

SMPTE STANDARD

for Television Digital Recording — 1/2-in Type D-3 Composite Format — 525/60



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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 code tracks.

One video channel and four independent audio channels are recorded in the digital format. Each of these channels is designed to be capable of independent editing.

The video channel records and reproduces a composite television signal in the 525-line system with a frame frequency of 29.97 Hz.

Figures 1 and 2 show a block diagram 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.

ANSI/SMPTE 244M-1995, Television — System M/NTSC Composite Video Signals — Bit-Parallel Digital Interface

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

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

ITU-R BS. 647-2 (1994), A Digital Audio Interface for Broadcasting Studios

ITU-R BT.470-4 (1994), Television Systems

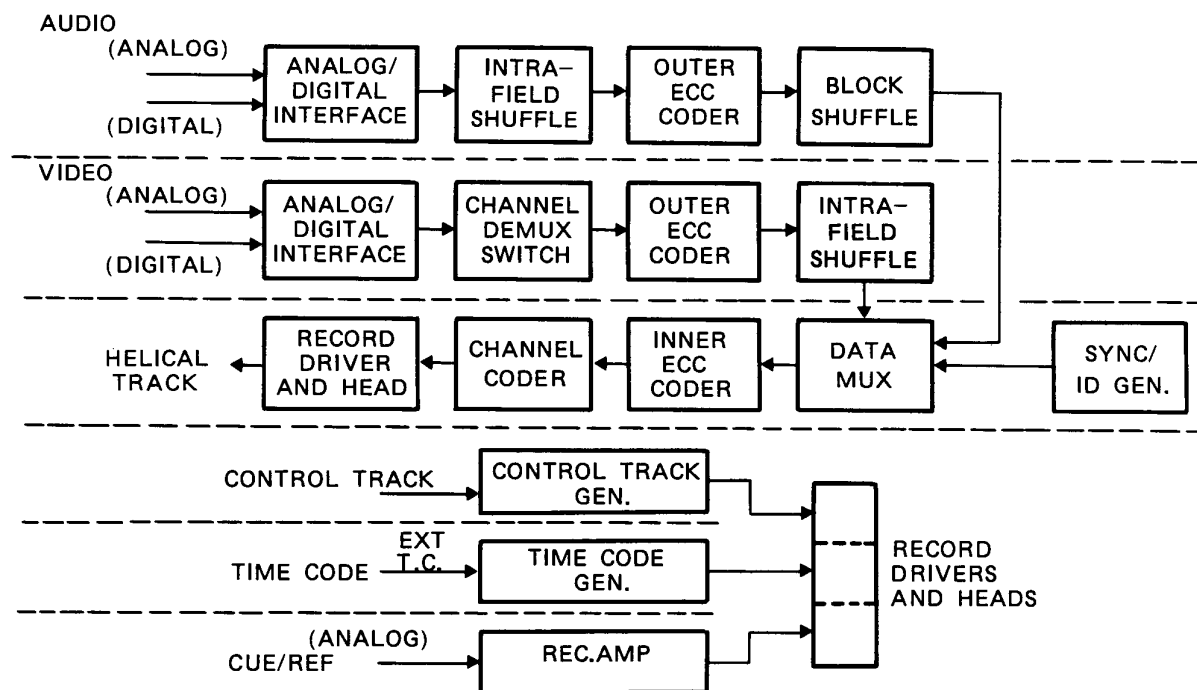


Figure 1 – Record block diagram

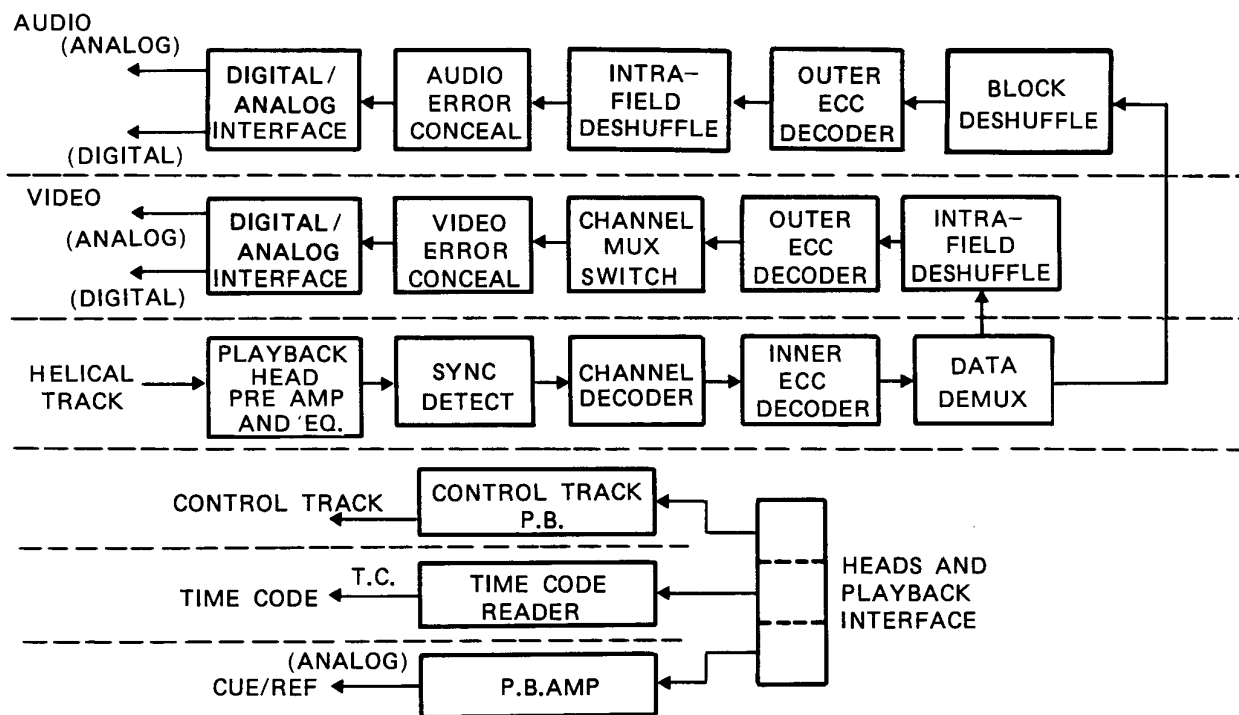


Figure 2 – Playback block diagram

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 $(20 \pm 1)^{\circ}\text{C}$
- Relative humidity $(50 \pm 2)\%$
- Barometric pressure 86 kPa to 106 kPa
- Tape conditioning not less than 24 h
- Center tape tension (0.31 ± 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 specified 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 video tape recorders and players in accordance with this standard.

3.3.1 Record locations and dimensions

The tolerances shown in table 1 shall be reduced by 50%.

3.3.2 Calibration signals

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

- (a) – Video: Color bars;
– Audio: 1 kHz-tone at -20 dB below full level;
– Cue: 1-kHz tone at reference level; 10-kHz tone at reference level.
- (b) A signal of constant recorded frequency (i.e., one-half the Nyquist frequency) only with tracks of field 0, segment 0 for the purpose of mechanical alignment.

4 Video tape

4.1 Base

The base material shall be polyester or equivalent.

4.2 Width

The tape width shall be $12.650 \text{ mm} \pm 0.008 \text{ mm}$. The tape, covered with glass, is measured without tension at a minimum of five different positions along the tape using a calibrated comparator having an accuracy of $1/1000 \text{ mm} = 1 \mu\text{m}$. The tape width is defined as the average of the five readings.

4.3 Width fluctuation

Tape width fluctuation shall not exceed $5 \mu\text{m}$ peak-to-peak. Measurement of tape width fluctuation shall be over a tape length of 900 mm at the beginning of tape winding. The value of tape width fluctuation shall be evaluated by measuring the tape width at 10 points each separated by a distance of 100 mm.

4.4 Reference edge straightness

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

4.5 Tape thickness

The thickness of the tape (including all coatings) shall be $10.2 \mu\text{m}$ to $11.0 \mu\text{m}$ and $13.0 \mu\text{m}$ to $14.0 \mu\text{m}$, respectively

4.6 Transmissivity

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

4.7 Offset yield strength

The offset yield strength shall be greater than 9 N for $11 \mu\text{m}$ tape and 10 N for $14 \mu\text{m}$ tape. The force to produce 0.2% tangential elongation of a 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.

Table 1 – Record location and dimensions

Dimensions		Millimeters	
		Nominal	Tolerance
A	Time code track lower edge	0	Basic
B	Time 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	1.567	Derived
F	Program area width	10.090	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
K	Video sector length	107.095	Derived
L	Helical track total length	117.667	Derived
M ₁	Audio sector 1 length ¹⁾	2.266	Derived
M	Audio sector 2–4 length ²⁾	2.185	Derived
P ₁	Control reference pulse to program reference point (see figure 22)	176.000	± 0.050
P ₂	Cue/time code signal (bit No. 0) to program reference point	177.430	± 0.100
W	Tape width	12.650	± 0.008
X ₁	Location of start of video sector	0	± 0.050
X ₂	Location of start of audio sector A ₄ ³⁾	110.155	± 0.050
X ₃	Location of start of audio sector A ₂ ³⁾	107.533	± 0.050
X ₄	Location of start of audio sector A ₃ ³⁾	2.623	± 0.050
X ₅	Location of start of audio sector A ₁ ³⁾	5.245	± 0.050
Y	Program area reference	2.030	Basic
θ	Track angle	4.9192° basic	
α ₀	Azimuth angle (track 0)	−20.019° ± 0.150°	
α ₁	Azimuth angle (track 1)	19.981° ± 0.150°	

¹⁾ Audio sectors located at the start of helical tracks.
²⁾ All other audio sectors.
³⁾ Audio channel numbers vary (see 10.9).

NOTE – 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).

4.8 Magnetic coating

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

4.9 Coating coercivity

The coating coercivity shall be a class 1600 (127300 A/m), with an applied field of 5000 Oe as measured by a 50- or 60-Hz B-H meter or vibrating sample magnetometer (VSM).

4.10 Particle orientation

The metal particles shall be longitudinally oriented.

5 Helical recording

5.1 Tape speed

The tape speed shall be 83.880 mm/s; the tolerance shall be ± 0.2%.

