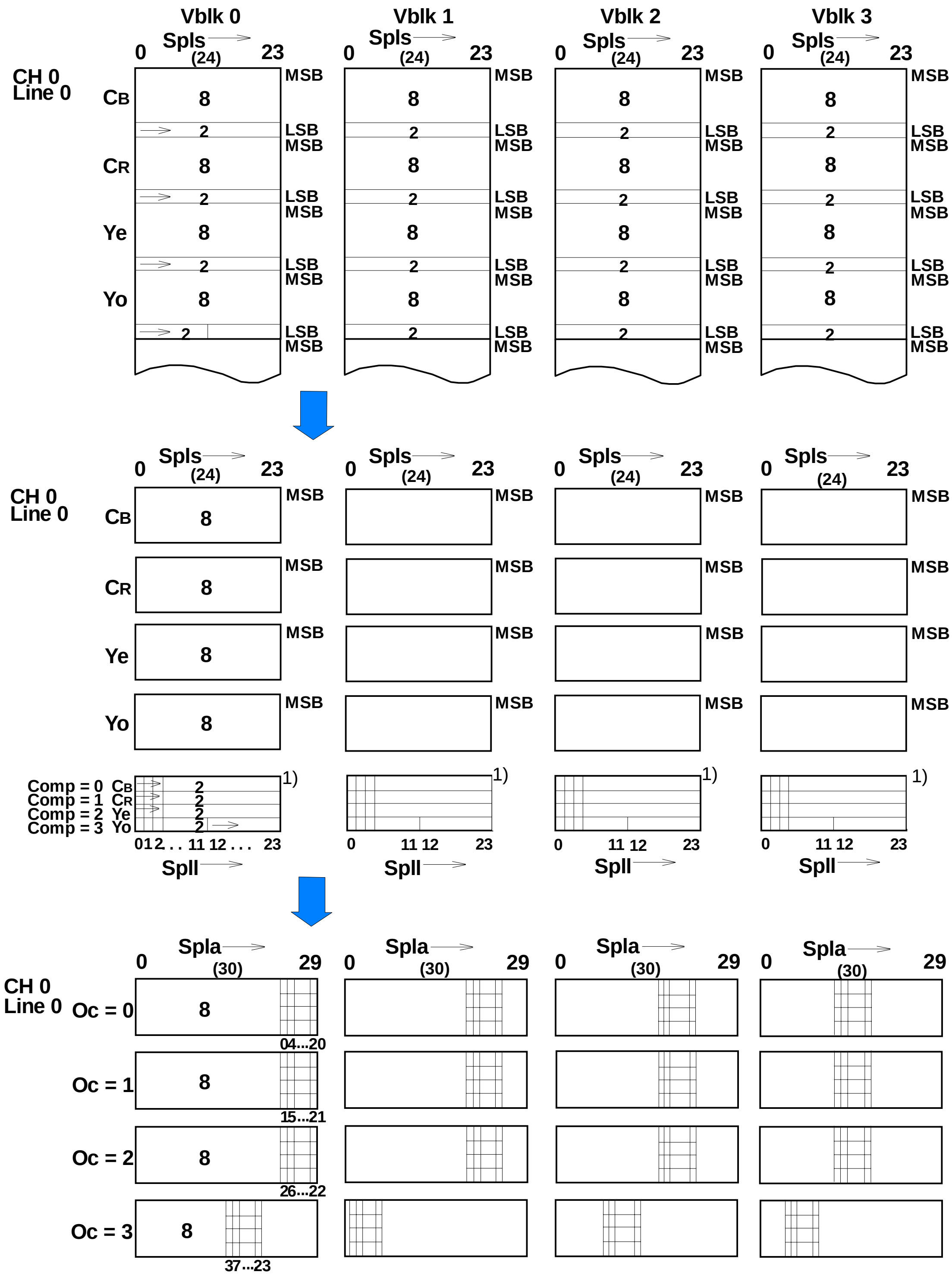
For 525/60 system

Oc = Comp
Spla = {Spls + 20 * Ch + A (Vblk) + 39 * L} mod 40 (Oc = 0, 1, 2)
Spla = {Spls + 20 * Ch + A (Vblk) + 39 * L + 19} mod 40 (Oc = 3)



1) See 9.5

Figure 29 – Word data arrangement in mode 1 (525/60 system)



1) See 9.5

Figure 30 – Word data arrangement in mode 1 (625/50 system)

where A (0) = 0
A (1) = 14
A (2) = 8

For 625/50 system

Oc = Comp
Spla = {Spls + 15 * Ch + A (Vblk) + 10 * L} mod 30 (Oc = 0,1,2)
Spla = {Spls + 15 * Ch + A (Vblk) + 10 * L + 21} mod 30 (Oc = 3)

where A (0) = 0
A (1) = 26
A (2) = 23
A (3) = 19

LSB 2-bit samples:

For 525/60 system

Oc = Spll mod 4
Spla = {32 + int (Spll/4) + 20 * Ch + A (Vblk) + 39 * L} mod 40 (Oc = 0, 1, 2)
Spla = {32 + int (Spll/4) + 20 * Ch + A (Vblk) + 39 * L + 19} mod 40 (Oc = 3)

where A (0) = 0
A (1) = 14
A (2) = 8

For 625/50 system

Oc = Spll mod 4
Spla = {24 + int (Spll/4) + 15 * Ch + A (Vblk) + 10 * L} mod 30 (Oc = 0, 1, 2)
Spla = {24 + int (Spll/4) + 15 * Ch + A (Vblk) + 10 * L + 21} mod 30 (Oc = 3)

where A (0) = 0
A (1) = 26
A (2) = 23
A (3) = 19

Let Splo be the sample number within an outer code block.

Splo = 40 * Vblk + Spla (525/60 system)
Splo = 30 * Vblk + Spla (625/50 system)
Splo = 0, 1, . . . 119

– Mode 2

Each data word consists of 8 bits.

Let Comp be the component signal number as follows:

Comp = 0: C_B signal
Comp = 1: C_R signal
Comp = 2: Y_e signal
Comp = 3: Y_o signal

Let Oc be the outer code number within a horizontal video line.

Oc = 0, 1, 2, 3.

Let Spla be the sample number within a video block of each outer code block.

Spla = 0, 1, . . . 39 (525/60 system)
Spla = 0, 1, . . . 29 (625/50 system)

For 525/60 system

Oc = Comp
Spla = {Spls + 20 * Ch + A (Vblk) + 39 * L} mod 40 (Oc = 0, 1, 2)
Spla = {Spls + 20 * Ch + A (Vblk) + 39 * L + 19} mod 40 (Oc = 3)

where A (0) = 0
A (1) = 14
A (2) = 8

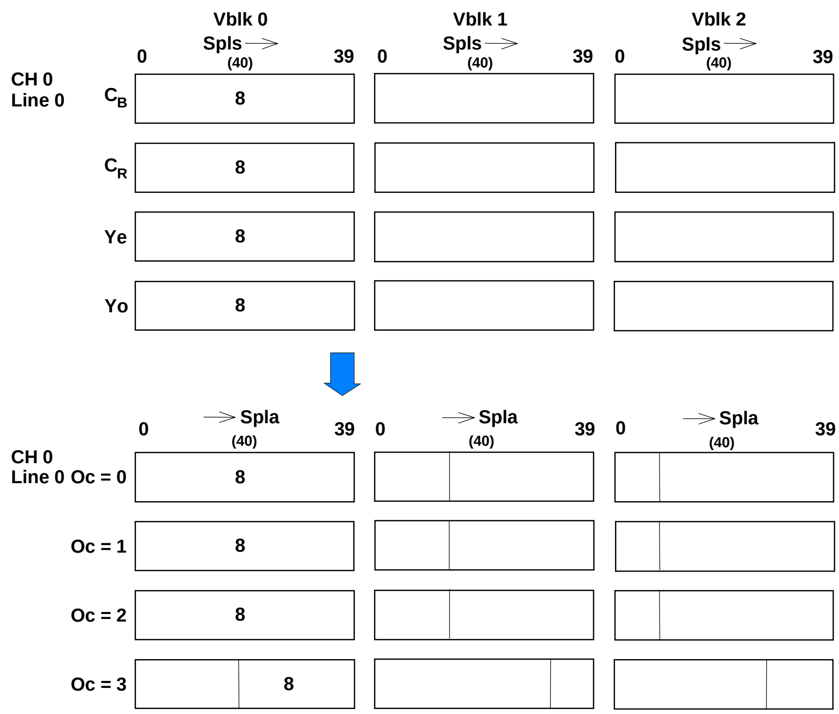
For 625/50 system

Oc = Comp
Spla = {Spls + 15 * Ch + A (Vblk) + 10 * L} mod 30 (Oc = 0, 1, 2)
Spla = {Spls + 15 * Ch + A (Vblk) + 10 * L + 21} mod 30 (Oc = 3)

where A (0) = 0
A (1) = 26
A (2) = 23
A (3) = 19

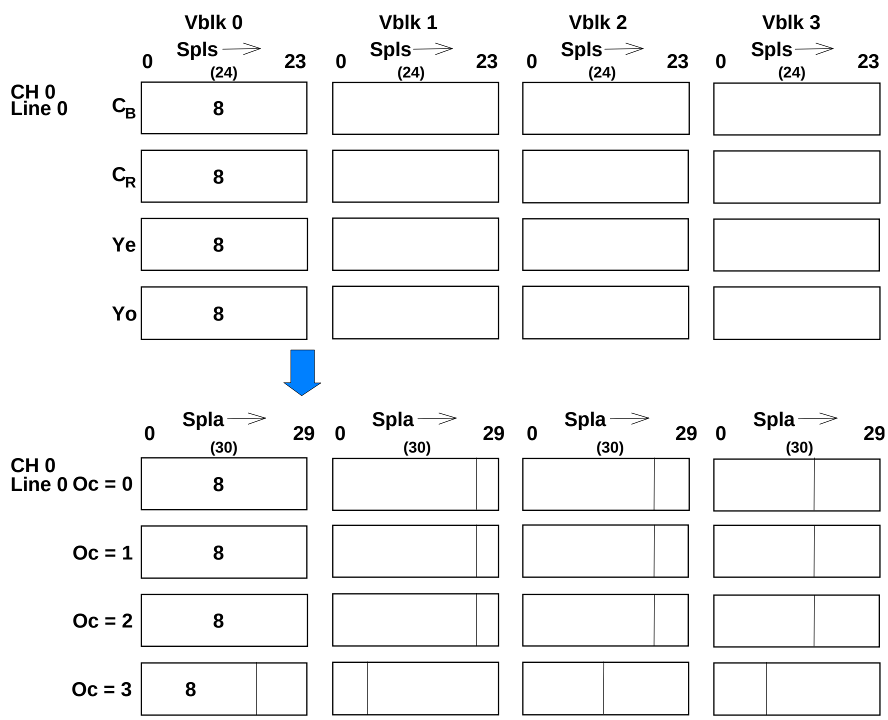
The word data arrangement is shown in figures 31 and 32.

Let Splo be the sample number within an outer code block.



1)See 9.5

Figure 31 – Word data arrangement in mode 2 (525/60 system)



1)See 9.5

Figure 32 – Word data arrangement in mode 2 (625/50 system)

Splo = 40 * Vblk + Spla (525/60 system)
Splo = 30 * Vblk + Spla (625/50 system)
Splo = 0, 1, . . . 119

– Mode 3

Each data word consists of 8 bits.

Let Comp be the component signal number as follows:

Comp = 0: C_B signal
Comp = 1: C_R signal
Comp = 2: Y_e signal
Comp = 3: Y_o signal

Let Oc be the outer code number within a horizontal video line.

Oc = 0, 1, 2, 3.

Let Spla be the sample number within a video block of each outer code block.

Spla = 0, 1, . . . 39

Oc = Comp
Spla = Spls
(Oc = 0, 1, 2, 3)

The word data arrangement is shown in figure 33.

Let Splo be the sample number within an outer code block.

Splo = 40 * Vblk + Spla
Splo = 0, 1, . . . 119

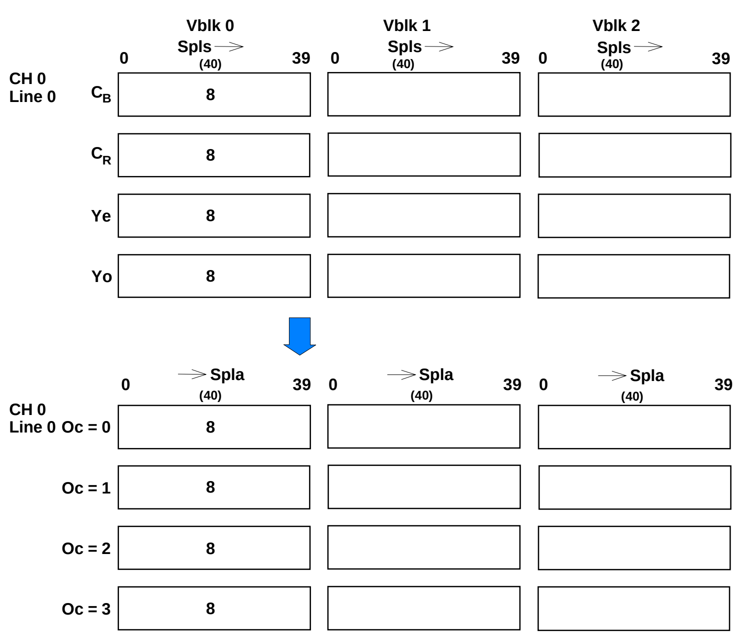
9.6 Video randomization

The following description applies to all modes: Video randomization is performed to further reduce direct current content of the video data stream. It is done after the 10/8 conversion, but prior to the integration of the outer code. Each video data word (byte) is replaced by a new word produced by an exclusive-OR operation between the original video data stream and a random data stream generated by the following polynomial function:

$x^8 + x^4 + x^3 + x^2 + 1$, (in GF(2)).

The random data stream shall be preset to the following value for each line:

M0 = 128 + (L mod 128)



[1)]See 9.5

NOTE – See note to figure 23.

Figure 33 – Word data arrangement in mode 3

9.7 Outer error protection

The following description applies to all modes: 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: $x^8 + x^4 + x^3 + x^2 + 1$, where x^i are place-keeping variables in GF(2), the binary field.

Order of use: Left-most term is most significant, and 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 02_h in GF(256).

Check characters: $K_7, K_6, K_5, K_4, K_3, K_2, K_1, K_0$ in $K_7x^7 + K_6x^6 + K_5x^5 + K_4x^4 + K_3x^3 + K_2x^2 + K_1x^1 + K_0$ are obtained as the remainder after dividing $x^8D(x)$ by G(x), where D(x) is the polynomial given by $D(x) = B_{119}x^{119} + B_{118}x^{118} + \ldots + B_2x^2 + B_1x + B_0$.

Equation of full code is given by:
$B_{119}x^{127} + B_{118}x^{126} + B_{117}x^{125} + \ldots + B_1x^9 + B_0x^8 + K_7x^7 + K_6x^6 + K_5x^5 + K_4x^4 + K_3x^3 + K_2x^2 + K_1x + K_0$.

9.8 Field data array

The columns and rows for every field are shown below:

	Columns/field	Rows/field
525/60 system	1020	128
625/50 system	1216	128

– Mode 1

The field data array is shown in figures 34 and 35.

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

The sample number of the data in the outer code block Oc, Splo, is written into the field memory at the coordinates shown below:

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

where B (0) = 1; B (1) = 2; B (2) = 0; B (3) = 3.

– Mode 2

The field data array is shown in figures 36 and 37.

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

The sample number of the data in the outer code block Oc, Splo, is written into the field memory at the coordinates shown below:

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

where B (0) = 1; B (1) = 2; B (2) = 0; B (3) = 3.

– Mode 3

The field data array is shown in figure 38.

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

The sample number of the data in the outer code block Oc, Splo, is written into the field memory at the coordinates shown below:

Row = Splo
Col = 4 * L + B (Oc)

where B (0) = 0; B (1) = 1; B (2) = 2; B (3) = 3.

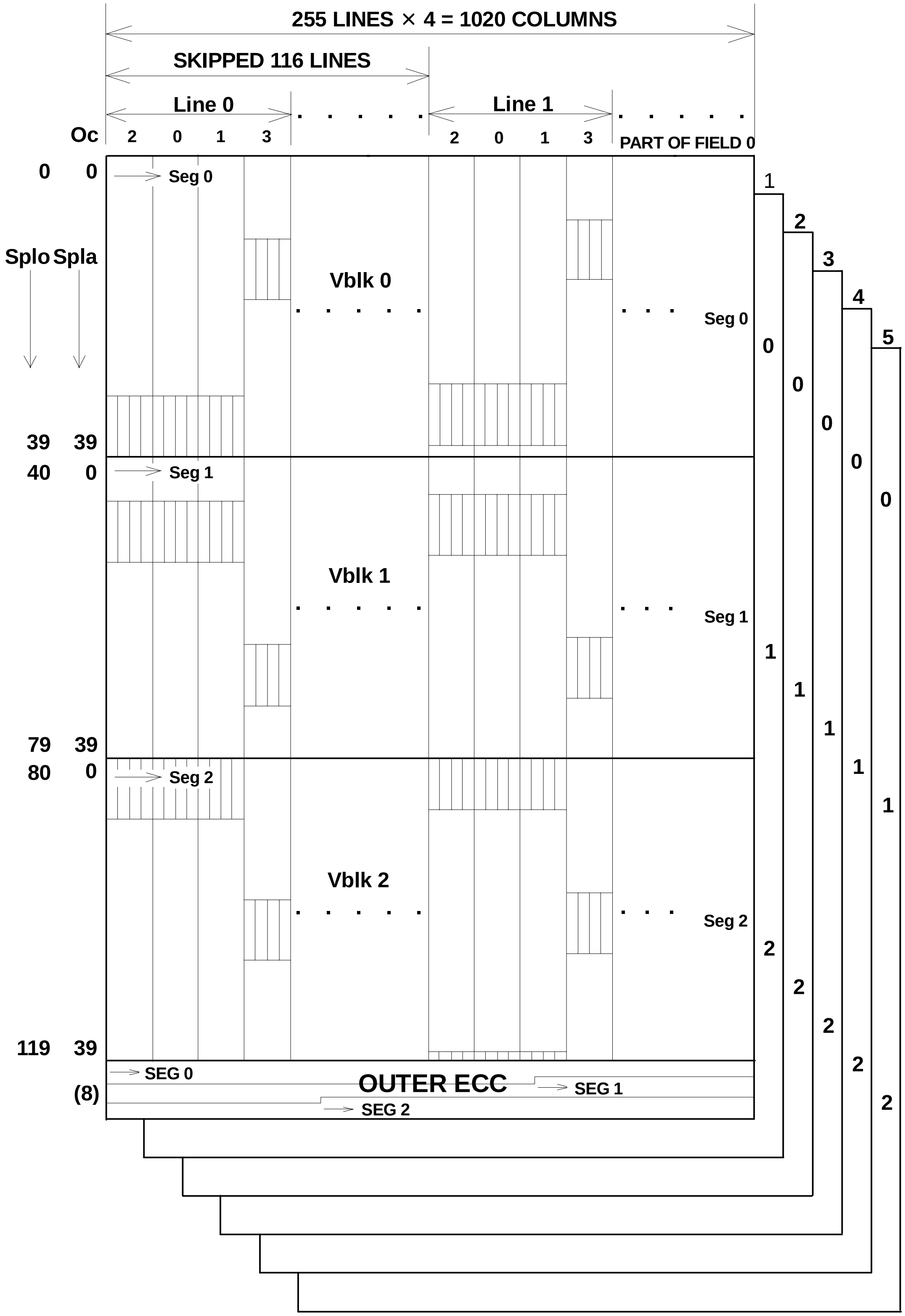
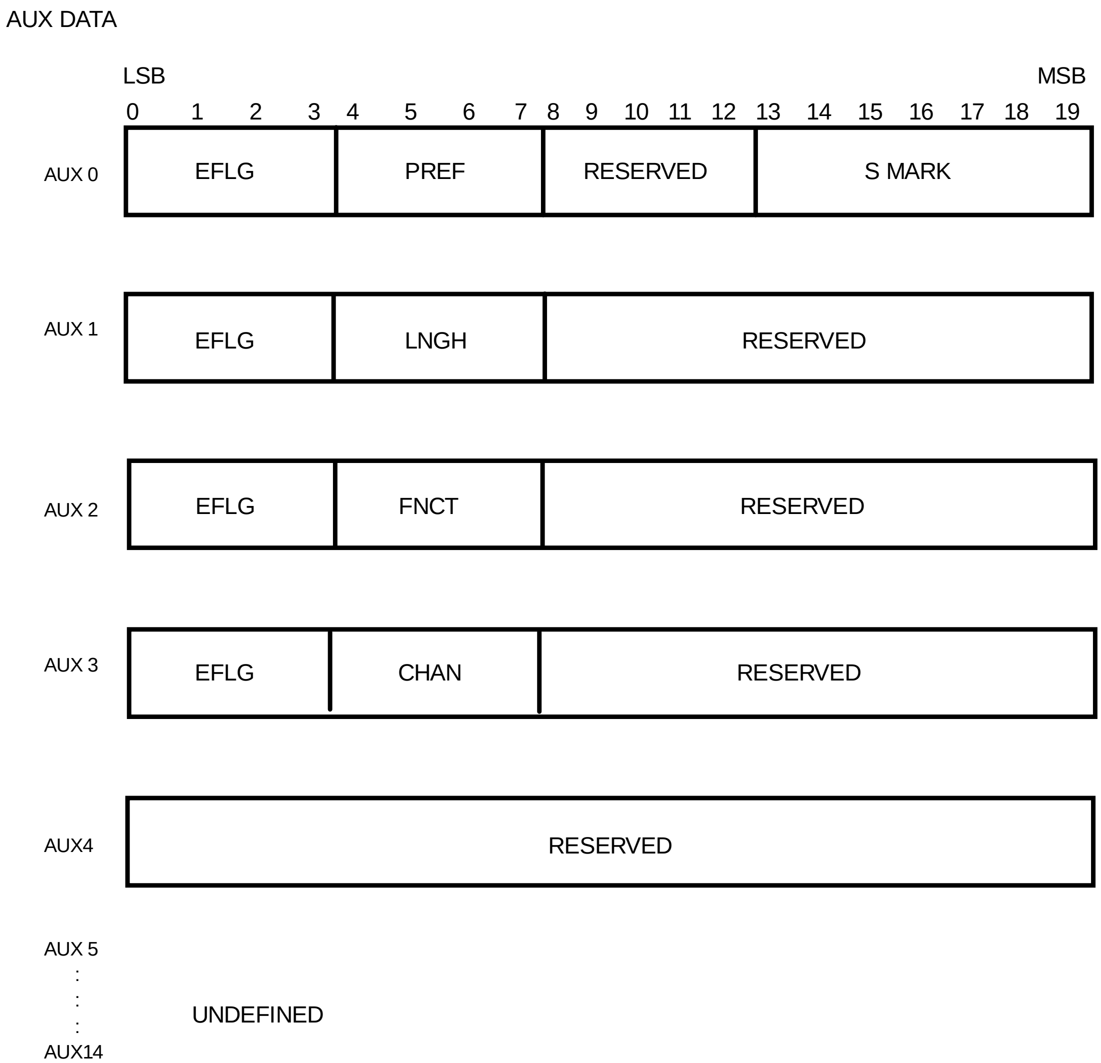
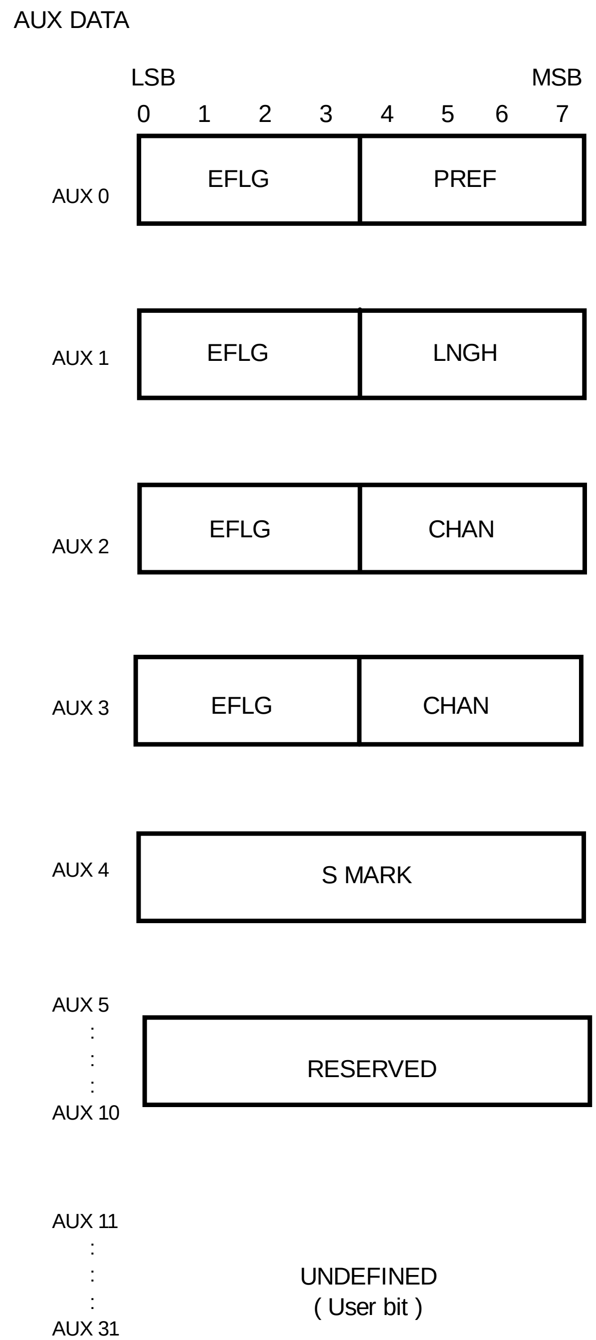


Figure 34 – Field data array in mode 1 (525/60 system)



NOTE - Reserved = 0_h or 000_h or 00000_h.

Figure 35 – Field data array in mode 1 (625/50 system)



NOTE - Reserved = 0_h or 00_h.

Figure 36 - Audio data block auxiliary data. (625/50 system)

Figure 36 – Field data array in mode 2 (525/60 system)

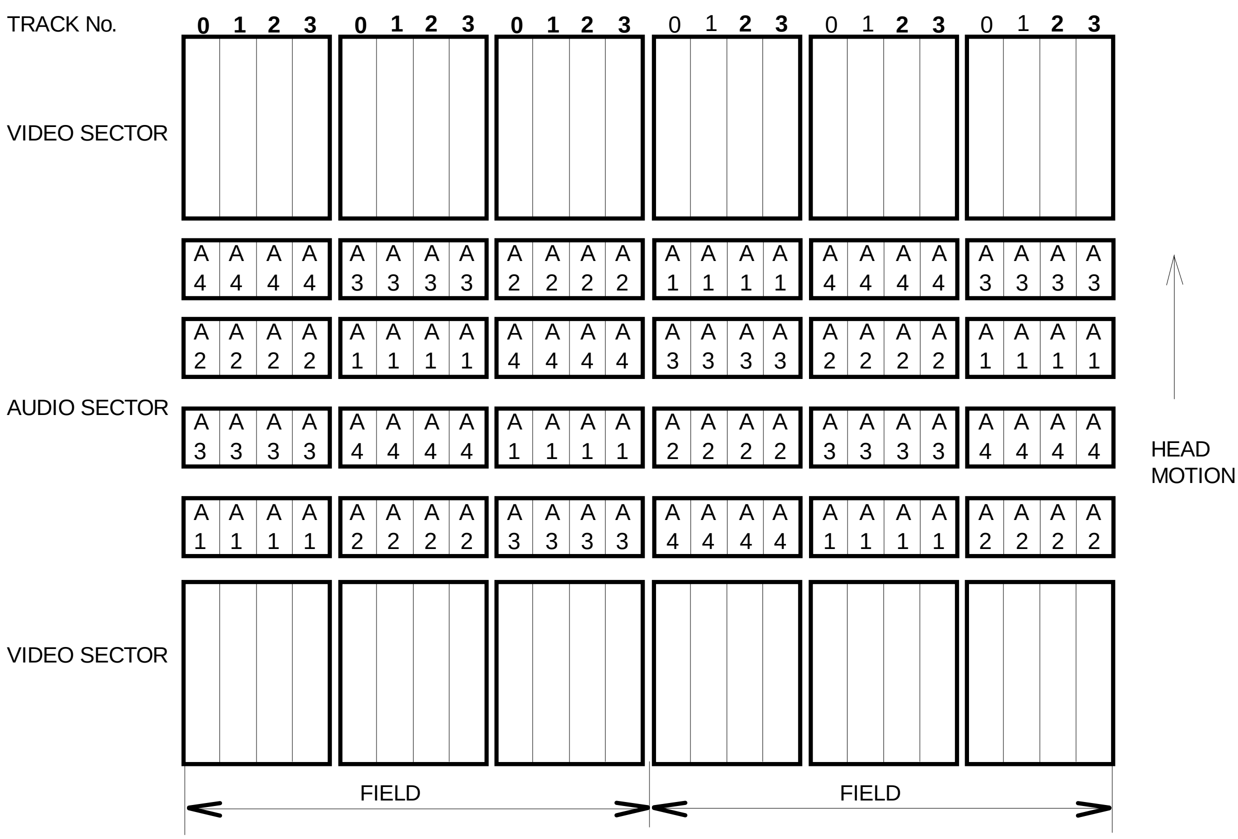


Figure 37 - Audio channel arrangement. (525/60 system)

Figure 37 – Field data array in mode 2 (625/50 system)

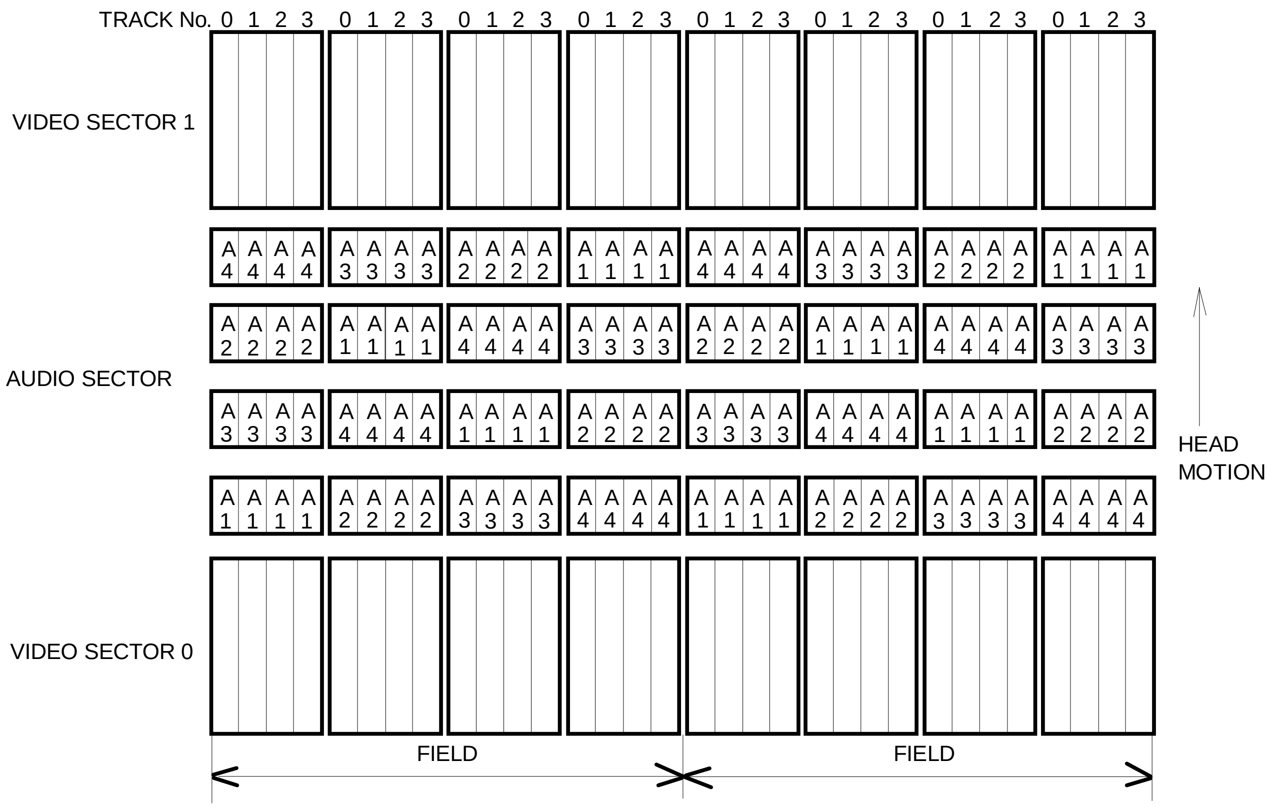


Figure 38 - Audio channel arrangement. (625/50 system)

NOTE – See note to figure 23.