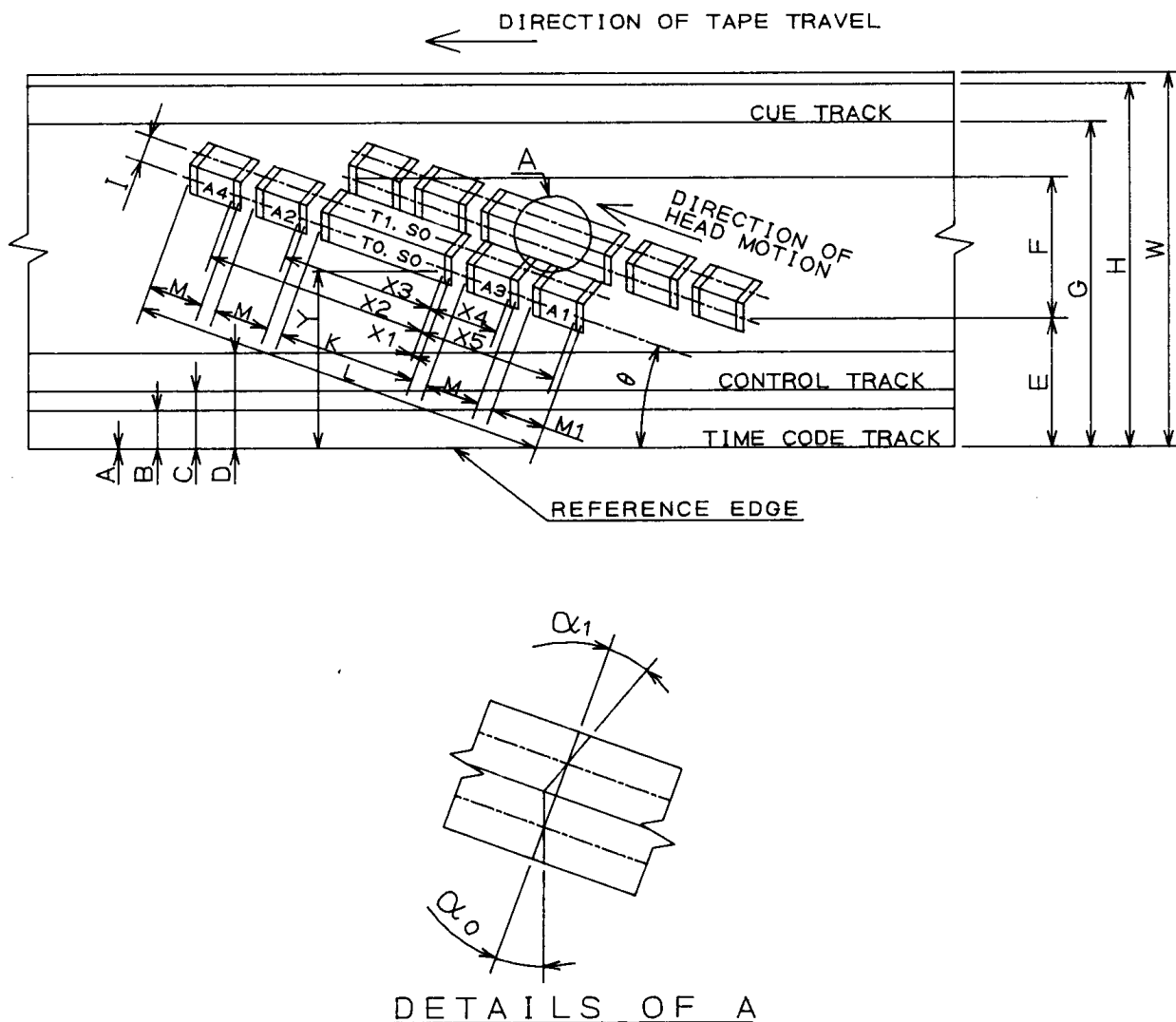
5.2 Record location and dimensions

5.2.1 The format requires a full-width erase head for continuous recording and a flying erase head for insert editing.

5.2.2 Record location and dimensions for continuous recording shall be as specified in figures 3 and 4 and table 1. In recording, sector locations

on each helical track shall be contained within the tolerance specified in table 1 and figure 3.

5.2.3 The reference edge of the tape for 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 annexes B and C.)



NOTES

- 1 A1, A2, A3, and A4 are audio sectors.
- 2 T0 and T1 are track numbers; S0 is a segment number (typical). The track number is identified by the azimuth angle.
- 3 Tape viewed from magnetic coating side.
- 4 Dimensions X1-X5 are determined by the program reference point as defined in figure 4.

Figure 3 – Location and dimensions of recorded tracks

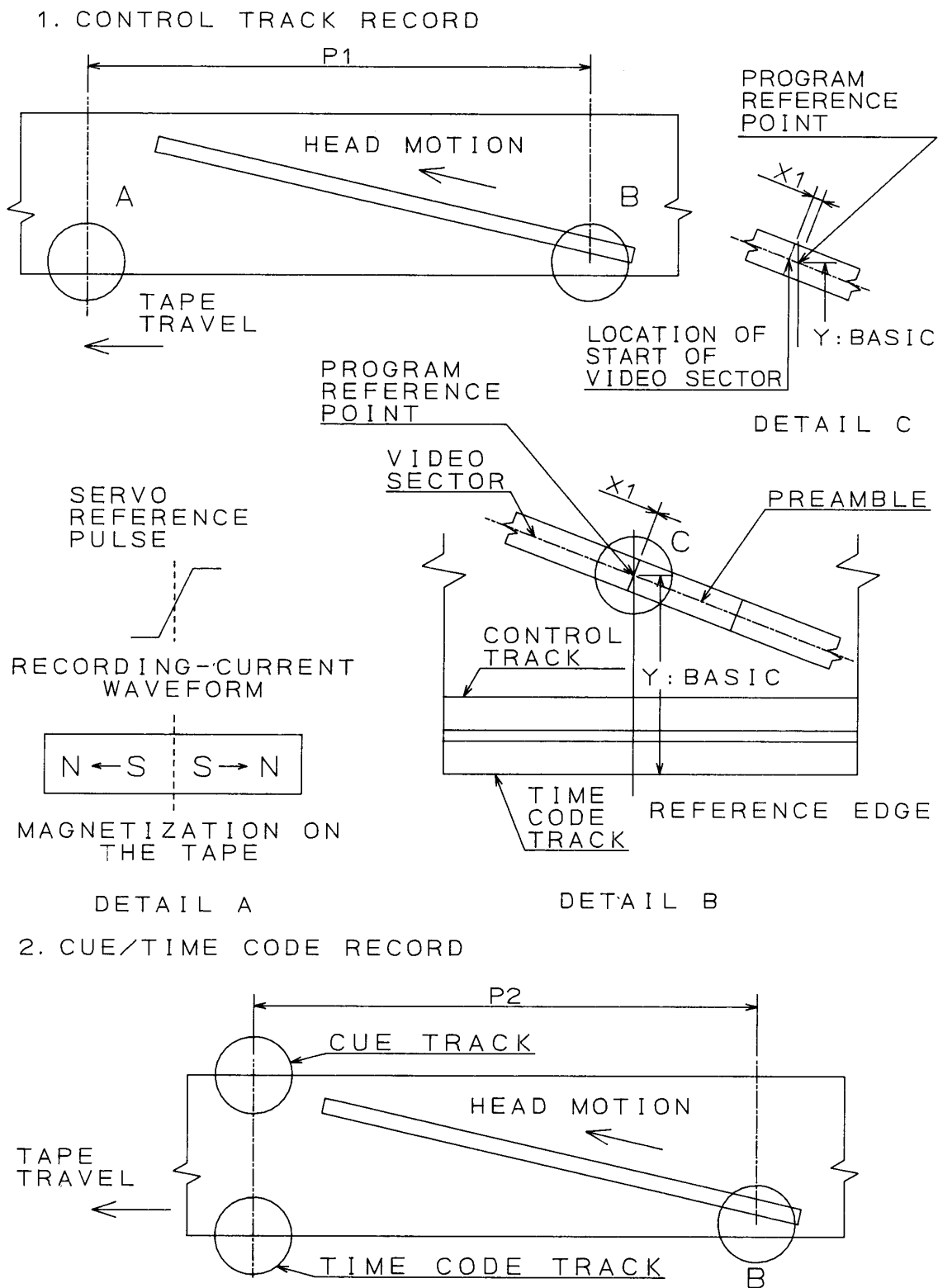


Figure 4 – Location of cue, time code and control track record

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 . The scanner head configuration should be chosen such that the recorded track widths are contained within the limits of 18 μm to 22 μm .

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

5.3 Helical track record tolerance zones

5.3.1 The lower edges of any four consecutive tracks starting at the first track in each video frame shall be contained within the pattern of the four tolerance zones established in figure 5. Each zone is defined by two parallel lines which are inclined at an angle of 4.9192° basic, with respect to the tape reference edge.

5.3.2 The centerlines of all zones shall be spaced apart 0.0200 mm basic. The width of zones 1, 3, and 4 shall be 0.006 mm basic. The width of zone 2 shall be 0.004 mm basic. These zones are established to contain track angle errors, track straightness errors, and vertical head offset tolerance. (Measuring techniques are shown in annexes B and C.)

5.4 Relative positions of recorded tracks

5.4.1 Relative positions of longitudinal tracks

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

5.4.2 Helical/control track relationship

The spatial relationship among the cue track record, time code record, control track record, and helical tracks is specified in figures 3 and 4.

5.4.3 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). The end of the preamble and the start of the video sector shall be recorded at the program area reference point; the tolerance is dimension X_1 . The locations are shown in figures 3 and 4; dimensions X_1 and Y are specified in table 1. The relationship between sectors and contents of each sector is specified in clause 6.

5.5 Gap azimuth

5.5.1 Cue track, control track, time code track

The azimuth angle of the cue, control track, and time 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 recording shall be inclined at angles α_0 and α_1 as specified in table 1 to the perpendicular to the helical track record. The azimuth of the first track of every field (segment 0, track 0) shall be oriented in a counterclockwise direction with respect to the line perpendicular to the 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 supports tape motion during normal playback mode. Data is recorded by 2 head pairs mounted at 180° angles from each other. Figure 6 shows one possible mechanical configuration of the scanner and table 2 shows the corresponding mechanical parameters. Figure 7 shows the relationship between the longitudinal heads and the scanner.

Other mechanical configurations are allowable provided the same footprint of recorded information is produced on tape. Erase heads are described in 5.2.1 and figure 6.