Figure 38 – Field data array in mode 3

9.9 Order of transmission to inner coding

The following description applies to all modes:

The field memory array data are written to tape first by ascending column order, then by ascending row order. Video data bytes and outer check bytes shall be divided into three segments (525/60 system) or four 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 color 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 = 1440 + 32 * Seg (525/60 system)
Xin = 1920 + 32 * Seg (625/50 system)

For the outer data bytes:

Xin = 480 * Seg mod 1440 (525/60 system)
Xin = (480 * Seg + 480 * Fld) mod 1920 (625/50 system)

The relationship 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)

10 Audio processing

10.1 Introduction

Audio in each of the four channels is processed independently and identically into a product block for each channel of dimensions 85 x 3 columns by 8 rows (525/60 system) or 76 x 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. Figures 39 (525/60 system) and 40 (625/50 system) show the audio data block field array.

10.2 Source coding

Audio records that meet the requirements of ITU-R BT.647 are formed independently for each of four audio channels, from audio and ancillary data at the input interface. The data include 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. CCITT J.17 preemphasis is not recognized.

Source data are defined as follows:

a) Audio data:

- Sampling frequency: 48 kHz ± 3 parts in 10^6, synchronous with video
- Word length: 20 bits
- Coding: Twos complement linear PCM

b) Channel status data:

- Bit rate: 48 kbit/s (nominal)
- Word rate: 6 kbyte/s
- Word length: 8 bits
- Block length: 192 bits, 24 words
- Coding: See ITU-R BT.647

NOTES

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 tables 10 and 11, respectively.

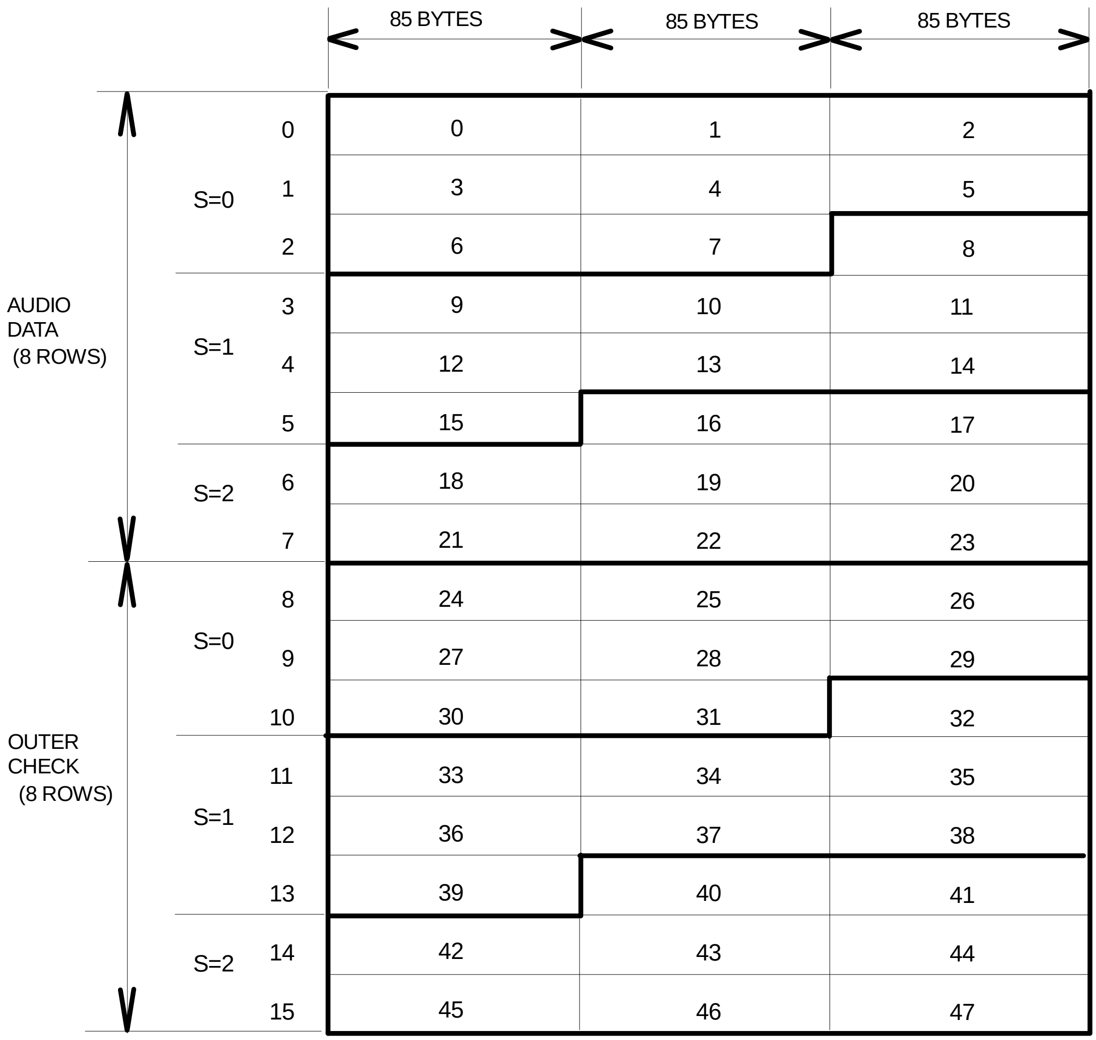
2 Bytes 22 and 23 of AES status data contain protection and validity information for bytes 0-21 and may be used in some source decoders.

c) User data:

- Bit rate: One bit associated with each audio word
- Coding: Undefined

d) Validity data:

- Bit rate: One bit associated with each audio word
- Coding: 0 = sample valid; 1 = sample defective



NOTES
1 Numeric table entries are audio sync block numbers.
2 S = segment number (0, 1, 2).

Figure 39 – Audio data block field array (525/60 system)

			76 BYTES	76 BYTES	76 BYTES	76 BYTES
AUDIO DATA (8 ROWS)	S=0	0	0	1	2	3
		1	4	5	6	7
	S=1	2	8	9	10	11
		3	12	13	14	15
	S=2	4	16	17	18	19
		5	20	21	22	23
	S=3	6	24	25	26	27
		7	28	29	30	31
OUTER CHECK (8 ROWS)	S=0	8	32	33	34	35
		9	36	37	38	39
	S=1	10	40	41	42	43
		11	44	45	46	47
	S=2	12	48	49	50	51
		13	52	53	54	55
	S=3	14	56	57	58	59
		15	60	61	62	63

NOTES
1 Numeric table entries are audio sync block numbers.
2 S = segment number (0, 1, 2, 3).

Figure 40 – Audio data block field array (625/50 system)

Table 10 – AES status data (byte 0)

LSB							MBS
0	1	2	3	4	5	6	7

Bit 0: 0 = consumer use
1 = professional use

Bit 1: 0 = audio
1 = data

Bit 2: Preemphasis 0

Bit 3: Preemphasis 1

Bit 4: Preemphasis 2

Bit 5: 0

Bit 6: Sampling frequency 0

Bit 7: Sampling frequency 1

NOTE – Bits 2, 3, and 4 of this byte are recorded in an auxiliary word.

Table 11 – AES status data (byte 1)

LSB							MBS
0	1	2	3	4	5	6	7

Bit 0: Channel mode bit 0

Bit 1: Channel mode bit 1

Bit 2: Channel mode bit 2

Bit 3: Channel mode bit 3

Bit 4: Reserved

Bit 5: Reserved

Bit 6: Reserved

Bit 7: Reserved

Mode	0	1	2	3	Definition
0	0	0	0	0	Undefined – 2 channel
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	Reserved
		through			
F	1	1	1	1	Reserved

NOTE – Bits 0, 1, and 3 of this byte are recorded in an auxiliary word.

e) Parity bit:

– Bit rate: One bit associated with each audio word
– Coding: Even parity of associated word including audio, status, user, and validity data

10.3 Source processing

10.3.1 Introduction

Audio data are 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.

10.3.2 Relative audio-video timing

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

10.3.3 Audio data in fields

Audio data in fields are 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 eight 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 byte 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: 15-word total (20 bits per word) (525/60 system); 32 words (8 bits per word) (625/50 system).

10.3.4 Intrafield shuffling

The audio data for each channel in each field are shuffled. The intrafield 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 the row number within an audio field:

Row = 0, 1, . . ., 15

Rows 8 to 15 contain the error correction data.

Let Oblk be the data block number:

Oblk = 3 x Row + int (Col/34) (525/60 system)
Oblk = 4 x Row + int (Col/31) (625/50 system)

The data block array is shown in figures 41 (525/60 system) and 42 (625/50 system). Then sample number Smp within an audio field is obtained according to the following formula:

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

$Smp = 32 \times (Col \bmod 31) + int(Oblk / 9) + 4 \times (Oblk \bmod 9)$ (625/50 system) $- 3 \times int[\{(Oblk \bmod 9) + int(Oblk / 9)\} / 8]$.

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

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

Figures 41 (525/60 system) and 42 (625/50 system) show the layout of the shuffled samples in a field array. Outer ECC codes are situated at Row = 8 to 15.

10.3.5 Block shuffling

The block shuffling process operates after the intrafield 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)

	Row	0							1							2						
		85bytes (34 words)							85bytes (34 words)							85bytes (34 words)						
AUDIO DATA 8 bytes	0	0	24	48	72	.....	768	792	3	27	51	75	.....	771	795	6	30	54	78	.....	774	798
	1	9	33	57	81	.....	777	AUX 0	12	36	60	84	.....	780	AUX 3	15	39	63	87	.....	783	AUX 6
	2	18	42	66	90	.....	786	AUX 9	21	45	69	93	.....	789	AUX 12	1	25	49	73	.....	769	793
	3	4	28	52	76	.....	772	798	7	31	55	79	.....	775	799	10	34	58	82	.....	778	AUX 1
	4	13	37	61	85	.....	781	AUX 4	16	40	64	88	.....	784	AUX 7	19	43	67	91	.....	787	AUX 10
	5	22	46	70	94	.....	790	AUX 13	2	26	50	74	.....	770	794	5	29	53	77	.....	773	797
	6	8	32	56	80	.....	776	800	11	35	59	83	.....	779	AUX 2	14	38	62	86	.....	782	AUX 5
	7	17	41	65	89	.....	785	AUX 8	20	44	68	92	.....	788	AUX 11	23	47	71	95	.....	791	AUX 14
OUTER CHECK 8 bytes	8	PV0	PV0	PV0	PV0	.....	PV0	PV0	PV0	PV0	PV0	PV0	.....	PV0	PV0	PV0	PV0	PV0	PV0	.....	PV0	PV0
	9	PV1	PV1	PV1	PV1	.....	PV1	PV1	PV1	PV1	PV1	PV1	.....	PV1	PV1	PV1	PV1	PV1	PV1	.....	PV1	PV1
	10	PV2	PV2	PV2	PV2	.....	PV2	PV2	PV2	PV2	PV2	PV2	.....	PV2	PV2	PV2	PV2	PV2	PV2	.....	PV2	PV2
	11	PV3	PV3	PV3	PV3	.....	PV3	PV3	PV3	PV3	PV3	PV3	.....	PV3	PV3	PV3	PV3	PV3	PV3	.....	PV3	PV3
	12	PV4	PV4	PV4	PV4	.....	PV4	PV4	PV4	PV4	PV4	PV4	.....	PV4	PV4	PV4	PV4	PV4	PV4	.....	PV4	PV4
	13	PV5	PV5	PV5	PV5	.....	PV5	PV5	PV5	PV5	PV5	PV5	.....	PV5	PV5	PV5	PV5	PV5	PV5	.....	PV5	PV5
	14	PV6	PV6	PV6	PV6	.....	PV6	PV6	PV6	PV6	PV6	PV6	.....	PV6	PV6	PV6	PV6	PV6	PV6	.....	PV6	PV6
	15	PV7	PV7	PV7	PV7	.....	PV7	PV7	PV7	PV7	PV7	PV7	.....	PV7	PV7	PV7	PV7	PV7	PV7	.....	PV7	PV7

NOTES

1 Numeric table entries are audio sample numbers.

2 PV0 to PV7 represent outer check bytes corresponding to audio data of each column.

Figure 41 – Audio data block layout (525/60 system)

	Row	0 (76bytes)						1 (76bytes)						2 (76bytes)						3 (76bytes)					
AUDIO DATA 8 bytes	0	0	32	64	.....	928	AUX 0	4	36	68	.....	932	AUX 4	8	40	72	.....	936	AUX 8	12	44	76	.....	940	AUX 12
	1	16	48	80	.....	944	AUX 16	20	52	84	.....	948	AUX 20	24	56	88	.....	952	AUX 24	28	60	92	.....	956	AUX 28
	2	29	61	93	.....	957	AUX 28	1	33	65	.....	929	AUX 1	5	37	69	.....	933	AUX 5	9	41	73	.....	937	AUX 9
	3	13	45	77	.....	941	AUX 13	17	49	81	.....	945	AUX 17	21	53	85	.....	949	AUX 21	25	57	89	.....	953	AUX 25
	4	26	58	90	.....	954	AUX 26	30	62	94	.....	958	AUX 30	2	34	66	.....	930	AUX 2	6	38	70	.....	934	AUX 6
	5	10	42	74	.....	938	AUX 10	14	46	78	.....	942	AUX 14	18	50	82	.....	946	AUX 18	22	54	86	.....	950	AUX 22
	6	23	55	87	.....	951	AUX 23	27	59	91	.....	955	AUX 27	31	63	95	.....	959	AUX 31	3	35	67	.....	931	AUX 3
	7	7	39	71	.....	935	AUX 7	11	43	75	.....	939	AUX 11	15	47	79	.....	943	AUX 15	19	51	83	.....	947	AUX 19
OUTER CHECK 8 bytes	8	PV0	PV0	PV0	.....	PV0	PV0	PV0	PV0	PV0	.....	PV0	PV0	PV0	PV0	PV0	.....	PV0	PV0	PV0	PV0	PV0	.....	PV0	PV0
	9	PV1	PV1	PV1	.....	PV1	PV1	PV1	PV1	PV1	.....	PV1	PV1	PV1	PV1	PV1	.....	PV1	PV1	PV1	PV1	PV1	.....	PV1	PV1
	10	PV2	PV2	PV2	.....	PV2	PV2	PV2	PV2	PV2	.....	PV2	PV2	PV2	PV2	PV2	.....	PV2	PV2	PV2	PV2	PV2	.....	PV2	PV2
	11	PV3	PV3	PV3	.....	PV3	PV3	PV3	PV3	PV3	.....	PV3	PV3	PV3	PV3	PV3	.....	PV3	PV3	PV3	PV3	PV3	.....	PV3	PV3
	12	PV4	PV4	PV4	.....	PV4	PV4	PV4	PV4	PV4	.....	PV4	PV4	PV4	PV4	PV4	.....	PV4	PV4	PV4	PV4	PV4	.....	PV4	PV4
	13	PV5	PV5	PV5	.....	PV5	PV5	PV5	PV5	PV5	.....	PV5	PV5	PV5	PV5	PV5	.....	PV5	PV5	PV5	PV5	PV5	.....	PV5	PV5
	14	PV6	PV6	PV6	.....	PV6	PV6	PV6	PV6	PV6	.....	PV6	PV6	PV6	PV6	PV6	.....	PV6	PV6	PV6	PV6	PV6	.....	PV6	PV6
	15	PV7	PV7	PV7	.....	PV7	PV7	PV7	PV7	PV7	.....	PV7	PV7	PV7	PV7	PV7	.....	PV7	PV7	PV7	PV7	PV7	.....	PV7	PV7

NOTES

1 Numeric table entries are audio sample numbers.

2 PV0 to PV7 represent outer check bytes corresponding to audio data of each column.

Figure 42 – Audio data block layout (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:

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

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

where

$N' = N + 4 \times \mathrm{int}\,(Tr/2)$
$Tr' = Tr \bmod 2$

Figure 43 shows the data block arrangement of an audio channel in three pairs of sectors for the 525/60 system. Figure 44 shows the data block arrangement of an audio channel in four pairs of sectors for the 625/50 system.

10.3.6 Audio data word processing

Input data are 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 (see table 12).

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

b) Each group of 20-bit words is divided into 8-bit bytes as shown in figures 45 (525/60 system) and 46 (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 figures 41 (525/60 system) and 42 (625/50 system).

d) For the 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 10.4.5. Furthermore, every fifth field of 800 samples is identified by the field address AF_2 for audio sync blocks, as defined in 6.3.3.

Table 12 – Audio data word mode

	Bit				
Word mode	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

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

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

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).

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

HEAD MOTION

T=0	T=1	T=2	T=3	T=0	T=1	T=2	T=3	T=0	T=1	T=2	T=3
27	26	31	30	35	34	39	38	43	42	47	46
2	3	6	7	10	11	14	15	18	19	22	23
25	24	29	28	33	32	37	36	41	40	45	44
0	1	4	5	8	9	12	13	16	17	20	21
SEG = 0				SEG = 1				SEG = 2			

NOTES
1 Numeric entries are audio sync block numbers.
2 S = segment number (0, 1, 2).
3 T = track number (0, 1, 2, 3).

Figure 43 – Audio data block arrangement (525/60 system)

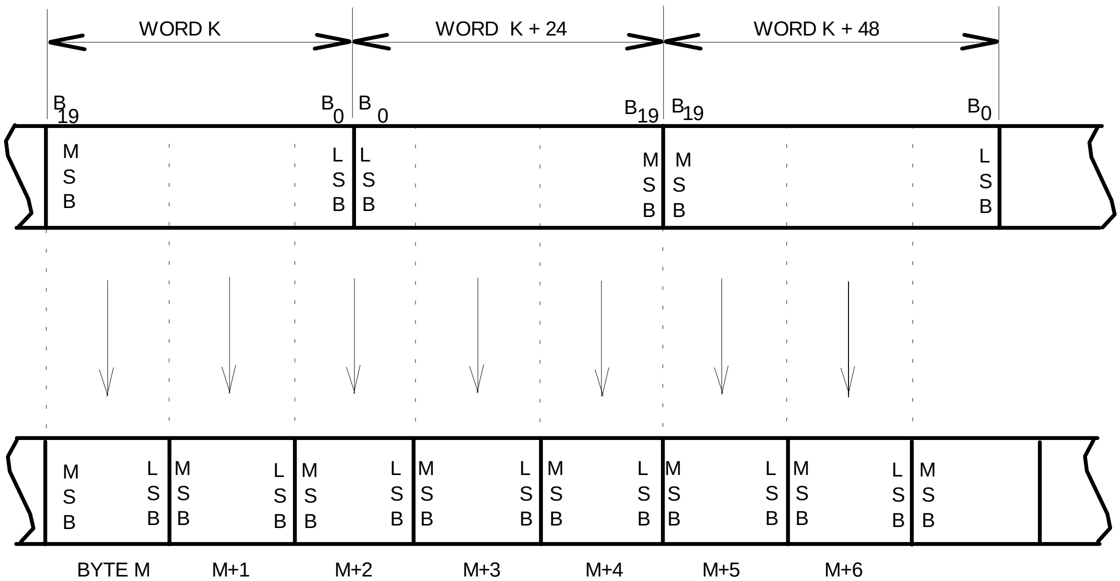
HEAD MOTION

T=0	T=1	T=2	T=3	T=0	T=1	T=2	T=3	T=0	T=1	T=2	T=3	T=0	T=1	T=2	T=3
35	34	39	38	43	42	47	46	51	50	55	54	59	58	63	62
2	3	6	7	10	11	14	15	18	19	22	23	26	27	30	31
33	32	37	36	41	40	45	44	49	48	53	52	57	56	61	60
0	1	4	5	8	9	12	13	16	17	20	21	24	25	28	29
SEG = 0				SEG = 1				SEG = 2				SEG = 3			

(FIELD)

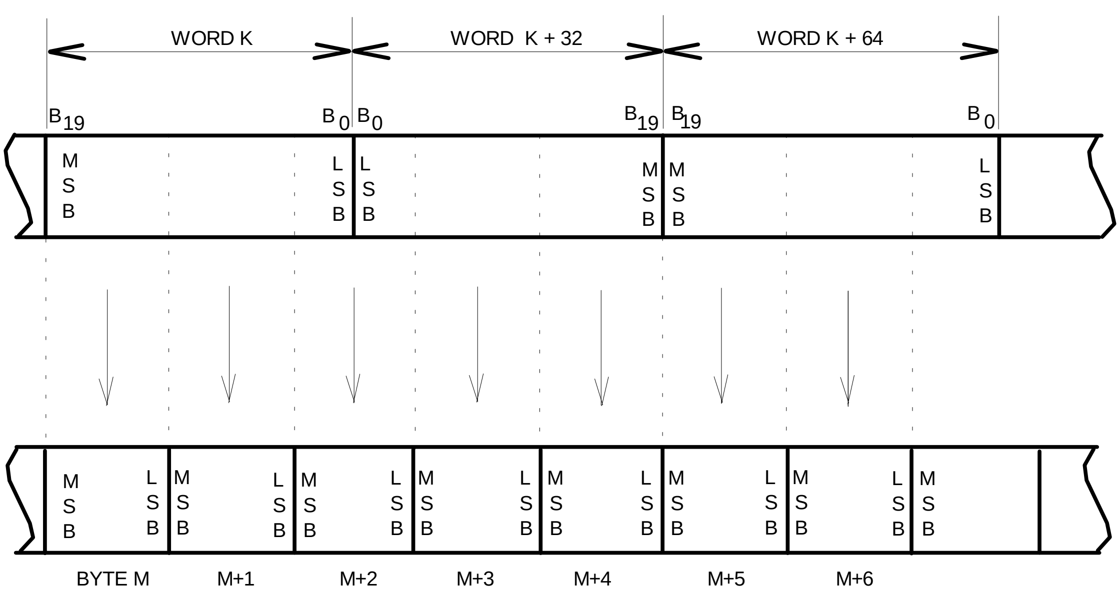
NOTES
1 Numeric entries are audio sync block numbers.
2 S = segment number (0, 1, 2, 3).
3 T = track number (0, 1, 2, 3).

Figure 44 – Audio data block arrangement (625/50 system)



NOTE – K = 0, 9, 18, 4, 13, 22, 8, and 17 in figure 39.

Figure 45 – Digital audio word-to-byte conversion (525/60 system)



NOTE – K = 0, 16, 29, 13, 26, 10, 23, and 7 in figure 40.

Figure 46 – Digital audio word-to-byte conversion (625/50 system)

10.4 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 four bits (525/60 system) or four words of four bits (625/50 system), plus one word of eight bits as defined in figures 47 (525/60 system) and 48 (625/50 system). The word EFLG is written four times in each audio block.

Figures 45 (525/60 system) and 46 (625/50 system) show the format of the auxiliary words in the audio data block.

10.4.1 Channel use (CHAN)

This word is four bits and specifies the usage of the two 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 system). (See table 13.)

LSB → MSB

0	1	2	3	4	5	6	7	Channel status

↓ ↓ ↓ ↓ (AES/EBU Byte 1)

0	1	2	3	CHAN

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 13 – 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

10.4.2 Preemphasis (PREF)

This word is four bits and specifies the usage of preemphasis in the audio coding. PREF is derived from channel status byte 0. PREF is inserted in bits 4-7 of AUX 0 (see table 14).

LSB → MSB

0	1	2	3	4	5	6	7	Channel status

↓ ↓ ↓ (AES/EBU Byte 0)

0	1	2	3	PREF

Bit 0 : Preemphasis bit 0
Bit 1: Preemphasis bit 1
Bit 2: Preemphasis bit 2
Bit 3: 0

Table 14 – Preemphasis control word

Mode	PREF bit 0	1	2	Value
0	0	0	0	Premphasis off – (default)
1	0	0	1	Reserved
2	0	1	0	Reserved
3	0	1	1	Reserved
4	1	0	0	Preemphasis off
5	1	0	1	Reserved
6	1	1	0	50/15 microsecond (CD type)
7	1	1	1	Reserved

10.4.3 Audio data word mode (LNGH)

This word is four 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 (see table 15).

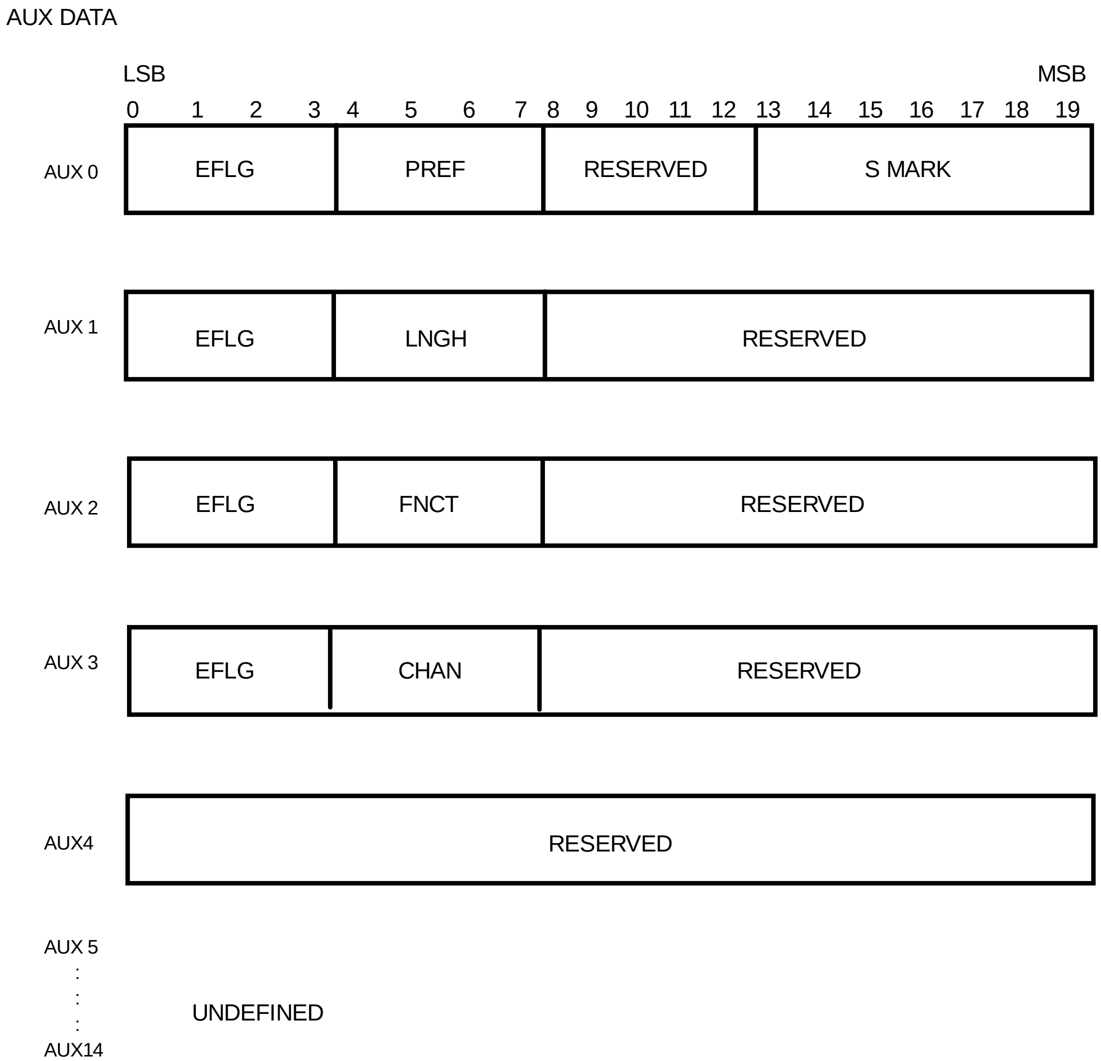
LSB → MSB

0	1	2	3	LNGH

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

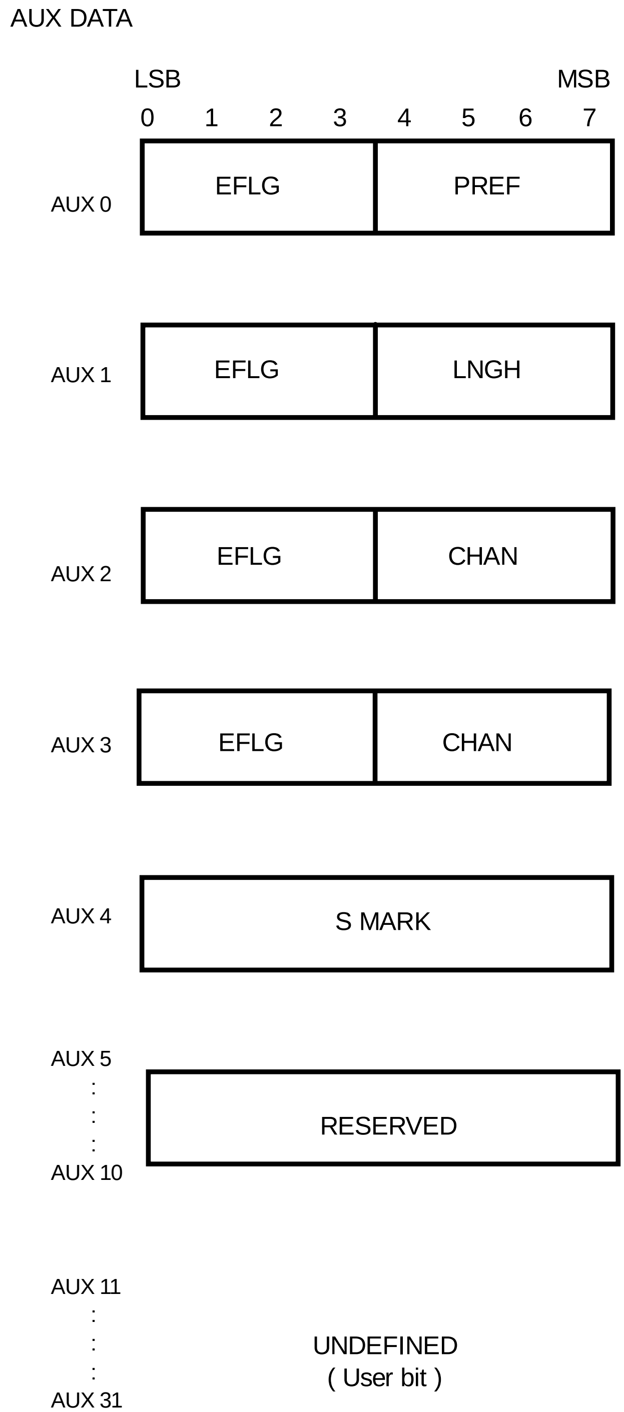
Table 15 – Word mode control word

Mode	LNGH bit 3	2	1	Audio length	Ancillary bit 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 the ancillary bit is recorded.								