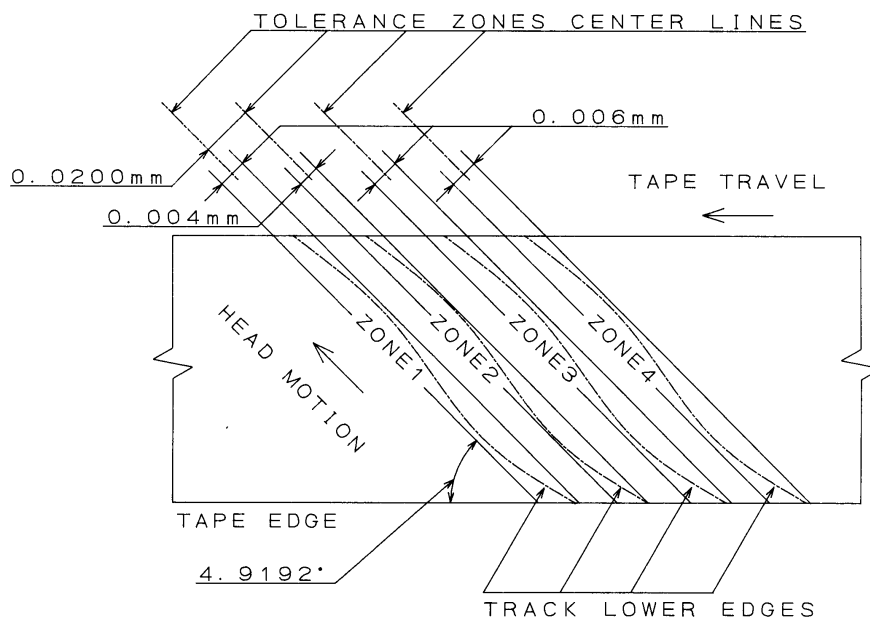


Figure 5 – Location and dimensions of tolerance zones of helical track record

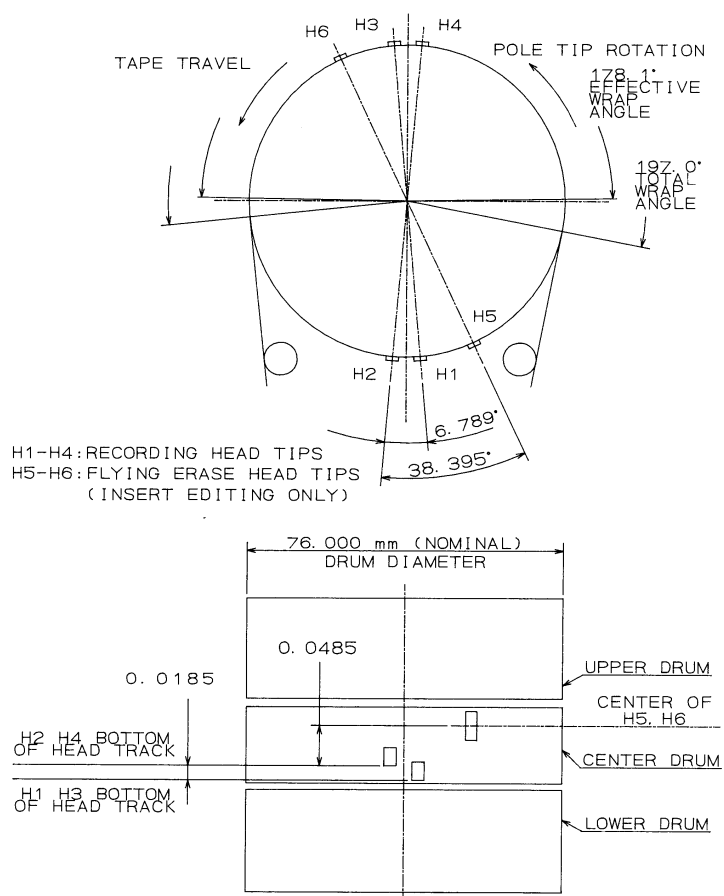
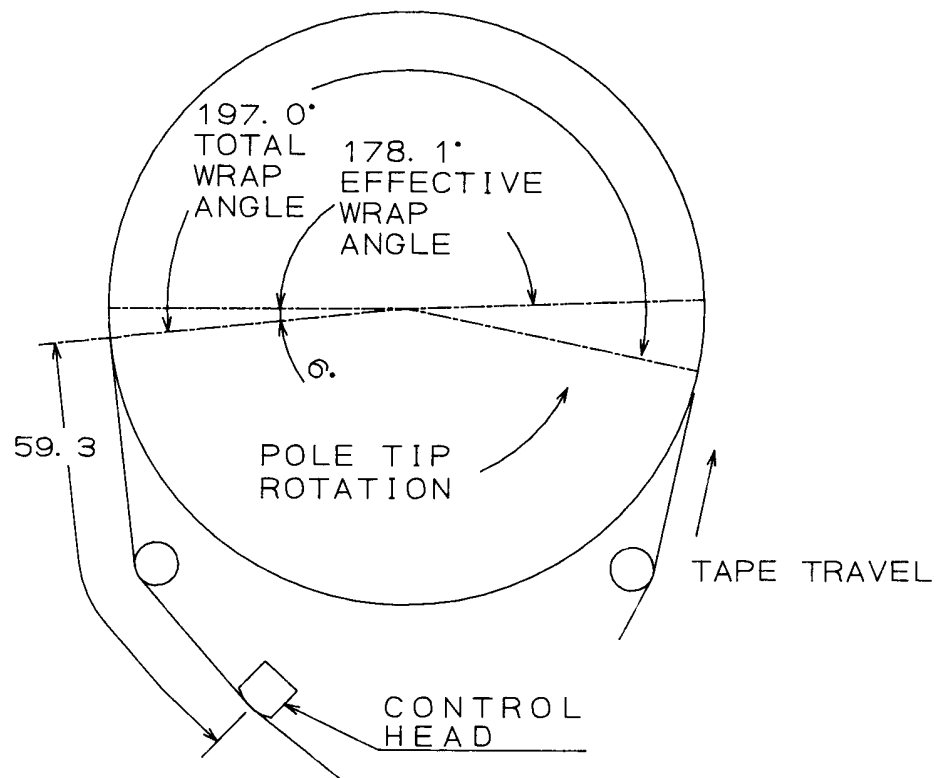
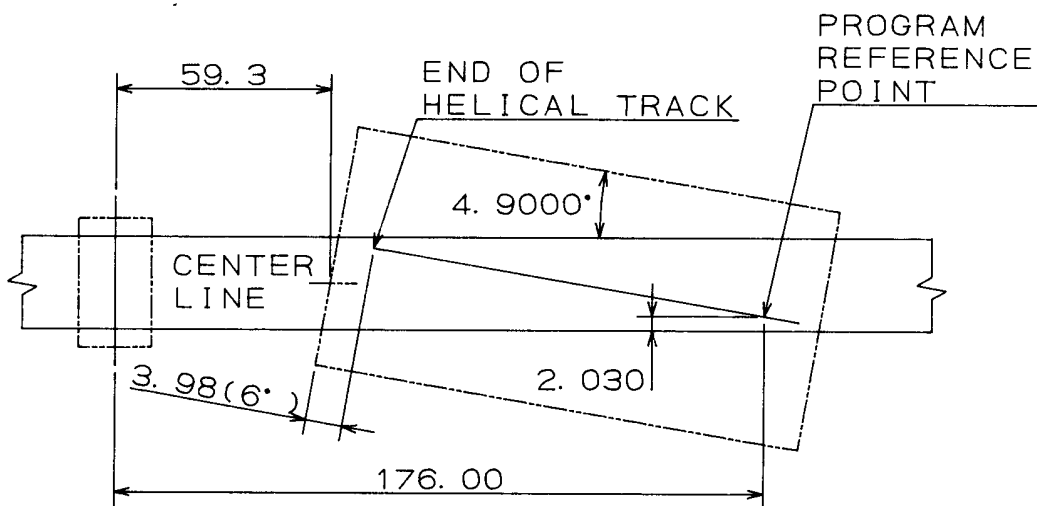


Figure 6 – A possible scanner configuration



TOP VIEW



NOTE – Unwrapped, viewed magnetic coating side.

Figure 7 – A possible longitudinal head location and tape wrap

Table 2 – Parameters for a possible scanner design

Parameters		Values
Scanner rotation speed (rps)		90/1.001
Number of tracks per rotation		4
Drum diameter (mm)		76.000
Center span tension (N)		0.31
Helix angle (degrees)		4.9000
Effective wrap angle (degrees)		178.1
Scanner circumferential speed (m/s)		21.5
H1,H3 overwrap head entrance (degrees)		12.9
H1,H3 overwrap head exit (degrees)		6
Angular relationship (degrees)	H1 – H2	6.789
	H3 – H4	6.789
	H1 – H3	180.00
Vertical displacement (mm)	H1 – H2	0.0185
	H3 – H4	0.0185
Maximum tip projection (μm)		35
Record head track width (μm)		20

6 Program track data

6.1 Introduction

Each TV field is recorded on six tracks.

The helical tracks contain digital data from the video channel and four audio channels. The audio data is contained in four recorded sectors per track, two at the beginning of the track and two at the end of the track. The video data is recorded in a sector in the middle part of each track. An edit gap between sectors accommodates timing errors during editing. Figure 8 shows the arrangement of video and audio sectors on the tape.

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

- Preamble containing clock run-up sequence, sync pattern, identification pattern, and fill pattern;

- Sync blocks containing sync pattern and identification pattern, followed by a fixed length data block with error control;

- Postamble containing sync pattern and identification pattern.

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

6.3.1 Sync block

The sync block format is common for both audio and video sectors. Each sync block contains a sync pattern (2 bytes) and an inner code block. Each inner code block contains an identification pattern (2 bytes) and 85 data bytes (outer check bytes are considered data) plus 8 inner check bytes. The inner code block protects the two bytes of the identification pattern together with 85 data bytes. Figure 9 shows the sync block format.

6.3.2 Sync pattern

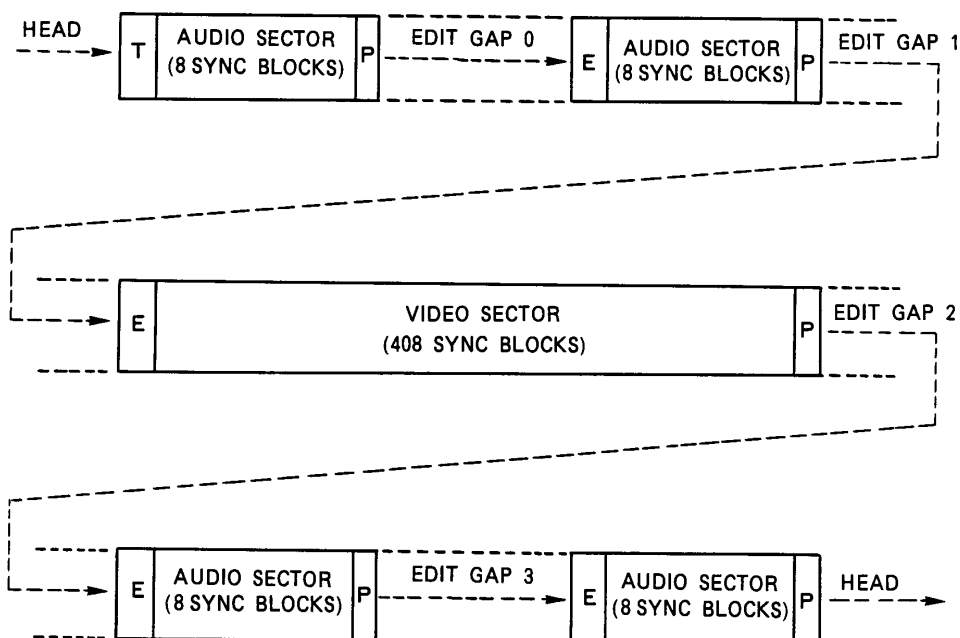
(a) Length: 16 bits (2 bytes).

(b) Pattern: 97F1 (in hexadecimal notation).

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

(c) Protection: None.

(d) Randomization: None.



NOTES

- 1 T = track preamble (58 bytes).
- 2 E = in-track preamble (28 bytes).
- 3 P = postamble (4 bytes).
- 4 Sync block = 97 bytes.
- 5 Edit gap = 162 bytes nominal.

Figure 8 – Sector arrangement on helical track

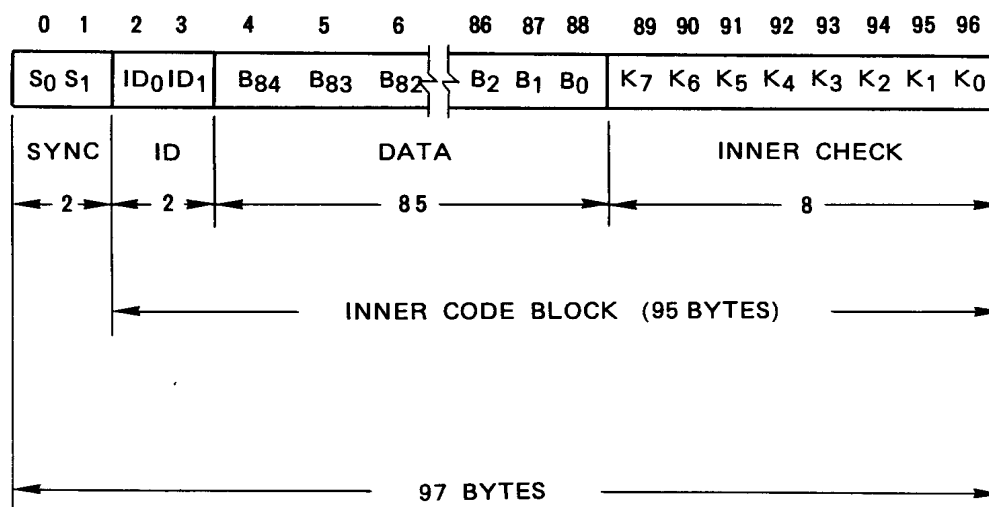


Figure 9 – Sync block format

6.3.3 Identification pattern

The first byte and bit 0 of the second byte of the identification pattern identify a particular sync block of a helical track. Bits 1-7 of the second byte of the identification pattern identify a particular track. Figure 10 shows the format of the identification pattern.