NOTE – Reserved = 0_h or 000_h or 00000_h.

Figure 47 – Audio data block auxiliary data (525/60 system)



NOTE – Reserved = 0_h or 00_h.

Figure 48 – Audio data block auxiliary data (625/50 system)

10.4.4 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 6.0 of ITU-R BT.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	
0	1	2	3	4	5	6	7	S MARK

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).

10.4.5 Field number count (FNCT)

In the 525/60 system, this word is four bits and specifies the number of audio samples in the current field. FNCT is inserted in bits 4-7 of AUX 2 (see table 16).

LSB			MSB	
0	1	2	3	FNCT

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

Table 16 – FNCT mode

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

10.4.6 Edit flag (EFLG)

This word is four 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	
0	1	2	3	EFLG

EFLG = D_h for the first field of the edit
EFLG = 7_h for the last field of the edit
EFLG = 0_h otherwise

10.5 Outer error protection

Rows 8 through 15 of the data block, as shown in figures 39 (525/60 system) and 40 (625/50 system) 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: The left-most term is the most significant, oldest 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: $K_7, K_6, K_5, K_4, K_3, K_2, K_1, K_0$ (also identified respectively as PV_7, PV_6, PV_5, PV_4, PV_3, PV_2, PV_1, PV_0) in $K_7x^7 + K_6x^6 + K_5x^5 + K_4x^4 + K_3x^3 + K_2x^2 + K_1x + K_0$ are obtained as the remainder after dividing the polynomial $x^8D(x)$ by $G(x)$, where $D(x)$ is the polynomial given by $D(x) = B_7x^7 + B_6x^6 + B_5x^5 + ... + B_1x + B_0$.

Polynomial of full code: $B_7x^{15} + B_6x^{14} + B_5x^{13} + . . . + B_1x^9 + B_0x^8 + K_7x^7 + K_6x^6 + . . . + K_2x^2 + K_1x + K_0$.

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 figures 41 (525/60 system) and 42 (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.

10.6 Inner protection

The inner protection and sync block format are identical to that for video (see 6.3 and 6.4).

10.7 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.

10.8 Channel code

The channel code is identical to that for video (see 6.5).

10.9 Allocation of audio sectors

The data blocks of an audio channel are arranged in three groups of four sectors (12 sectors) as shown in figure 43 (525/60 system) or four groups of four sectors (16 sectors) as shown in figure 44 (625/50 system). A group of four sectors of each of the four audio channels is recorded according to figures 49 (525/60 system) and 50 (625/50 system). Audio sectors labeled A1, A2, A3, and A4 correspond to audio input channels 1, 2, 3, and 4, respectively. For the 525/60 system, the allocation of a group of sectors is a four-field sequence. Field address AF_0, AF_1 of sector ID of four audio sync blocks is defined in 6.3.3.

11 Longitudinal tracks

11.1 Relative timing

11.1.1 Time and control code input

An external 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 program reference point of a track with an even-field address (count) for the video data is defined by figure 4 and tables 1 and 2.

11.1.2 Time and control code information

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

11.1.3 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 4 and tables 1 and 2.

11.1.4 Control track servo pulse

Control track servo pulse record timing is described in 11.2.

11.2 Control track

11.2.1 Method of recording

The control track shall be recorded using the hysteresis (direct recording) method.

11.2.2 Servo reference pulse

The control track servo reference pulse, at the time of recording, shall be a series of pulses with a period of 11.122 ms $\pm$ 6 μs as shown in figure 51 (525/60 system) or 10.000 ms $\pm$ 6 μs as shown in figure 52 (625/50 system).

11.2.3 Flux polarity

The polarities of the recorded flux shall be as shown in figure 4.

11.2.4 Flux level

The recording shall attenuate any previous recording by at least 30 dB.

11.2.5 Pulse width

The recorded pulses shall have periods of 4T, 5T, or 6T where T equals 1.1122 ms nominal (525/60 system) or 1.000 ms nominal (625/50 system). The rise and fall times of the record current (10% to 90% points) shall be less than 150 μs.

11.2.6 Servo reference pulse timing

The servo reference pulses and the data of the program reference point, when recorded according to figure 4, shall occur at the same time.

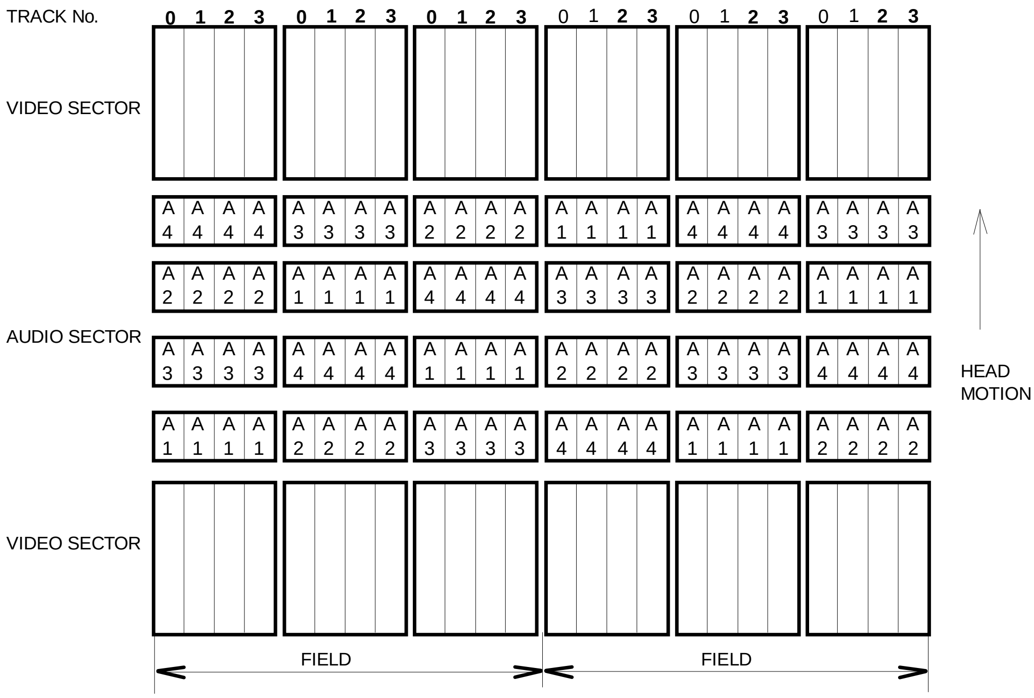


Figure 49 – Audio channel arrangement (525/60 system)

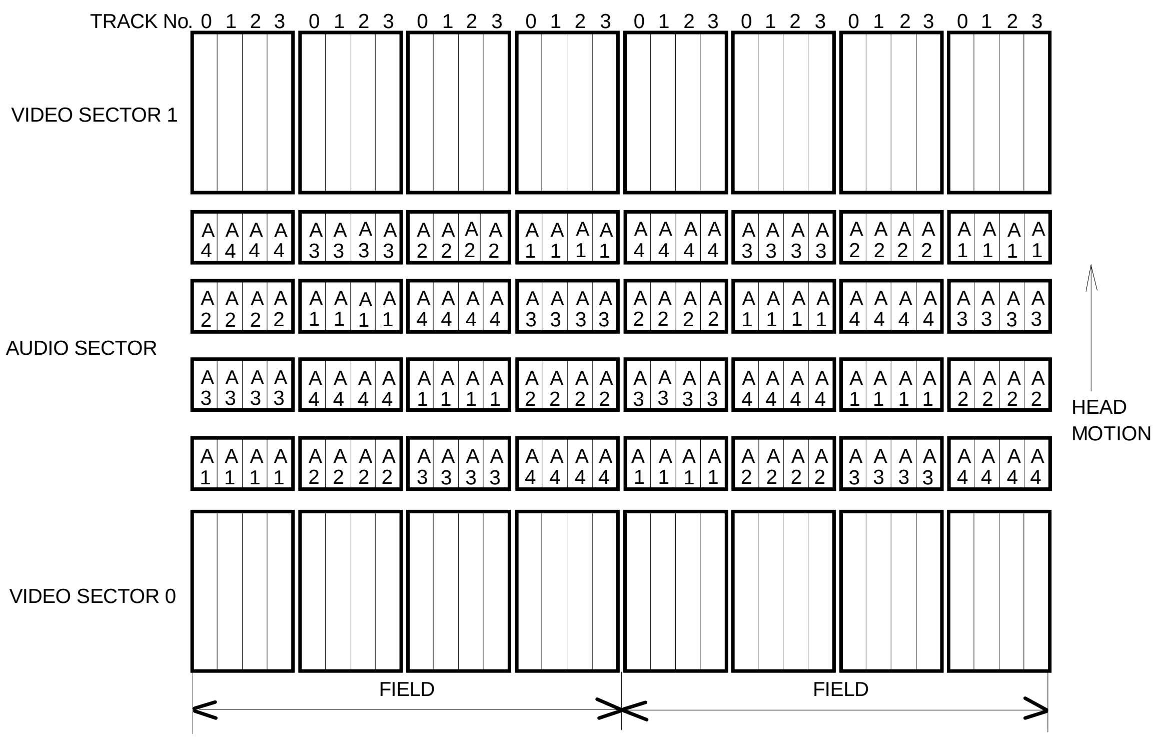


Figure 50 – Audio channel arrangement (625/50 system)

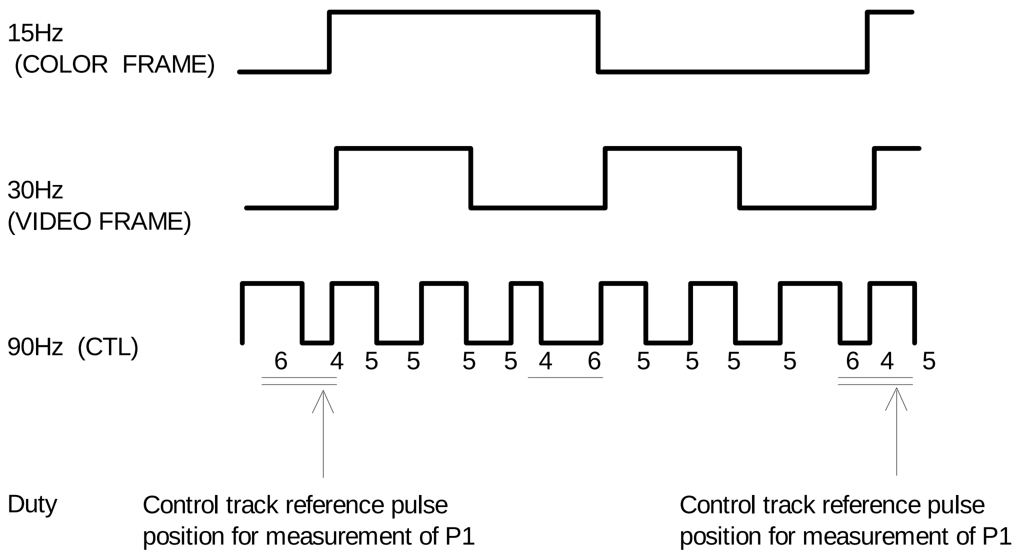


Figure 51 – Recorded control record waveform timing (525/60 system)

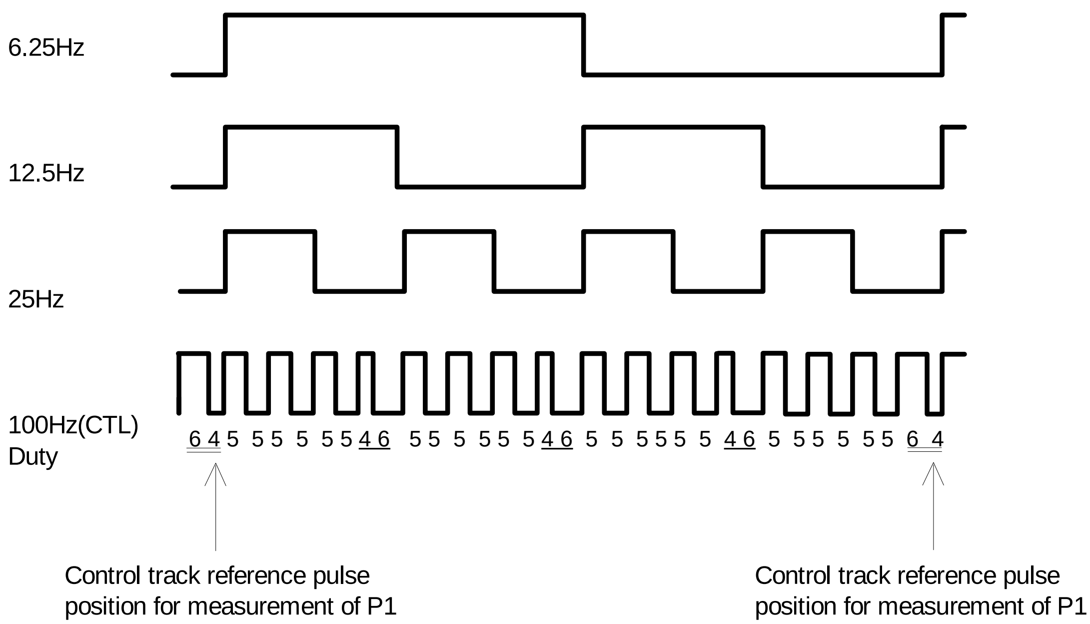


Figure 52 – Recorded control record waveform timing (625/50 system)

11.2.7 Color frame pulse

A color 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 color frame commences with color frame A field 1. 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 6.3.3.

11.2.8 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 6.3.3.

11.3 Cue record

11.3.1 Method of recording

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

11.3.2 Flux level

The recorded reference audio level shall correspond to an rms magnetic short circuit flux level of 125 nWb/m ± 3 nWb/m of track width at 1000 Hz.

11.4 Time and control code record

11.4.1 Method of recording

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

11.4.2 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.

11.4.3 Input signal

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

Annex A (normative)
Tape tension

The value measured with a tension monitor on the entrance side of the scanner may vary among manufacturers, but would typically be 0.31 N ± 0.05 N.

Annex B (normative)
Cross-tape track measurement technique

The cross-tape measuring technique utilizes the fact that all tracks of a helical-scan video recording, recorded by the same head at constant tape speed, have the same longitudinal track pitch, the same track angle, and the same track curvature.

From a ferrofluid development, measurements are made of the actual track positions and the distance between a minimum of 200 control track pitches. All measurements shall be made under the environmental conditions described in 3.1, except that the measurements are made without tape tension (see table B.1 and figure B.1). The tape is then mathematically stretched to account for tape tension (see figure B.2). The theoretical track position is calculated from the corrected longitudinal track pitch and the theoretical track angle. The track location error is calculated as the difference between the theoretical track position and the actual track position (see table B.1 and figure B.3).