(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 11 shows the sequence of sync block numbers.

The sector ID (bits 1–7 of byte 3) identifies a particular sector. The (V/A) bit distinguishes between audio and video sectors.

The segment count is modulo 3. The field count for video sectors is modulo 4 ($F_2 = 0$ in byte 3). The field count for audio sectors is modulo 4 (for F_0 and F_1 in byte 3) and F_2 (in byte 3) is used for the identification of the five-field sequences.

(c) The field address F_0 , F_1 , F_2 (bits 4, 5, and 6 of byte 3) for video sync blocks shall identify the four-field color sequences as defined in ITU-R BT.470, and have the values as shown below:

	F_0	F_1	F_2
Color frame A, color field I	0	0	0
Color frame A, color field II	1	0	0
Color frame B, color field III	0	1	0
Color frame B, color field IV	1	1	0

The field address F_0 and F_1 (bits 4 and 5 of byte 3) for audio sync blocks shall identify the four fields of the five-field sequences. When audio sectors are edited, the four-field sequences shall be maintained.

The field address F_2 (bit 6 of byte 3) for audio sync blocks shall identify the number of audio samples in the current field as shown below:

The number of audio samples in the current field:

	F_2
801	0
800	1

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

(e) Randomization: The identification pattern is randomized before being channel coded. The randomizing is equivalent to performing the EXOR operation between the serial data stream and the serial stream generated by the polynomial function $x^8 + x^4 + x^3 + x^2 + 1$ (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 80h 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. 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.

(b) Arrangement: See figure 9.

(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: Leftmost term is most significant, oldest in time computationally, and first written to tape.

Code generator polynomial in $GF(256)$:

$G(x) = (x+1)(x+a)(x+a^2)(x+a^3)(x+a^4)(x+a^5)(x+a^6)(x+a^7)$, where a is given by 02h in $GF(256)$.

Check characters: $K_7, K_6, K_5, K_4, K_3, K_2, K_1, K_0$ in $K_7x^7 + K_6x^6 + K_5x^5 + K_4x^4 + K_3x^3 + K_2x^2 + K_1x + K_0$ obtained as the remainder after dividing $x^8D(x)$ by $G(x)$, where $D(x) = ID_0x^{86} + ID_1x^{85} + B_{84}x^{84} + \dots + B_2x^2 + B_1x + B_0$.

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

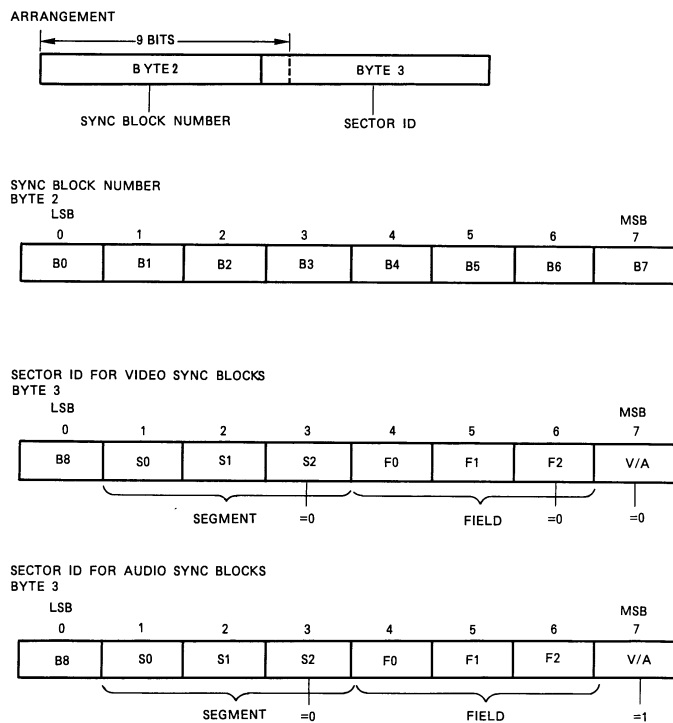


Figure 10 – Sync block identification format

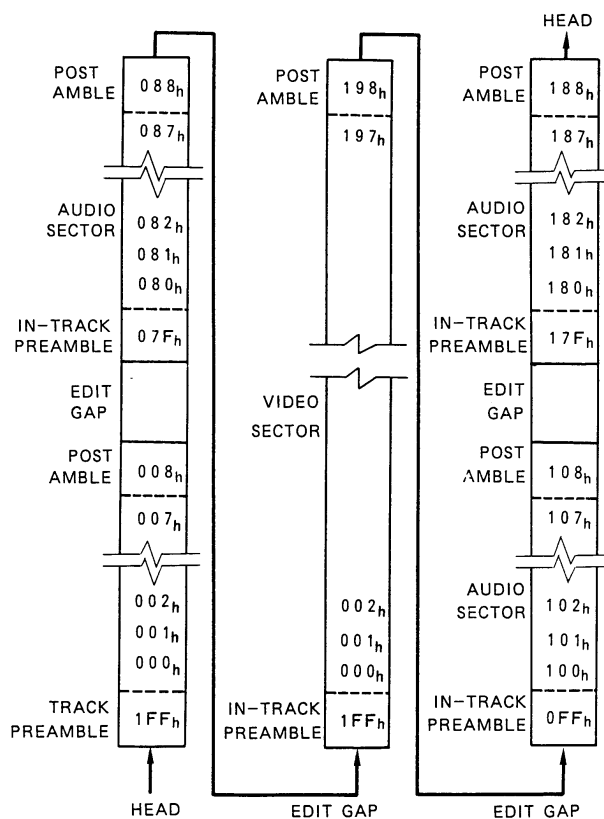


Figure 11 – Sync block number

(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(e).

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 run-up sequence, shall be recorded.

6.3.5.1 Track preamble

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

(a) Length: 58 bytes.

(b) Arrangement: See figure 12(a).

(c) Run-up pattern: 2C_h.

LSB	MSB
<u>0 0 1 1 0 1 0 0</u>	

(d) Fill pattern: 00_h.

(e) Protection: None.

(f) Randomization: Only the identification pattern (2 bytes) and fill pattern (4 bytes) are randomized before being channel coded. The randomization is equivalent to randomization as defined in 6.3.3(e).

6.3.5.2 In-track preamble

This preamble precedes every sector except the first sector of a track. The run-up sequence is 20 bytes long and contains 2C_h.

(a) Length: 28 bytes.

(b) Arrangement: See figure 12(b).

(c) Run-up pattern: 2C_h.

LSB	MSB
<u>0 0 1 1 0 1 0 0</u>	

(d) Fill pattern: 00_h.

(e) Protection: None.

(f) Randomization: Only the identification pattern (2 bytes) and the fill pattern (4 bytes) are randomized before being channel coded. The randomization is equivalent to randomization as defined in 6.3.3(e).

6.3.6 Sector postamble

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

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

(a) Length: 4 bytes.

(b) Arrangement: See figure 12(c).

(c) Protection: None.

(d) Randomization: Only the identification pattern (2 bytes) is randomized before being channel coded. The randomization is equivalent to randomization as defined in 6.3.3(e).

6.4 Edit gaps

The space between sectors on a track, exclusive of postamble and preamble, is nominally 162 bytes long, and is used to accommodate timing errors during editing. In an original recording, the edit gap shall contain the pattern 2C_h.

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

(a) Protection: None.

(b) Randomization: None.

Table 3 – 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
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	011100111110000	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
	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	10001111110011	2

Table 3 (continued)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
1(A)	40	01111001100111	4	1(B)	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		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
	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	10011111110011	4
	61	01111000111001	2	2(B)	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		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
1(A)	71	01100111111000	2		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

Table 3 (continued)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
2(A)	80	00111111100000	0	2(B)	80	11000000011111	0
	81	00111111000001	0		81	11000000111110	0
	82	001111110011000	0		82	11000001100111	0
	83	001111110001100	0		83	11000001110011	0
	84	001111110000110	0		84	11000001111001	0
	85	001111110000011	0		85	11000001111100	0
	86	001111100111000	0		86	11000011000111	0
	87	001111100110001	0		87	11000011001110	0
	88	001111100011100	0		88	11000011100011	0
	89	001111100011001	0		89	11000011100110	0
	8A	001111100001110	0		8A	11000011110001	0
	8B	001111100000111	0		8B	11000011111000	0
	8C	001110011111000	0		8C	11000110000111	0
	8D	00111001110001	0		8D	11000110001110	0
	8E	001110011001110	0		8E	11000110011001	0
	8F	00111001100011	0		8F	11000110011100	0
	90	001110001111100	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	001100111111000	0		95	11001100000111	0
	96	00110011110001	0		96	11001100001110	0
	97	001100111001110	0		97	11001100011001	0
	98	00110011100011	0		98	11001100011100	0
	99	001100110011110	0		99	11001100110001	0
	9A	00110011000111	0		9A	11001100111000	0
	9B	001100011111100	0		9B	11001110000011	0
	9C	00110001111001	0		9C	11001110000110	0
	9D	00110001110011	0		9D	11001110001100	0
	9E	00110001100111	0		9E	11001110011000	0
	9F	001100001111110	0		9F	11001111000001	0
	A0	00110000011111	0		A0	11001111100000	0
	A1	00111111100001	2		A1	11001100111110	4
	A2	001111110011100	2		A2	11001110011110	4
	A3	001111110001110	2		A3	11001111000111	4
	A4	00111111000011	2		A4	11001111001110	4
	A5	001111110011100	2		A5	11001111100011	4
	A6	001111110011001	2		A6	11001111100110	4
	A7	001111110001110	2	3(B)	A7	11100001111110	4
	A8	001111110000111	2		A8	11100011100111	4
	A9	001111100111100	2		A9	11100011110011	4
	AA	001111100111001	2		AA	11100011111100	4
	AB	001111100110011	2		AB	11100110011110	4
	AC	001111100011110	2		AC	11100111000111	4
	AD	001111100001111	2		AD	11100111001110	4
	AE	001111001111100	2		AE	11100111100011	4
	AF	001111001111001	2		AF	11100111100110	4
	B0	001111001110011	2		B0	11100111110000	4
	B1	001111001100111	2		B1	11100000011111	2
	B2	001111000111110	2		B2	11100000111110	2
	B3	001111000011111	2		B3	11100001100111	2
	B4	001100111111100	2		B4	11100001110011	2
	B5	00110011111001	2		B5	11100001111001	2
	B6	00110011110011	2		B6	11100001111100	2
	B7	00110011100111	2		B7	11100011000111	2
	B8	00110011001111	2		B8	11100011001110	2
	B9	001100011111110	2		B9	11100011100011	2
	BA	00110000111111	2		BA	11100011100110	2
	BB	001111111001110	4		BB	11100011110001	2
	BC	00111111100011	4		BC	11100011111000	2
	BD	001111111001110	4		BD	11100110000111	2
	BE	001111111000111	4		BE	11100110001110	2
	BF	001111110011110	4		BF	11100110011001	2