Track location error, which is expressed by the lower edge error of the tracks, includes track angle errors, track straightness errors, and track pitch errors. The starting point for calculations and measurements is, for example, the cross point of the lower edge of the track containing the program reference point and the line along the measurement path in figure B.2. The values for each eighth track are the errors for tolerance zone one. Shifting one track, the second tolerance zone can be measured, and so on. It is not necessary to measure all tracks; a suitable number can be 20 samples per zone. A plot of the track location error against the track number must be computed (see figure B.3). The peak-to-peak value shall lie within the tolerance zones specified in 5.3.

Table B.1 – Nomenclature and calculation of track location error

		525/60 system	625/50 system
Y_0	Program area reference (basic)	1.640 mm	1.728 mm
θ	Track angle (basic)	4.9384°	4.9345°
T	Tension	0.31 N	
E	Young's modulus	8000 N/mm^2	
A	Cross sectional area	Thickness $\times$ width	
CTM	Distance of n control track pitches without tape tension		
CTM′	Distance of n control track pitches with tape tension	CTM′ = CTM (1 + T/(A $\times$ E))	
g	Longitudinal track pitch	g = CTM′ / 4n	
i	Track number, i = 0 for track containing reference point		
Y_i	Measured position of track i at the recorded pattern		
ΔY	Cross section track pitch	$\Delta Y = g \times \tan \theta$	
Y_{it}	Theoretical position of track i at the recorded pattern	$Y_{it} = Y_0 + i \times \Delta Y$	
I	Track pitch	$I = g \times \sin \theta$	
TLE	Track location error	$TLE = Y_i - Y_{it}$	
Z	Tolerance zone	Z4 = 0.004 mm Z1, Z2, Z3, Z5, Z6, Z7, Z8 = 0.006 mm	
NOTE – For tolerance zone Z1: i = … –8, 0, +8, +16, … Z2: i = … –9, –1, +7, +15, … Z3: i = … –10, –2, +6, +14, … Z4: i = … –11, –3, +5, +13, … Z5: i = … –12, –4, +4, +12, … Z6: i = … –13, –5, +3, +11, … Z7: i = … –14, –6, +2, +10, … Z8: i = … –15, –7, +1, +9, …			

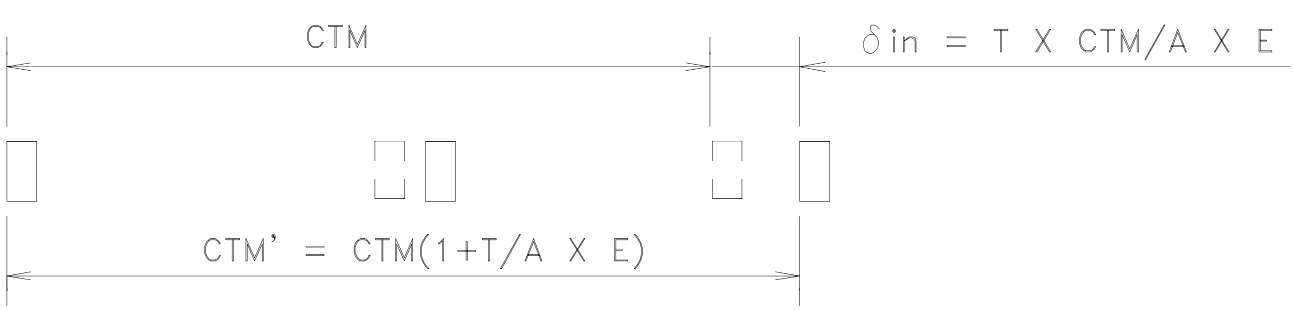
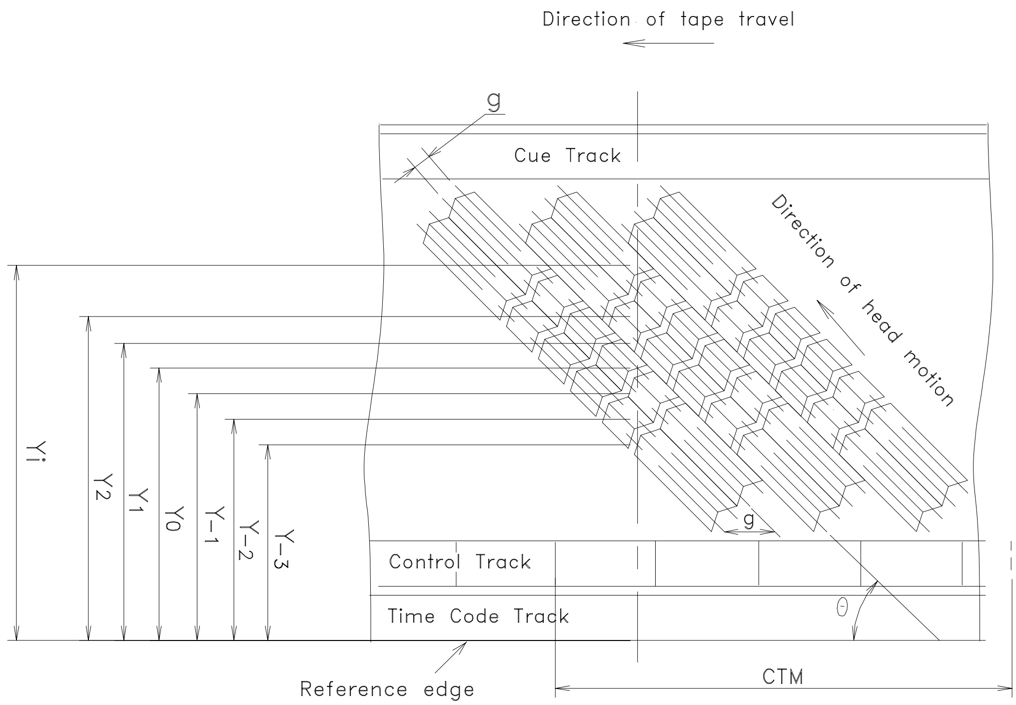


Figure B.1 – Correction factors (actual tape speed and tension)



NOTE – The same head must be used for Y_i measurement (i.e., every fourth track); CTM is the distance of n control track pitches (n = 200 minimum).

Figure B.2 – Cross-tape measurement technique

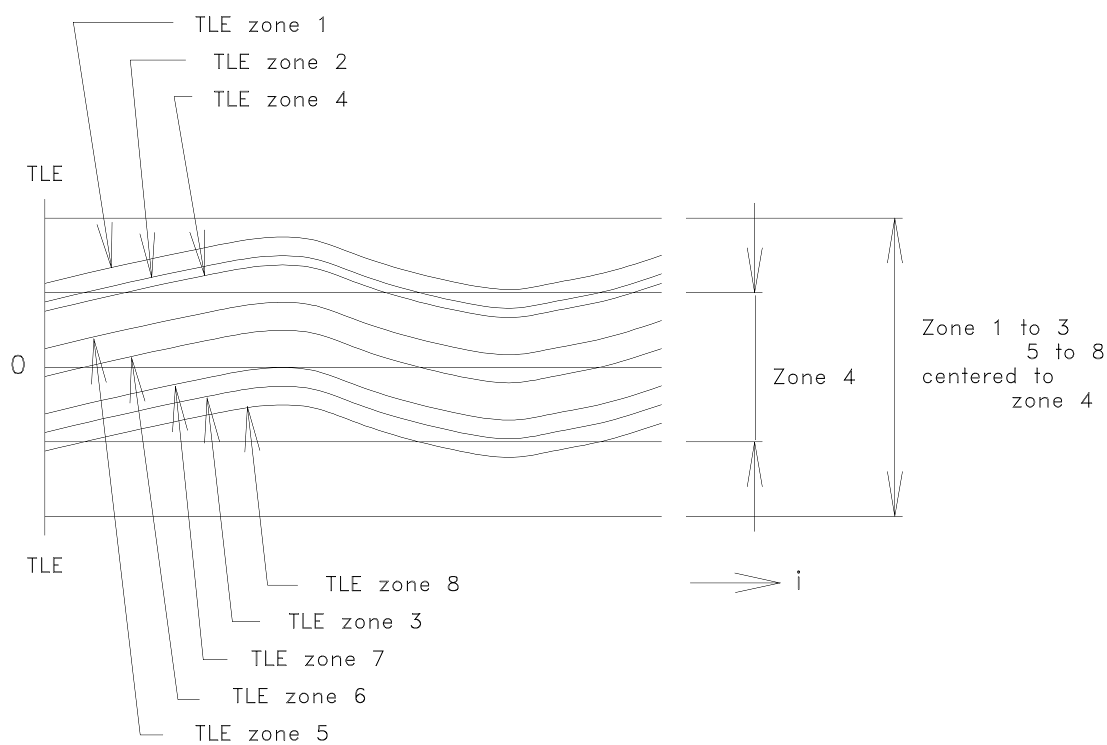
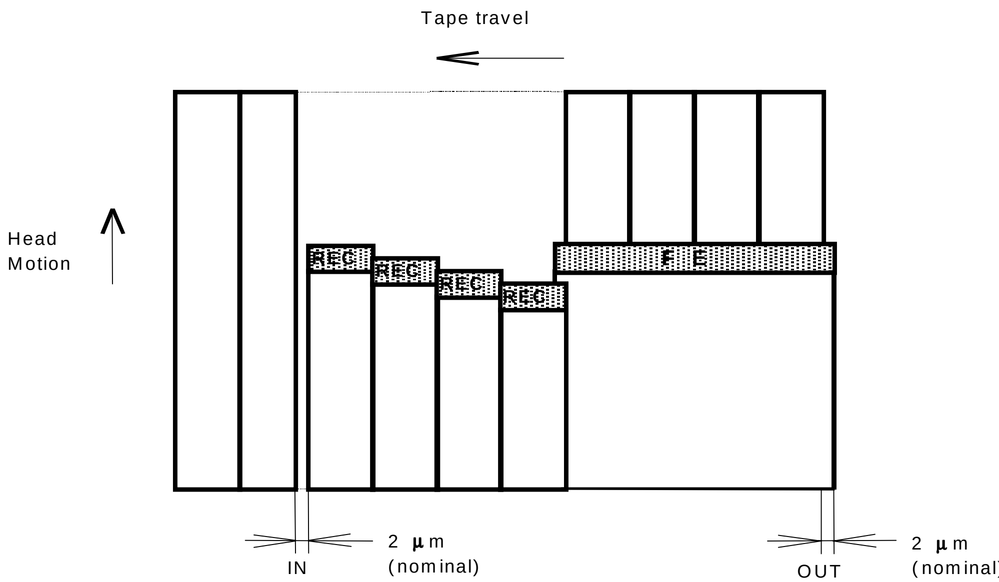


Figure B.3 – Track location error plot (example)

Annex C (normative)
Track pattern during insert editing

A guard band of 2 µm (nominal) at editing points only is shown in figure C.1.



NOTES
1 REC is a recording head.
2 FE is a flying erase head.

Figure C.1 – A typical pattern during insert editing

Annex D (informative)
Application of D-5 format system for recording of wide-screen 525/60 television signal

D.1 Support document for D-5 format system in mode 1

525/60 system

Luminance signal Y, color-difference signals C_R, C_B (see figure D.1)

4 × 3 aspect ratio component system, 13.5-MHz clock:

Luminance: 720 samples/TV line
Color-difference: 2 × 360 samples/TV line
Quantization: 10 bits

16 × 9 aspect ratio component system, 18-MHz clock:

Luminance (4/3) × 720: 960 samples/TV line
Color-difference: 2 × 480 samples/TV line
Quantization: 8 bits

Data capacity (number of bits)/TV line:

13.5 MHz: 2 x 720 x 10 bits = 14400 bits/TV line
18 MHz: 2 x 960 x 8 bits = 15360 bits/TV line

Basic memory arrangement: 384 samples × 4 channels × 10 bits = 15360 bits/TV line.

Sample arrangement: Luminance samples are divided into odd and even samples Y_o, Y_e.

Color-difference samples and Y_e are processed together as one group forming the following sample arrangement:

Y_o
Y_e, C_R, C_B

All samples have 10-bit quantization.

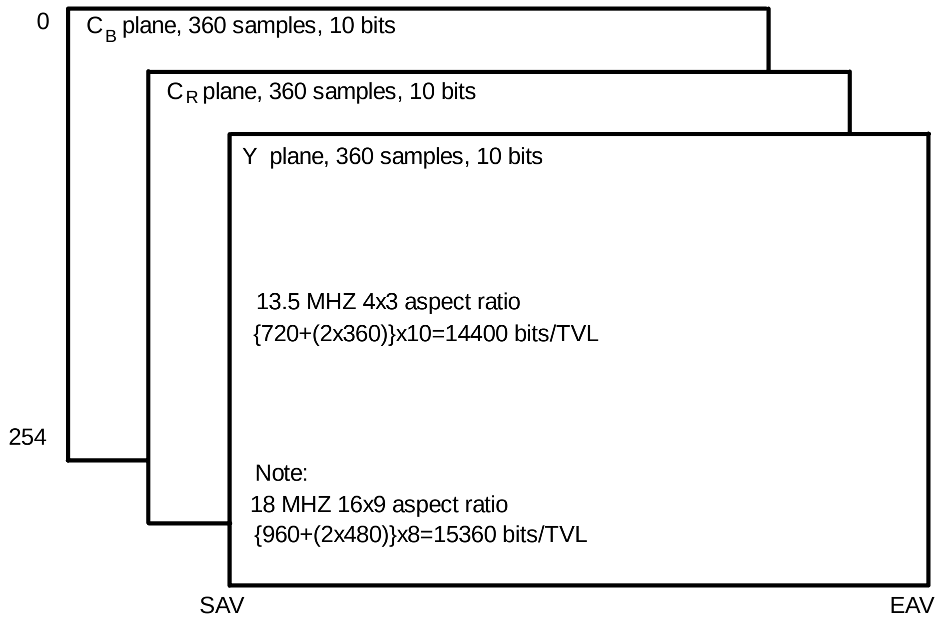


Figure D.1 – 4:2:2 signal, sampling frequency 13.5 MHz, aspect ratio 4:3

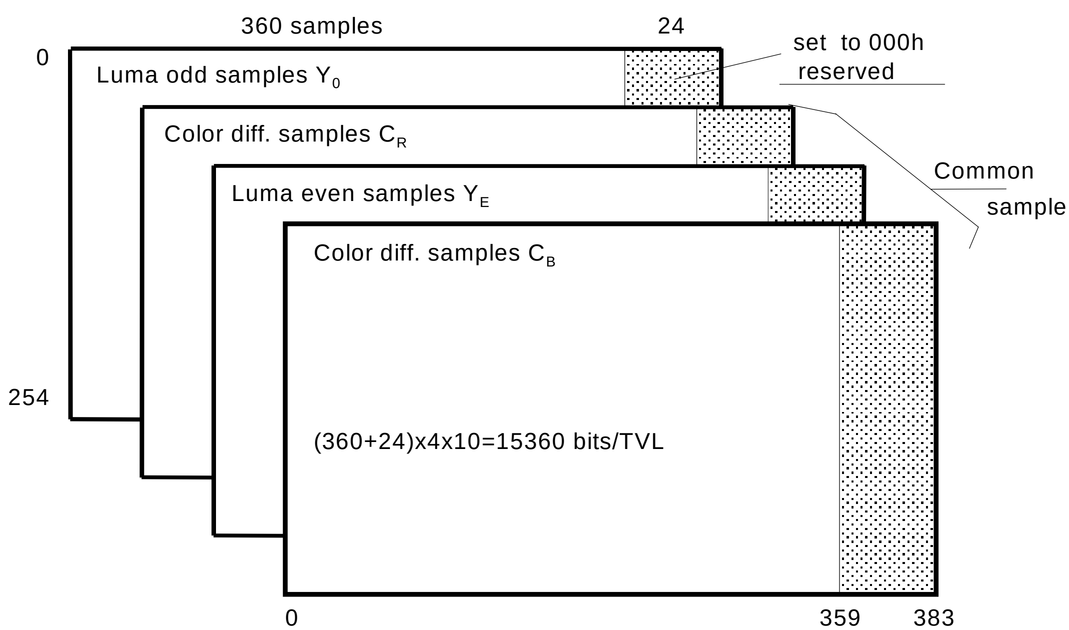


Figure D.2 – Basic processing channel arrangement

As a result of this arrangement, the format uses four different signal channels each containing 360 samples. The sample rearrangement is depicted in figure D.2.