Table 3 (concluded)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
2(A)	C0	00111110001111	4	3(B)	C0	11100110011100	2
	C1	001111100111110	4		C1	11100111000011	2
	C2	001111100011111	4		C2	11100111000110	2
	C3	001111001111110	4		C3	11100111001100	2
	C4	001111000111111	4		C4	11100111100001	2
	C5	001100111111110	4		C5	11100111110000	2
3(A)	C6	000111111110000	0		C6	11100000001111	0
	C7	000111111100001	0		C7	11100000011110	0
	C8	000111111001100	0		C8	11100000110011	0
	C9	000111111000110	0		C9	11100000111001	0
	CA	000111111000011	0		CA	11100000111100	0
	CB	000111110011100	0		CB	11100001100011	0
	CC	000111110011001	0		CC	11100001100110	0
	CD	000111100011110	0		CD	11100001110001	0
	CE	000111100001111	0		CE	11100001111000	0
	CF	000111100111100	0		CF	11100011000011	0
	D0	000111100111001	0		D0	11100011000110	0
	D1	000111100110011	0		D1	11100011001100	0
	D2	000111100011110	0		D2	11100011100001	0
	D3	000111100001111	0		D3	11100011110000	0
	D4	000110011111100	0		D4	11100110000011	0
	D5	000110011110011	0		D5	11100110000110	0
	D6	000110011100111	0		D6	11100110001100	0
	D7	000110011001111	0		D7	11100110011000	0
	D8	000110001111110	0		D8	11100111000001	0
	D9	000110000111111	0		D9	11100111100000	0
	DA	000111111110001	2	4(B)	DA	11110001111100	4
	DB	000111111100110	2		DB	111100111111000	4
	DC	000111111100011	2		DC	11110000001111	2
	DD	000111111001110	2		DD	11110000011110	2
	DE	000111111000111	2		DE	11110000110011	2
	DF	000111110011110	2		DF	11110000111001	2
	E0	000111110001111	2		E0	11110000111100	2
	E1	000111100111110	2		E1	11110001100011	2
	E2	000111100011111	2		E2	11110001100110	2
	E3	000110011111110	2		E3	11110001110001	2
	E4	000110001111111	2		E4	11110001111000	2
	E5	000111111110011	4		E5	11110011000011	2
	E6	000111111001111	4		E6	11110011000110	2
	E7	000111111001111	4		E7	11110011001100	2
	E8	000111110011111	4		E8	11110011100001	2
	E9	000111001111111	4		E9	11110011110000	2
4(A)	EA	000011111111000	0	5(B)	EA	11110000000111	0
	EB	000011111110001	0		EB	11110000001110	0
	EC	000011111100110	0		EC	11110000011001	0
	ED	000011111100011	0		ED	11110000011100	0
	EE	000011111001110	0		EE	11110000110001	0
	EF	000011111000111	0		EF	11110000111000	0
	F0	000011100111110	0		F0	11110001100001	0
	F1	000011100011111	0		F1	11110001110000	0
	F2	000011001111110	0		F2	11110011000001	0
	F3	000011000111111	0		F3	11110011100000	0
5(A)	F4	00001111111001	2		F4	11111000000111	2
	F5	00001111110011	2		F5	11111000001110	2
	F6	00001111100111	2		F6	11111000011001	2
	F7	00001111100111	2		F7	11111000011100	2
	F8	00001110011111	2		F8	11111000110001	2
	F9	00001100111111	2		F9	11111000111000	2
	FA	000001111111100	0		FA	11111001100001	2
5(A)	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 4 – 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
1(C)	00	01111110000001	0	1(D)	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	10011000000111	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
	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	011100000011001	-2		3F	10000110001100	-4

Table 4 (continued)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
1(C)	40	01110000001110	-2	1(D)	40	10000110011000	-4
	41	01110000000111	-2		41	10000111000001	-4
	42	01100111100000	-2		42	10000111100000	-4
	43	01100111000001	-2		43	10001100000001	-4
	44	01100110011000	-2		44	10001100000011	-4
	45	01100110001100	-2		45	10001100000110	-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	10011000000011	-4
	4C	01100011000011	-2		4C	10011000000110	-4
	4D	01100001111000	-2		4D	10011000001100	-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		52	10000001100111	-2
	53	01100000110011	-2		53	10000001100111	-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	10000110000011	-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
2(C)	61	00111000011000	-4	1(D)	61	10000111000110	-2
	62	00111000001100	-4		62	10000111001100	-2
	63	00111111000000	-2		63	10000111100001	-2
	64	00111110000001	-2		64	10000111110000	-2
	65	00111110011000	-2		65	10001100000011	-2
	66	00111110001100	-2		66	10001100000110	-2
	67	00111110000110	-2		67	10001100011001	-2
	68	00111110000011	-2		68	10001100011100	-2
	69	00111110000001	-2		69	10001100110001	-2
	6A	00111100111000	-2		6A	10001100111000	-2
	6B	00111100110001	-2		6B	10001110000011	-2
	6C	00111100011100	-2		6C	10001110000110	-2
	6D	00111100011001	-2		6D	10001110001100	-2
	6E	00111100001110	-2		6E	10001111001100	-2
	6F	00111100001100	-2		6F	10001111100001	-2
	70	00111100000110	-2		70	10001111100000	-2
	71	00111100000011	-2		71	10011000000011	-2
	72	00110011110000	-2		72	10011000000110	-2
	73	00110011100001	-2		73	10011000001100	-2
	74	00110011001100	-2		74	10011000011100	-2
	75	00110011000110	-2		75	10011000110001	-2
	76	00110011000011	-2		76	10011000111000	-2
	77	00110001111000	-2		77	10011001100001	-2
	78	00110001110001	-2		78	10011001110000	-2
	79	00110001100110	-2		79	10011100000011	-2
	7A	00110001100011	-2		7A	10011100000011	-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

Table 4 (continued)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
2(C)	80	00111111100000	0	2(D)	80	11000000011111	0
	81	00111111100001	0		81	11000000111110	0
	82	001111110011000	0		82	11000000110011	0
	83	001111110001100	0		83	11000000111001	0
	84	001111110000110	0		84	11000000111001	0
	85	001111110000011	0		85	11000000111100	0
	86	001111100111000	0		86	11000001100011	0
	87	001111100110001	0		87	11000001100110	0
	88	001111100011100	0		87	11000001110001	0
	89	001111100011001	0		89	11000001110010	0
	8A	001111100001110	0		8A	110000011110001	0
	8B	001111100000111	0		8B	110000011111000	0
	8C	001111001111000	0		8C	11000110000111	0
	8D	001111001110001	0		8D	11000110001110	0
	8E	001111001100110	0		8E	11000110011001	0
	8F	001111001100011	0		8F	11000110011100	0
	90	001111000111100	0		90	11000111000011	0
	91	001111000111001	0		91	11000111000110	0
	92	001111000110011	0		92	11000111001100	0
	93	001111000011110	0		93	11000111100001	0
	94	001111000001111	0		94	11000111110000	0
	95	001100111111000	0		95	11001100000011	0
	96	00110011110001	0		96	11001100000110	0
	97	00110011100110	0		97	11001100011001	0
	98	00110011100011	0		98	11001100011100	0
	99	00110011001110	0		99	11001100110001	0
3(C)	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
	A7	00011110000001	-4		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	000111110011000	-2		B3	11000111100000	-2
	B4	000111110001100	-2		B4	11001100000011	-2
	B5	000111110000110	-2		B5	11001100000010	-2
	B6	000111110000011	-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	11000000110001	-4

Table 4 (concluded)

Class	8-bit data	Modulation codes beginning with "0"	CDS	Class	8-bit data	Modulation codes beginning with "1"	CDS
3(C)	C0	00011001100011	-2	2(D)	C0	11000001110000	-4
	C1	00011000111100	-2		C1	110000111000001	-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
4(C)	D8	00011000111110	0		D8	11100111000001	0
	D9	00011000011111	0		D9	11100111100000	0
	DA	00001110000011	-4		DA	11100000001110	-2
	DB	00001100000011	-4		DB	11100000011001	-2
	DC	00001111110000	-2		DC	11100000011100	-2
	DD	00001111100001	-2		DD	11100000110001	-2
	DE	00001111001100	-2		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

(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 smaller number in table 5) according to table 5. Likewise, when the end DSV of the code is $+2$, select a code of higher priority (corresponding to smaller number in table 6) according to table 6.

(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 7, 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.

Table 5 – Priority of modulation code selection (end DSV = -2)

Modulation codes	Priority
xxxxxxxxxx001	4
xxxxxxxxxx0011	1
xxxxxxxxxx00111	2
xxxxxxxxxx001111	3
xxxxxxxxxx0011111	8
xxxxxxxxxx110	10
xxxxxxxxxx1100	5
xxxxxxxxxx11000	6
xxxxxxxxxx110000	7
xxxxxxx1100000	9
xxxxxxx11000000	11
NOTES	
1 x is a "don't care" bit.	
2 The table shall be used in the case where DSV at the end of the modulation code is -2 .	

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

Modulation codes	Priority
xxxxxxxxxx110	4
xxxxxxxxxx1100	1
xxxxxxxxxx11000	2
xxxxxxxxxx110000	3
xxxxxxx1100000	8
xxxxxxxxxx001	10
xxxxxxxxxx0011	5
xxxxxxxxxx00111	6
xxxxxxxxxx001111	7
xxxxxxx0011111	9
xxxxxxx00111111	11
NOTES	
1 x is a "don't care" bit.	
2 The table shall be used in the case where DSV at the end of the modulation code is $+2$.	

Table 7 – Data rate and wavelength

Parameters	Values
Total average data rate	125.2 Mb/s
Instantaneous channel data rate	63.3 Mb/s
Shortest recorded wavelength	0.77 μm

6.6.2 Recorded equalization

The record head current applied to a head should generate the 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.

7 Video interface

7.1 Encoding parameters

The digital composite video signal shall be encoded according to ANSI/SMPTE 244M. The input video signal is sampled at $4f_{sc}$ and uniformly quantized 8 or 10 bits per sample. Only 8 bits per sample are recorded on tape, although 10 bits per sample may be present at the digital parallel interface.

7.2 Parallel digital signal interface

The principal mode of interface shall be analog. If a parallel digital video interface is used, it shall conform to ANSI/SMPTE 244M.

8 Audio interface

8.1 Encoding parameters

The digital audio signal shall be encoded according to the following parameters:

8.1.1 Sampling

(a) The sampling frequency shall be 48.000 kHz and be related to the horizontal frequency as follows:
 $48 \text{ kHz} = F_H \times 1144 / 375$.

(b) The resolution of each sample shall be 16 bits minimum and 20 bits maximum.

(c) The coding shall be twos complement linear PCM.

8.1.2 Reference level

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

8.2 Digital signal interface

The principal mode of interface shall be 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 the ITU-R BS.647 interface without error checking.

9 Video processing

9.1 Recorded data

9.1.1 Recorded samples and lines of the television frame

Centered about the active picture, 768 samples per line shall be recorded. The relationship between video signals in the analog and digital domains together with the address numbers of the digitized samples for zero degrees ScH phase of the incoming signal shall be as shown in figure 3 of ANSI/SMPTE 244M. Under this condition, sample number 785 occurs 44.2 ns (57° at f_{sc}) after the 50% point of the leading edge of the horizontal sync pulse.

From each field, 255 consecutive lines shall be recorded. The first recorded sample of each field shall vary over a four-field sequence as follows, with the line numbers defined as in ITU-R BT.470 and sample numbers defined as in figure 3 of ANSI/SMPTE 244M:

- From color frame A field I, the first recorded sample is number 0 of line 9;
- From color frame A field II, the first recorded sample is number 0 of line 271;
- From color frame B field III, the first recorded sample is number 2 of line 9;
- From color frame B field IV, the first recorded sample is number 2 of line 271.

The first recorded sample of each field shall be the –I sample.

All the samples of the first recorded line shall be set at $3C_h$ and reserved for future use.

9.1.2 Nonrecorded data

(a) Information received during the line blanking and 9-line vertical intervals are not recorded on tape. The appropriate blanking, sync, and burst data are recreated for output during playback.

(b) The digital horizontal blanking interval shall be as defined in figure 8 of ANSI/SMPTE 244M.

9.1.3 Source precoding

No source precoding shall be applied to the input video data.

9.2 Channel distribution of samples

The samples shall be distributed between 2 channels in a checkerboard pattern, which alternates from line to line.

Figure 13 shows the distribution of samples. In figure 13, the channel number (0 or 1) shall coincide with the track number as defined in figure 14.

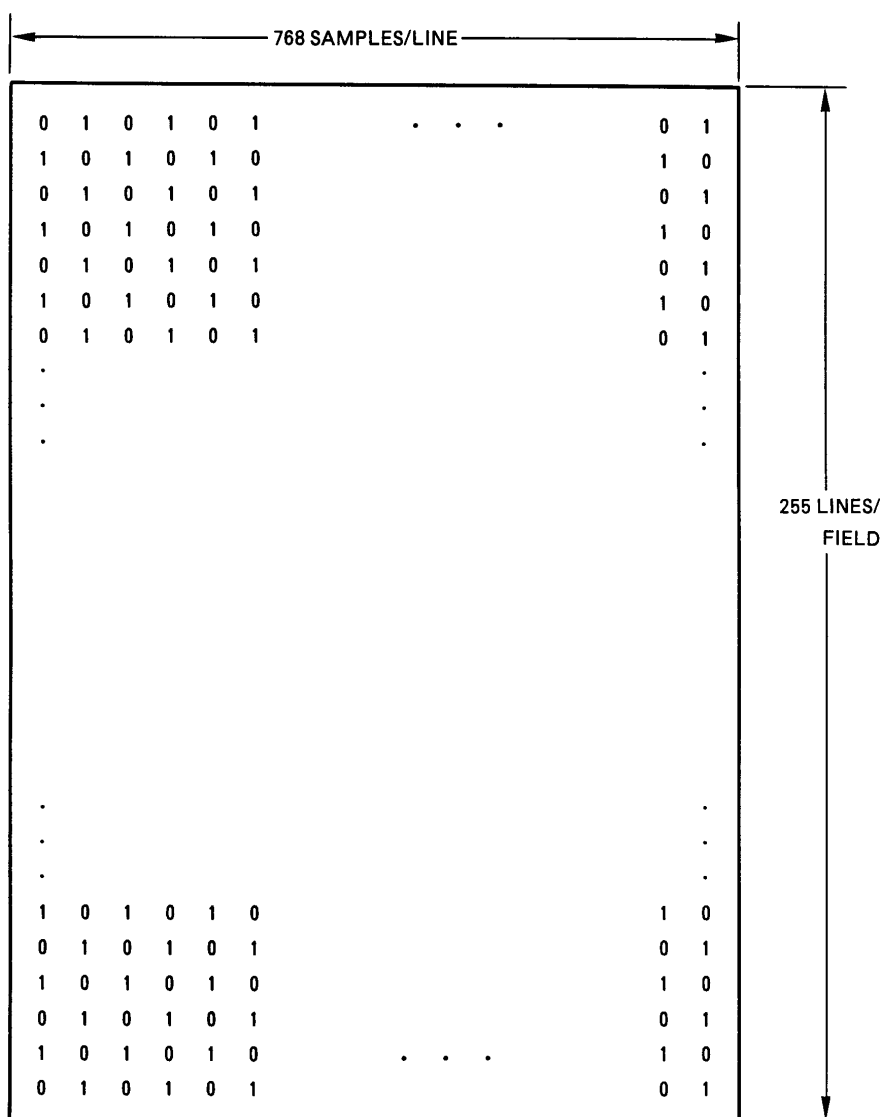
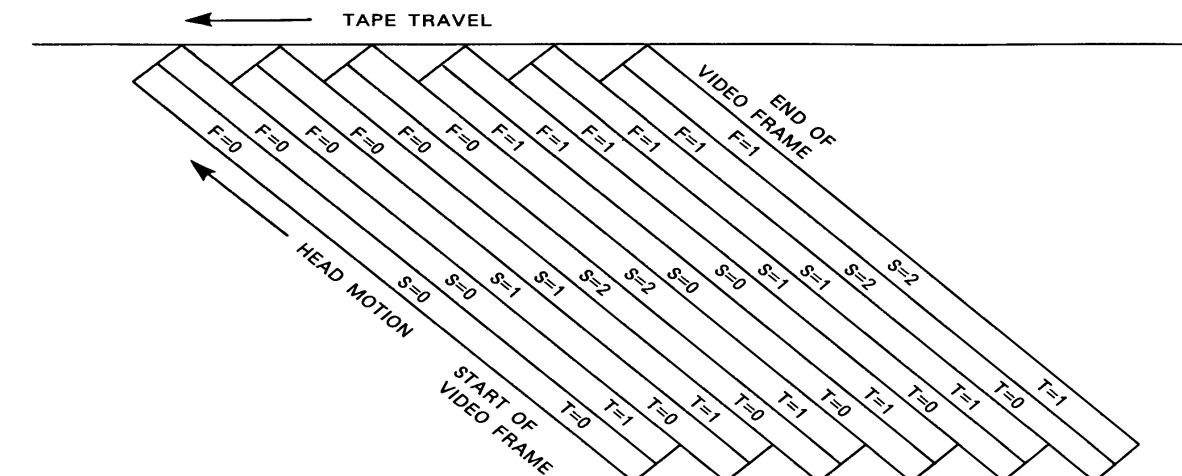


Figure 13 – Channel distribution of samples



NOTES

- 1 F = field number (0, 1, 2, 3).
- 2 S = segment number (0, 1, 2).
- 3 T = track number (0, 1). The track number is identified by the azimuth angle.
- 4 Audio sectors are not shown.

Figure 14 – Track, segment and field numbers

9.3 Shuffling

9.3.1 Introduction

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

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

Each television line contains 3 outer code blocks per channel. The samples within each outer code block are spaced 6 samples horizontally within the television line, although they appear in a permuted order within the outer block.

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

outer block is a constant which generates a permutation of every 6 samples within a television line.

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

9.3.2 Algebraic definition

The shuffling process shall operate identically for all video fields.

Let L be the television line number within a video field:
 $L = 0, 1, \dots, 254$.

Let h be the horizontal sample location within line L :
 $h = 0, 1, \dots, 767$.

Let i_h be the horizontal sample index following the channel distribution process described in 9.2:

$ih = \text{int}(h/2)$, $ih = 0, 1, \dots, 383$, where $\text{int}(x)$ means the largest integer less than or equal to x .

Let Oblk be the outer block number within line L :
 $\text{Oblk} = 0, 1, 2$.

Let Obyt be the sample number within outer block
 Oblk : $\text{Obyt} = 0, 1, \dots, 127$.

(Outer code check bytes shall not be included in the intraline shuffle process.)

Then ih within line L shall be mapped to Obyt according to the following formula:

$$\text{Obyt} = \{107 \times \text{int}(ih/3) + 78 \times \text{Oblk} + 46 \times L\} \bmod 128, \text{ where } \text{Oblk} = ih \bmod 3.$$

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

$\text{Obyt} = 128, 129, 130, 131, 132, 133, 134$, and 135 , respectively.

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

$$\begin{aligned} \text{Row} &= \text{Obyt} \\ \text{and} \\ \text{Col} &= L + 255 \times \text{Oblk}. \end{aligned}$$

The field memory array data shall be written to tape first by column order $(0, 1, \dots, 764)$, then by ascending row order $(0, 1, 2, \dots, 134, 135)$.

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

Let Seg be the segment number within a video field:
 $\text{Seg} = 0, 1, 2$.

Let Fld be the field number within a color frame:
 $\text{Fld} = 0, 1, 2, 3$.

Let Tr be the recording track number: $\text{Tr} = 0, 1$.

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

For the outer check bytes, $Xin = 1152 + 24 \times \text{Seg}$;
 and for the outer data bytes, $Xin = (384 \times \text{Seg} + 96 \times \text{Fld} + 576 \times \text{Tr}) \bmod 1152$.

The relationship between Xin and Row or Col of the field memory shall be $Xin = 9 \times \text{Row} + \text{int}(\text{Col} / 85)$.

9.4 Field data array

The field data array is 765 columns (9 times 85 bytes), and 136 rows (128 video data plus 8 outer check bytes). Figure 15 illustrates the field data array.

9.5 Outer error protection

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

Type: Reed Solomon.

Galois field: $\text{GF}(256)$.

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

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

Code generator polynomial in $\text{GF}(256)$: $G(x) = (x+1)(x+a)(x+a^2)(x+a^3)(x+a^4)(x+a^5)(x+a^6)(x+a^7)$, where a is given by 02_h in $\text{GF}(256)$.

Check characters are $K_7, K_6, K_5, K_4, K_3, K_2, K_1, K_0$ in $K_7x^7 + K_6x^6 + K_5x^5 + K_4x^4 + K_3x^3 + K_2x^2 + K_1x + K_0$, obtained as the remainder after dividing $x^8D(x)$ by $G(x)$, where $D(x)$ is the polynomial given by $D(x) = B_{127}x^{127} + B_{126}x^{126} + \dots + B_2x^2 + B_1x + B_0$.

Equation of full code is given by: $B_{127}x^{135} + B_{126}x^{134} + \dots + B_1x^9 + B_0x^8 + K_7x^7 + K_6x^6 + K_5x^5 + K_4x^4 + K_3x^3 + K_2x^2 + K_1x + K_0$.

9.6 Order of transmission to inner coding

Video data bytes (outer check bytes are considered data) shown in figure 15 are sent to the inner coder first by column (0 through 8 of 85-byte data block), then by row (0 through 135).