This arrangement is chosen to minimize picture degradation due to burst error propagation from dropouts. Even samples from the high-resolution luminance signal and lower resolution color-difference signals are processed together to realize the following advantages:

a) A loss of one pixel affects the image only at one point in the picture.

b) Improved picture quality in the shuttle due to updating of picture elements containing the even luminance sample and its associated color-difference samples.

Additional design constraints are that each sample group is placed in one sync block and the error concealment system is highly effective during head clogs.

D.2 Signal channel distribution (see figures D.3–D.5)

The following is an example of how the 13.5-MHz Y, C_R, and C_B picture samples are distributed and eventually mapped into four-channel spaces:

Line 0, first 12 samples, 10-bit samples:

Luminance odd samples:

Y1	Y3	Y5	Y7	Y9	Y11	Y13	Y15	Y17	Y19	Y21	Y23

Common samples:

CR0	CR2	CR4	CR6	CR8	CR10	CR12	CR14	CR16	CR18	CR20	CR22
Y0	Y2	Y4	Y6	Y8	Y10	Y12	Y14	Y16	Y18	Y20	Y22
CB0	CB2	CB4	CB6	CB8	CB10	CB12	CB14	CB16	CB18	CB20	CB22

The samples illustrated above are mapped into 12 processing blocks. Detailed mapping results are shown in figures 24 and 25 and simplified below to help the reader. It should be noted that Vblk (video block) corresponds to the X coordinate of the resulting map. All samples at this step contain 10 bits.

From the equations which are defined in the standard, a single example was selected to show how the mapping process is accomplished:

Example of 525/60 equation: Ch = {Chi (H mod 6) + int (H/6) + L} mod 4

Modulo n of a number A: A mod n = A-[int (A/n)]n

Process for line L = 0; H = sample numbers from 0 to 15:

H	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
H mod 6	0	1	2	3	4	5	0	1	2	3	4	5	0	1	2	3
Chi	0	2	1	1	3	0	0	2	1	1	3	0	0	2	1	1
int (H/6)	0	0	0	0	0	0	1	1	1	1	1	1	2	2	2	2

Process for line L = 0: Channel number

H	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
CH (P_X)	0	1	3	1	2	0	2	3	1	3	0	2	0	1	3	1
CH (Y_O)	2	1	0	3	2	1	0	3	2	1	0	3	2	1	0	3

where P_X is C_R, Y_e, C_B = group of samples;
Y_o = single sample.

The video block number is mapped in a similar way.

The same process is used to develop coordinates for writing samples into the video block. The following examples show the mapping coordinates for a line with samples 0 through 11:

H	0	1	2	3	4	5	6	7	8	9	10	11

X coordinate (video block number)

P_X	0	1	2	0	1	2	0	1	2	0	1	2
Y_O	2	0	1	2	0	1	2	0	1	2	0	1

Y coordinate (channel number)

P_X	0	1	3	1	2	0	2	3	1	3	0	2
Y_O	2	1	0	3	2	1	0	3	2	1	0	3

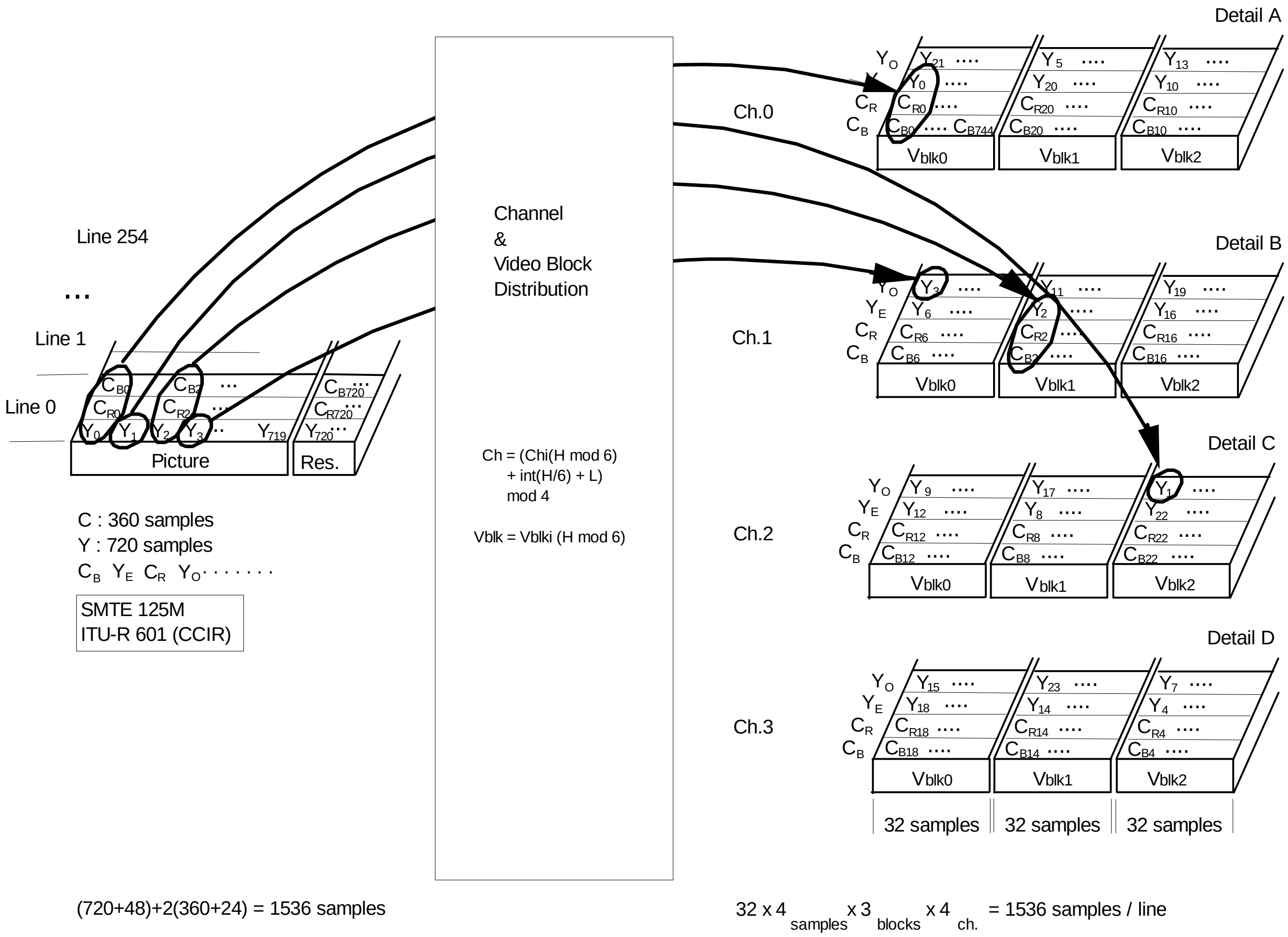


Figure D.3 – D-5 video processing (1) (525/60 system)

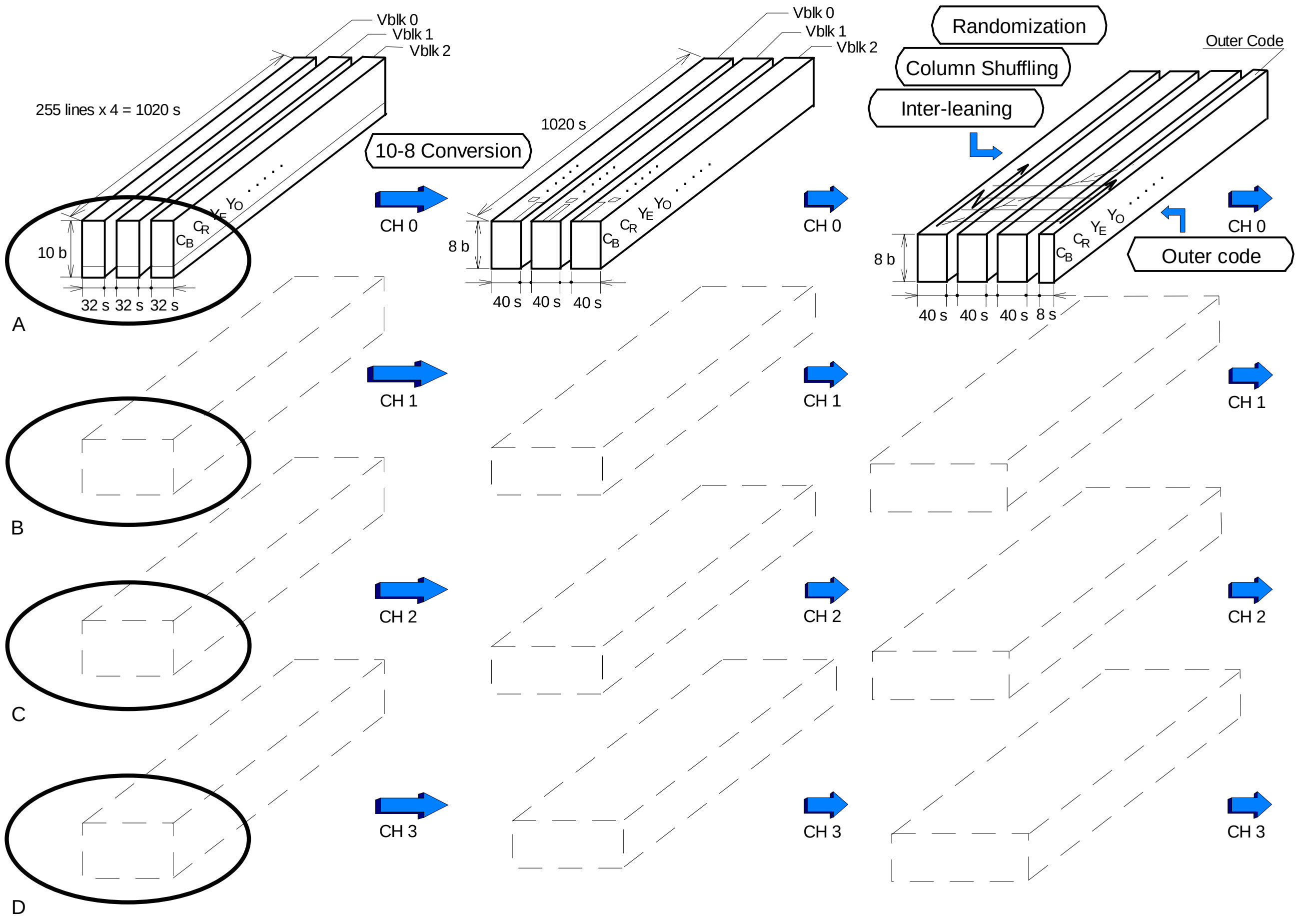


Figure D.4 – D-5 video processing (2) (525/60 system)

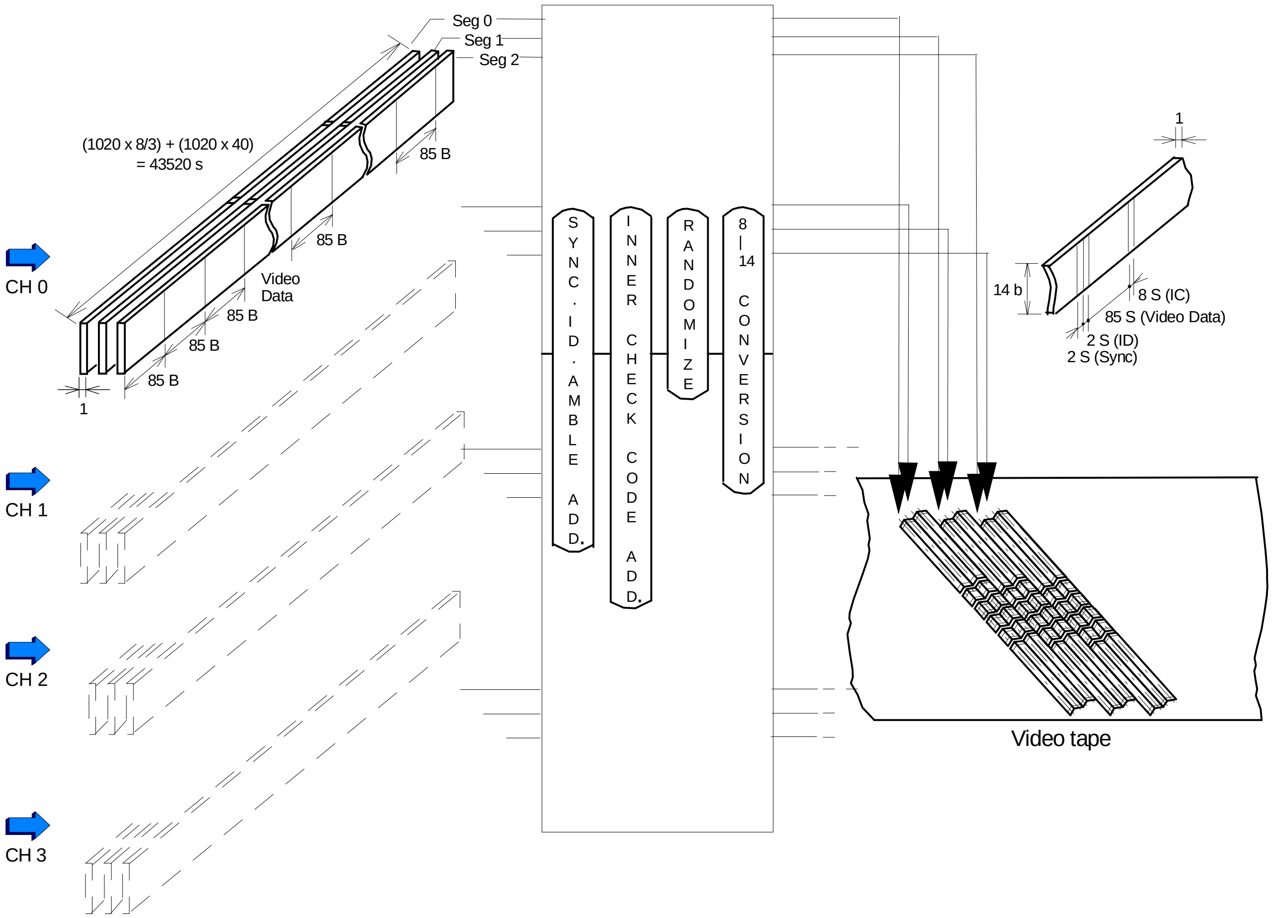


Figure D.5 – D-5 video processing (3) (525/60 system)

Resulting map arrangement (all samples are 10-bits):

Channel 0

Video block 0		Video block 1		Video block 2	
CR0 CB0 Y0	....	CR20 CB20 Y20	....	CR10 CB10 Y10	....
Y21	....	Y5	....	Y13	....

Channel 1

Video block 0		Video block 1		Video block 2	
CR6 CB6 Y6	....	CR2 CB2 Y2	....	CR16 CB16 Y16	....
Y3	....	Y11	....	Y19	....