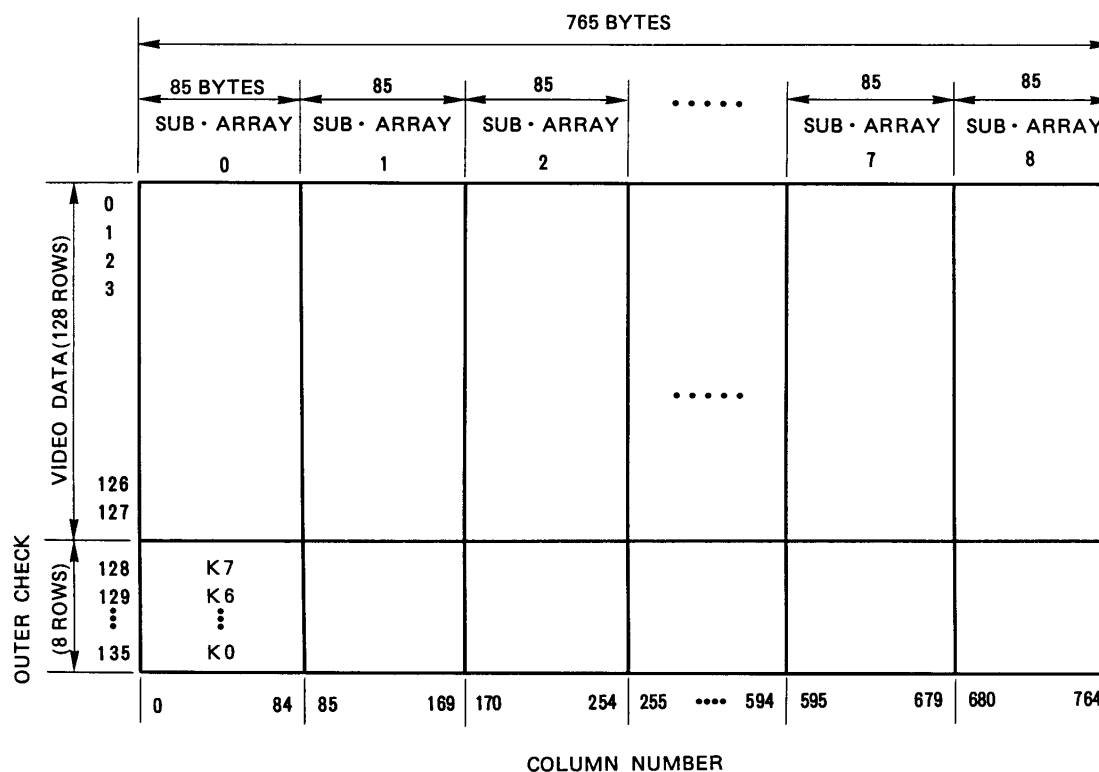


Figure 15 – Video field data array

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 85×3 columns by 8 rows. The audio samples of each channel are shuffled in a field before the addition of error correction data in the vertical (row) direction. Error correction in the horizontal (column) dimension is common with video data.

Auxiliary words are multiplexed with the audio data in the product to provide housekeeping in the interface and in processing. Figure 16 shows the audio data block field array.

10.2 Source coding

Audio records that meet the requirements of ITU-R BS. 647 are formed independently for each of four audio channels, from audio and ancillary data at the input interface. This data includes audio data, channel status data (C), user data (U), and validity data (V). Parity bits are discarded. The remaining bit positions in the audio data words are reserved (R) for future use.

Block sync marks for ancillary data are also processed. CCITT J.17 preemphasis is not recognized.

Source data is defined as follows.

(a) Audio data:

- Sampling frequency: $48 \text{ kHz} \pm 3 \text{ parts in } 10^6$, synchronous with video;
- Word length: 20 bits;
- Coding: Twos complement linear PCM.

(b) Channel status data:

- Bit rate: 48 kbit/sec (nominal);
- Word rate: 6 kbyte/sec;
- Word length: 8 bits;
- Block length: 192 bits, 24 words;
- Coding: See ITU-R BS.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 8 and 9, 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.

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

Table 8 – AES status data (byte 0)

LSB	MSB						
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 9 – AES status data (byte 1)

LSB	MSB						
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, 2, and 3 of this byte are recorded in an auxiliary word.					

(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.

(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 is processed in fields. Each field contains 801 or 800 audio samples 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 \pm 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 is processed into an audio block of $85 \times 3 \times 16$ bytes, each corresponding to six audio sectors on tape. The data portion of the block is $85 \times 3 \times 8$ bytes and the outer error check byte portion of the block is also $85 \times 3 \times 8$.

Audio data words: 801 or 800 words with associated C, U, V, R bits (20 bits total per word).

Auxiliary data words: A total of 15 words (20 bits per word).

10.3.4 Intrafield shuffling

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

Let Col be the column number within an audio field:
Col = 0, 1, . . . , 101.

Let Row be 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 = $3 \times \text{Row} + \text{int}(\text{Col} / 34)$.

The data block array is shown in figure 17. Then sample number Smp within an audio field is obtained according to the following formula :

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

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

Figure 17 shows 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, . . . , 7.

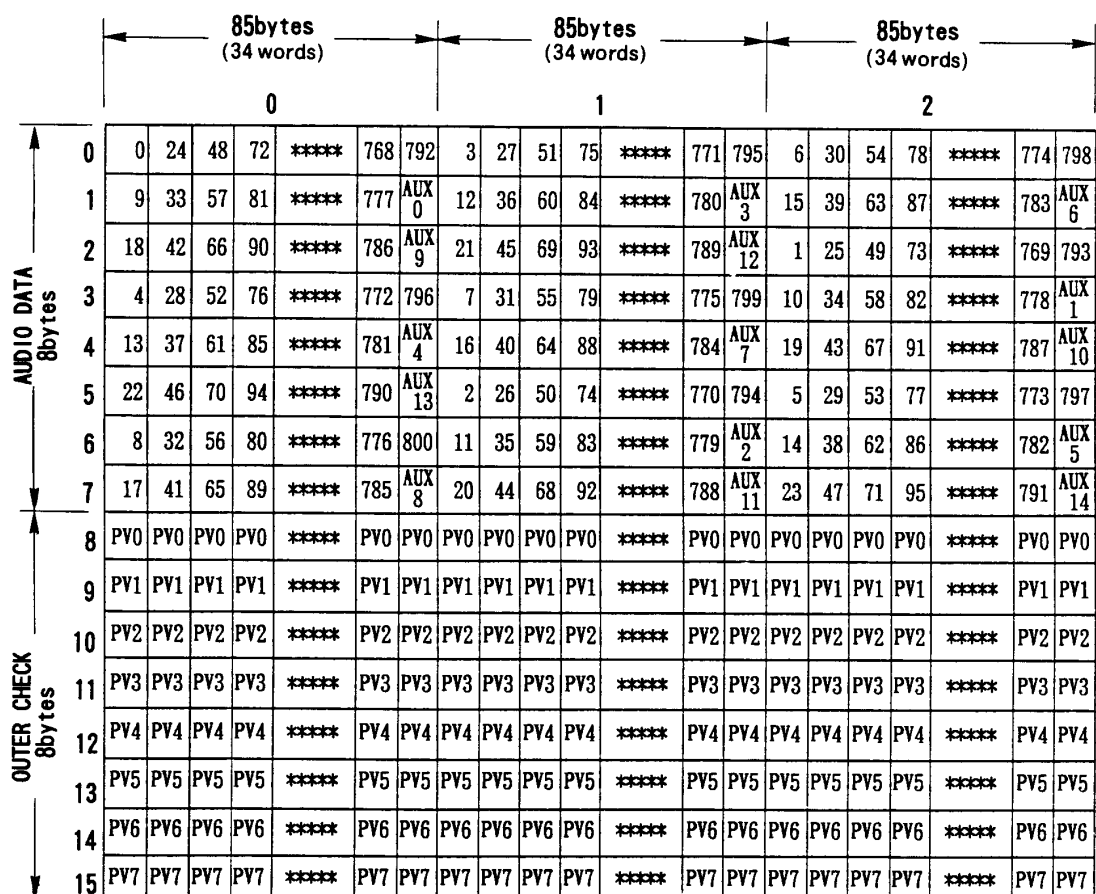
Let Seg be the segment number: Seg = 0, 1, 2.

Let Tr be the track number: Tr = 0, 1.

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

$$\text{Oblk} = N + \text{Tr} + 8 \times \text{Seg} + 2 \times (12 - \text{Tr}) \times (N \bmod 2).$$

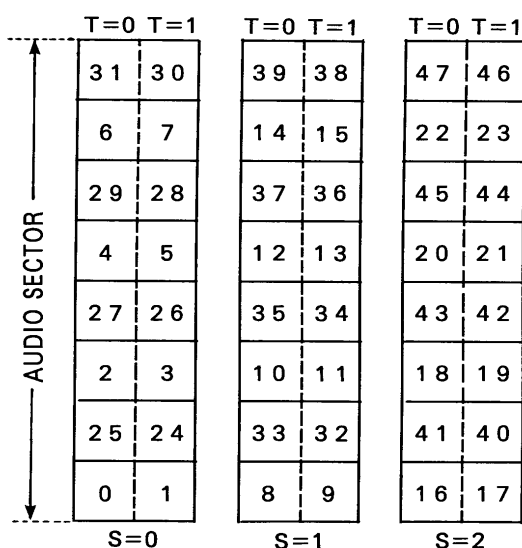
Figure 18 shows the data block arrangement of an audio channel in three pairs of sectors.



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 17 – Audio data block layout



NOTES

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

Figure 18 – Audio data block arrangement in three pairs of sectors (one channel)

10.3.6 Audio data word processing

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

(a) Assignment of the 20-bit word to audio and associated data is controlled by user input (see table 10). The most significant bit of the audio word is bit 19 and

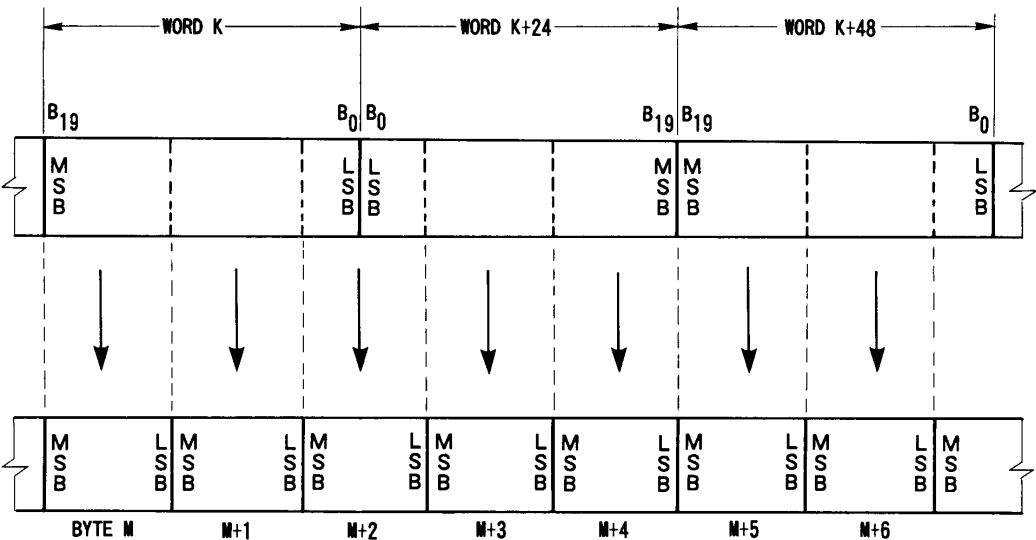
unused bits of lower significance are removed. Auxiliary word LNGH (four bits) signals the word mode selected.

(b) Each group of 20-bit words is divided into 8-bit bytes as shown in figure 19, and arranged alternately by the MSB and the LSB of the first word of the word group.

Table 10 – Audio data word mode

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

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.



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

Figure 19 – Digital audio word to byte conversion

(c) Each group is distributed into the product block in accordance with figure 17.