Channel 2

Video block 0		Video block 1		Video block 2	
CR12 CB12 Y12	....	CR8 CB8 Y8	....	CR22 CB22 Y22	....
Y9	....	Y17	....	Y1	....

Channel 3

Video block 0		Video block 1		Video block 2	
CR18 CB18 Y18	....	CR14 CB14 Y14	....	CR4 CB4 Y4	....
Y15	....	Y23	....	Y7	....

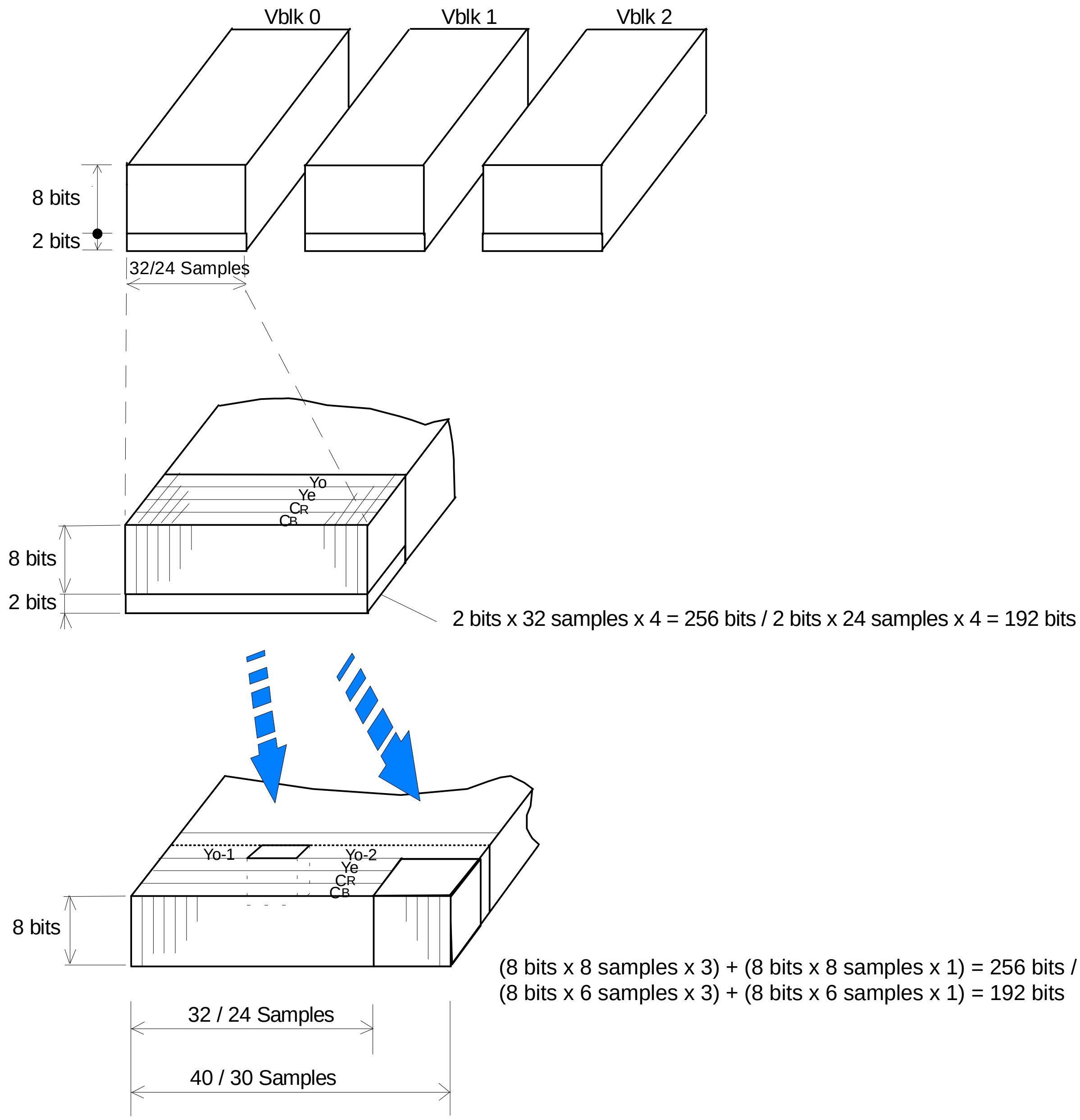
D.3 10-bit to 8-bit conversion (see figure D.6)

The next step in the processing is 10- to 8-bit separation (conversion) channel process (figure 29); 4 channels deep.

There are two groups of words, one consisting of 8 MSBs of each original word and a combined word that consists of the remaining two LSBs organized into (2 x 4) bits which equal one 8-bit combined word.

626/50 system

Video processing for the 625/50 system is similar to that for the 525/60 system and is shown in figures D.7 to D.9.



NOTE: 525/60 system/ 625/50 system

Figure D.6 – 10-8 conversion

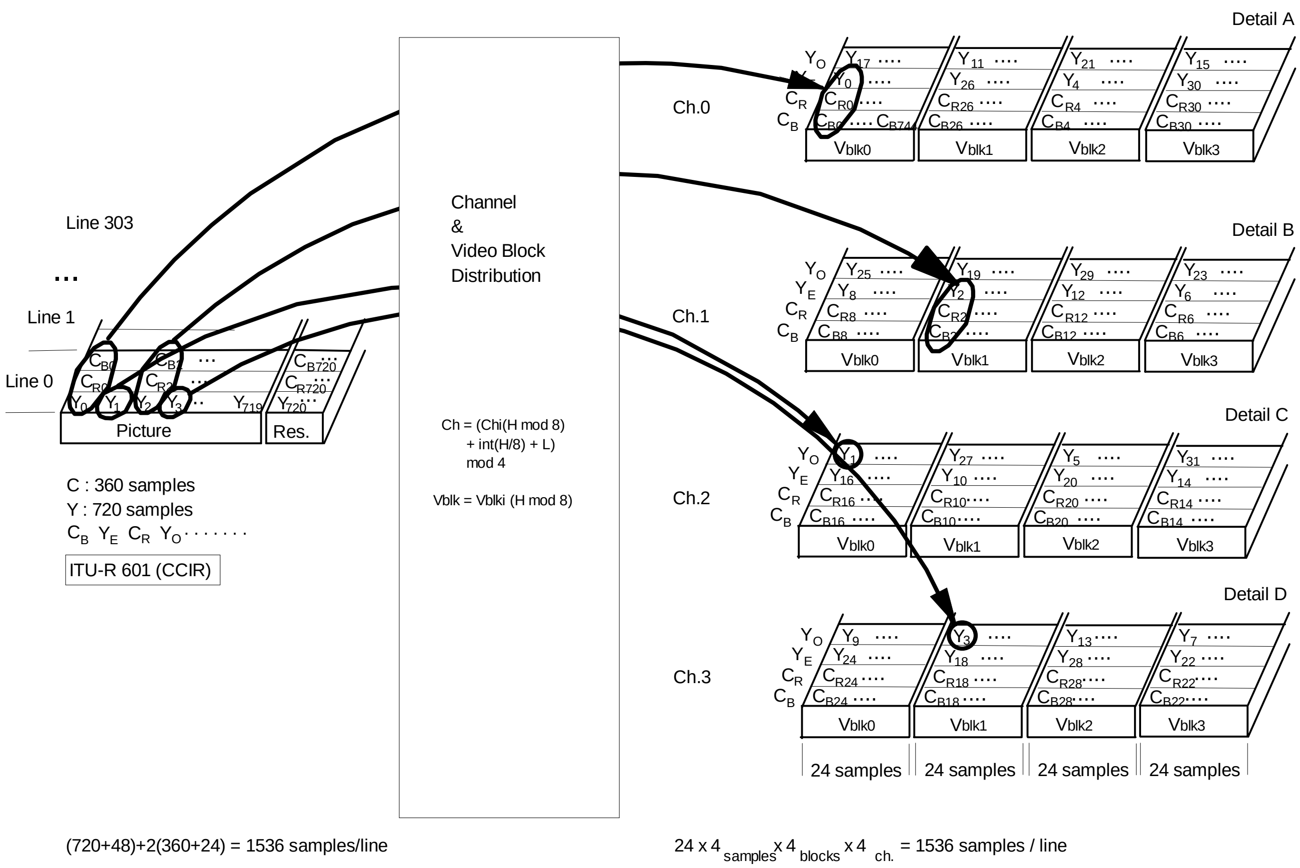


Figure D.7 – D-5 video processing (1) (625/50 system)

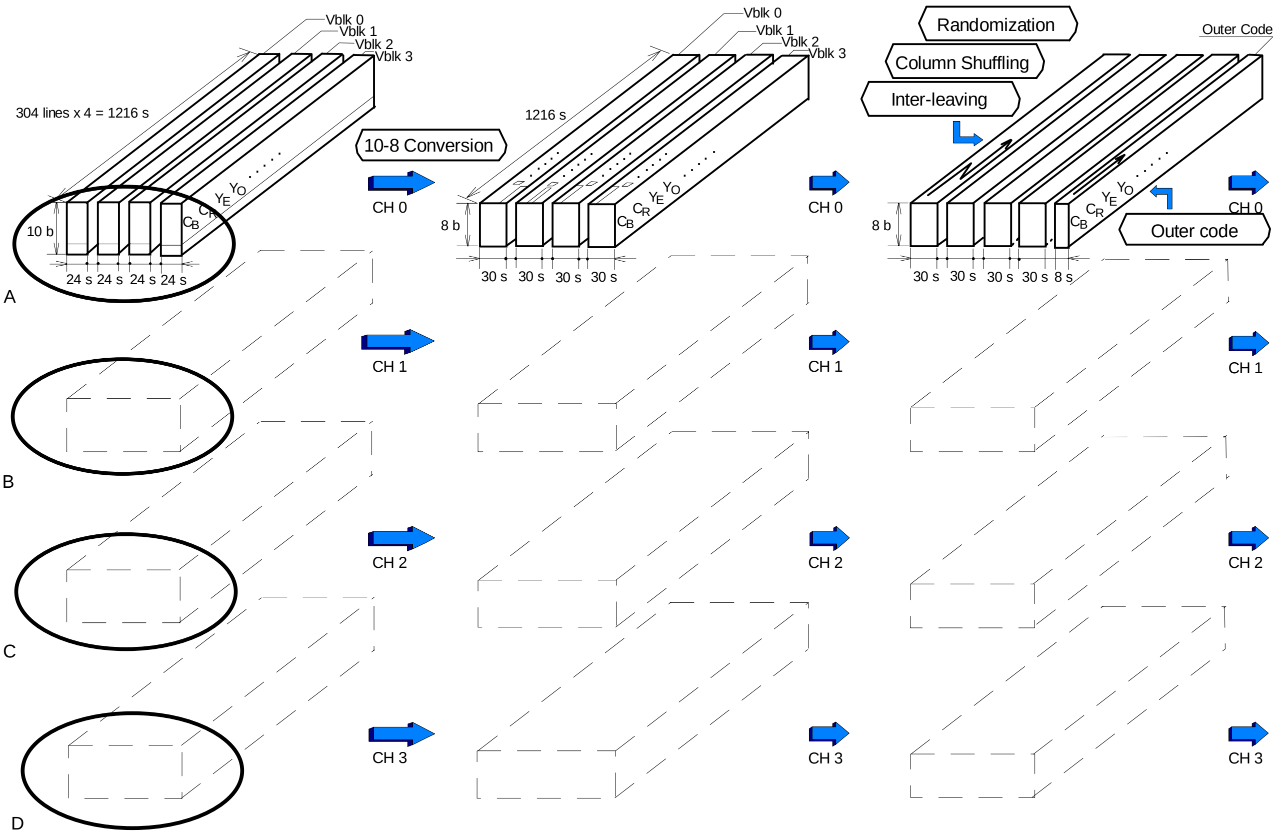


Figure D.8 – D-5 video processing (2) (625/50 system)

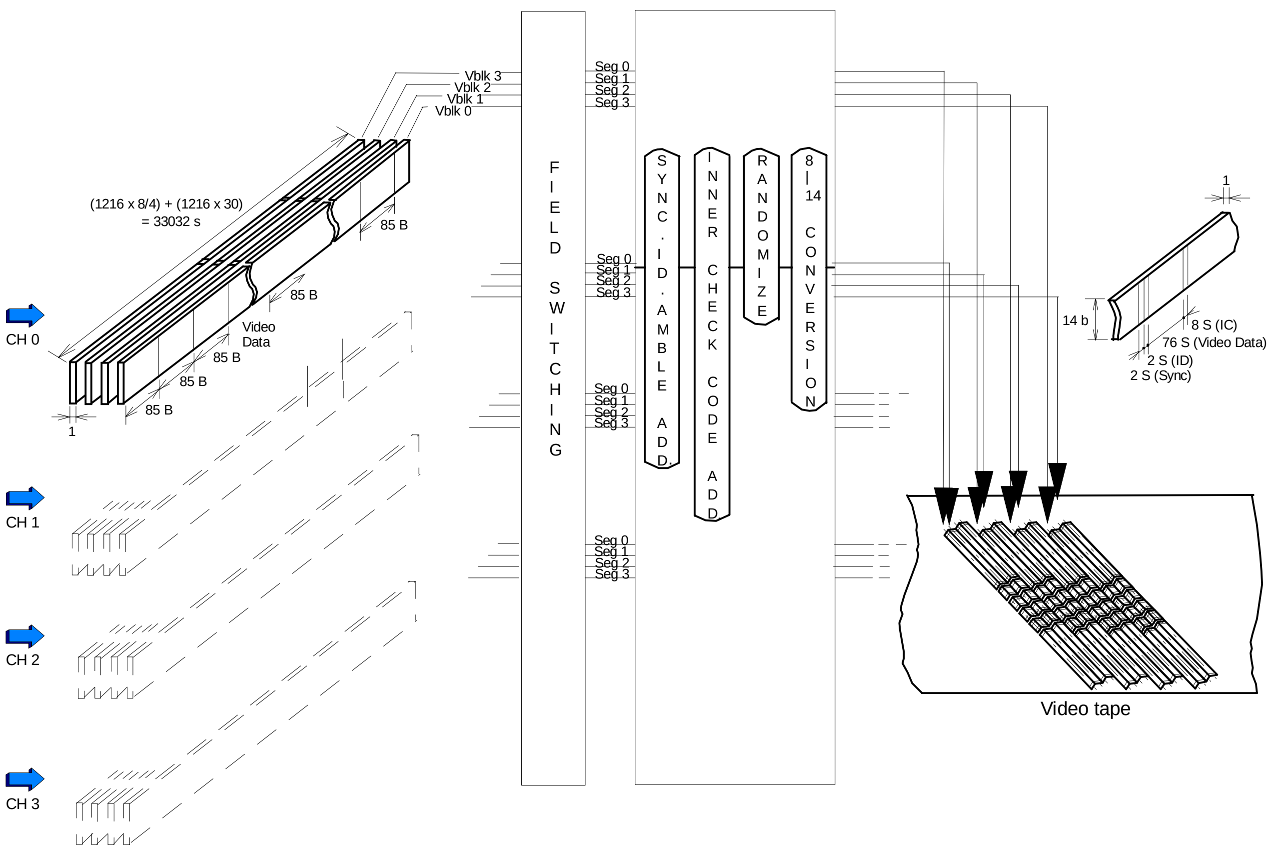


Figure D.9 – D-5 video processing (3) (625/50 system)

Annex E (informative)
Data volume of one field

– Mode 1

10 bits x (720 samples + 48 samples) x 2 x 255 lines = 3,916,800 bits/field

– Mode 2

8 bits x 960 samples x 2 x 255 lines = 3,916,800 bits/field

– Mode 3

8 bits x 85 bytes x 5760 DIF blocks = 3,916,800 bits/field.

Annex F (informative)
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