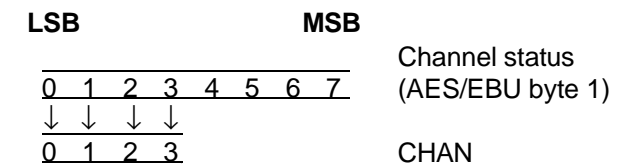
(d) Sample number 800 may be unoccupied. Every fifth field shall contain 800 samples. All other fields shall contain 801 samples. The 5-field sequence of the number of audio samples begins at an arbitrarily chosen field. Continuity of the 5-field sequence shall be preserved throughout the recording, 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 F2 for audio sync blocks, as defined in 6.3.3.

10.4 Auxiliary words

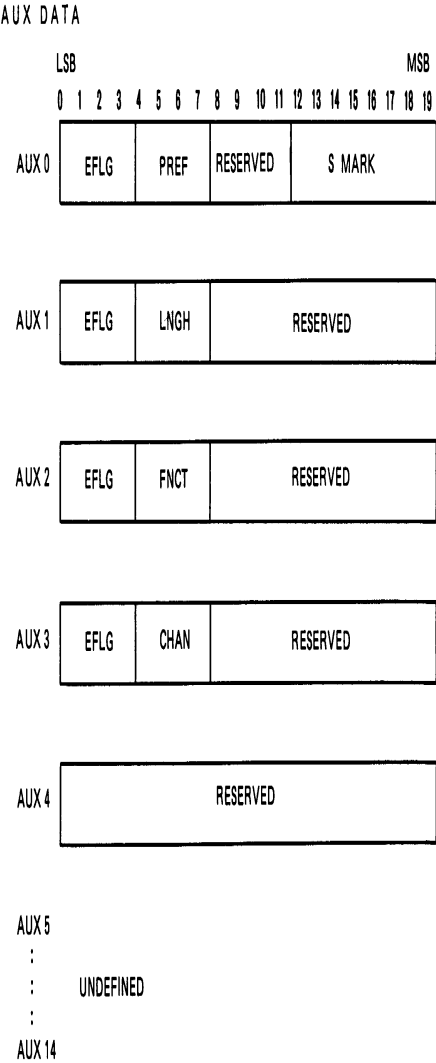
Auxiliary words are generated at the input interface from incoming data or user selection and serve to signal this information to the output interface. Auxiliary words are five words of four bits, plus one word of eight bits as defined in figure 20. The word EFLG is written four times in each audio block. Figure 20 shows 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.



- Bit 0: Channel mode bit 0
- Bit 1: Channel mode bit 1
- Bit 2: Channel mode bit 2
- Bit 3: Channel mode bit 3



NOTE – Reserved = 0h, 000h, or 00000h.

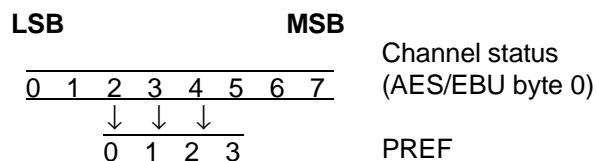
Figure 20 – Audio data block auxiliary data

Table 11 – Channel use control word

Mode	CHAN bit				Value
	0	1	2	3	
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.



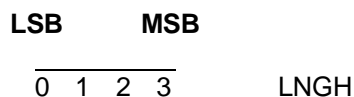
Bit 0: Preemphasis bit 0
 Bit 1: Preemphasis bit 1
 Bit 2: Preemphasis bit 2
 Bit 3: 0

Table 12 – Preemphasis control word

Mode	PREF bit			Value
	0	1	2	
0	0	0	0	Preemphasis 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. LNGH is inserted in bits 4-7 of AUX 1.



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

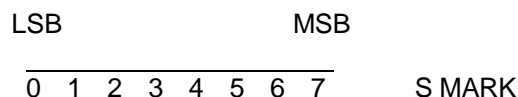
Table 13 – Word mode control word

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

NOTE – X means that the ancillary bit is recorded.

10.4.4 Block sync location (S MARK)

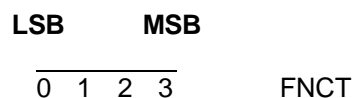
S MARK is an 8-bit word. S MARK specifies the location of the block sync associated with channel status and user data, as defined in clause 6.0 of ITU-R BS.647. S MARK contains the word count, in the current block, of the first block sync detected; i.e., the word address in the block pointing to the first sample after the block sync mark.



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.

10.4.5 Field number count (FNCT)

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.



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

Table 14 – FNCT mode

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

10.4.6 Edit flag (EFLG)

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

LSB	MSB			EFLG
0	1	2	3	

EFLG = D_h for the first field of the edit.

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

EFLG = 0_h otherwise.

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

10.5 Outer error protection

Rows 8 through 15 of the data block as shown in figure 16 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: Leftmost 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 $K_7x^7 + K_6x^6 + K_5x^5 + K_4x^4 + K_3x^3 + K_2x^2 + K_1x + K_0$, obtained as the remainder after dividing the polynomial $x^8D(x)$ by $G(x)$, where $D(x)$ is the polynomial given by: $D(x) = B_7x^7 + B_6x^6 + B_5x^5 + \dots + B_1x + B_0$.

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

Outer-code check characters in each column of the $85 \times 3 \times 8$ blocks are calculated using the data order existing prior to the rearrangement into the pattern shown in figure 17; 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

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 on the three pairs of sectors (6 sectors) as shown in figure 18. A pair of sectors from each of the four audio channels is recorded according to figure 21. The audio sectors labeled A1, A2, A3, and A4 correspond to audio input channels 1, 2, 3, and 4, respectively. The allocation of a pair of sectors is 4-field sequence. Field address F_0, F_1 of sector ID four audio sync blocks as defined in 6.3.3 shall identify 4-field sequence and have the values as shown below.

	F_0	F_1
– Audio field I	0	0
– Audio field II	1	0
– Audio field III	0	1
– Audio field IV	1	1

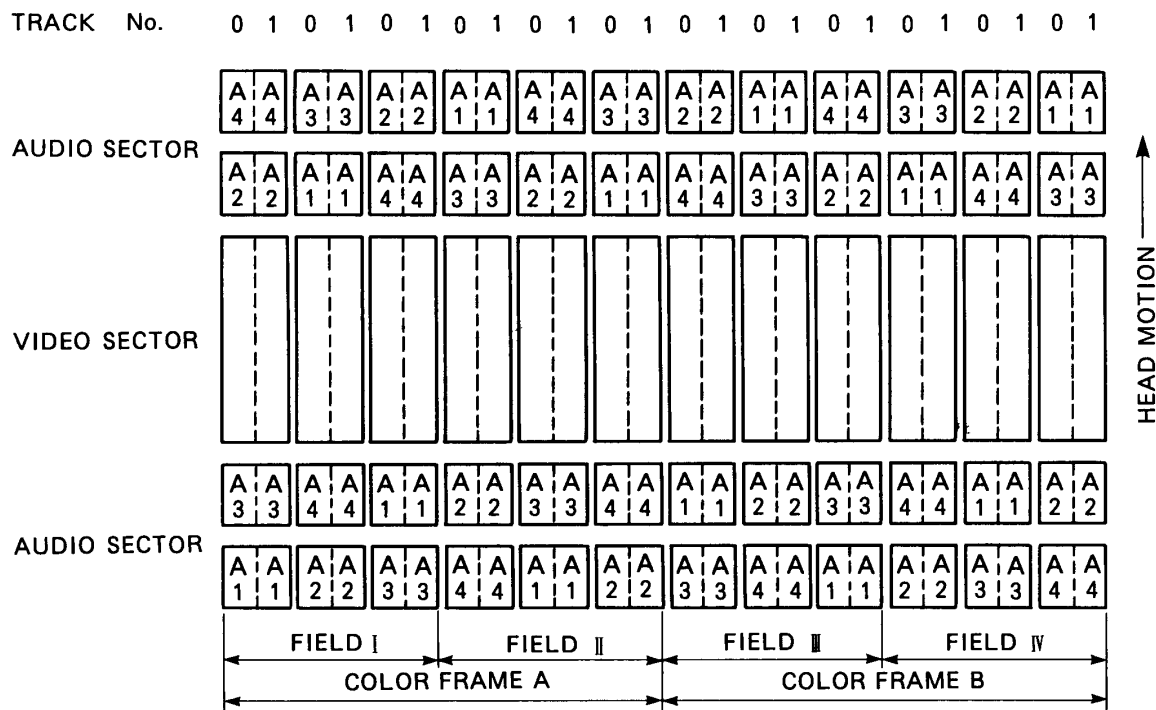


Figure 21 – Audio channel arrangement

11 Longitudinal track

11.1 Relative timing

11.1.1 Time code input

An external record time code input that meets the specifications described in IEC 461 or a time 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 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 table 1.

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 table 1.

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 $11.122 \text{ ms} \pm 6 \mu\text{s}$ as shown in figure 22.

11.2.3 Flux polarity

The polarity 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.

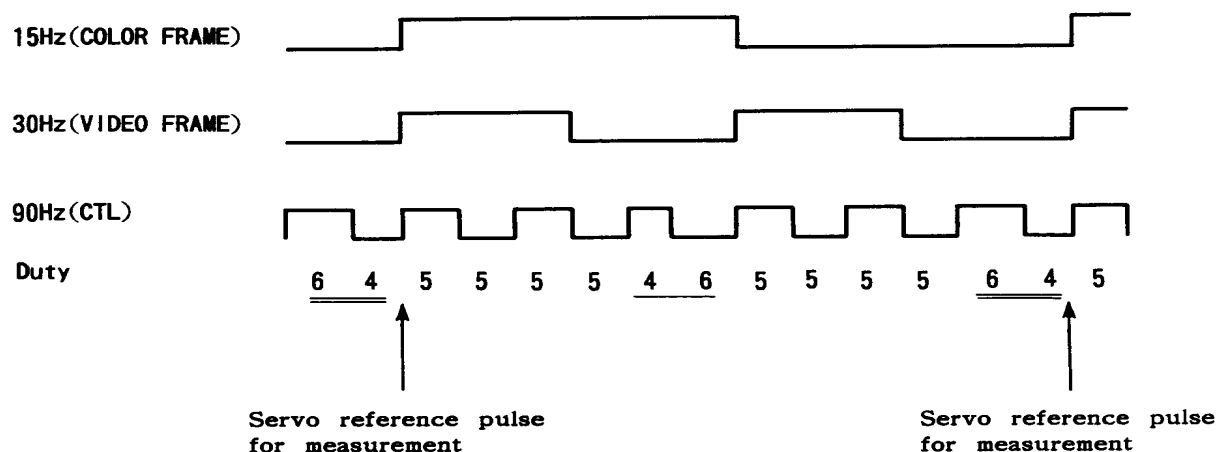


Figure 22 – Recorded control record waveform timing

11.2.5 Pulse width

The recorded pulses shall have periods of 4T, 5T, or 6T where T equals 1.1122 ms nominal. The rise and fall times of the record current (10% to 90% points) shall be less than 150 μ s.

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.

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 I. It shall be located at the rising point after the 6T–4T duration pulses, coinciding with a segment count and a field count of zero in the video sector identification pattern, as defined in 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 \pm 3 nWb/m of track width at 1000 Hz.

11.4 Time code record

11.4.1 Method of recording

The signals shall be recorded using the anhysteresis (ac bias) recording 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 \pm 20 nWb/m of track width.

11.4.3 Input signal

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

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 (0.30 ± 0.03) 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.

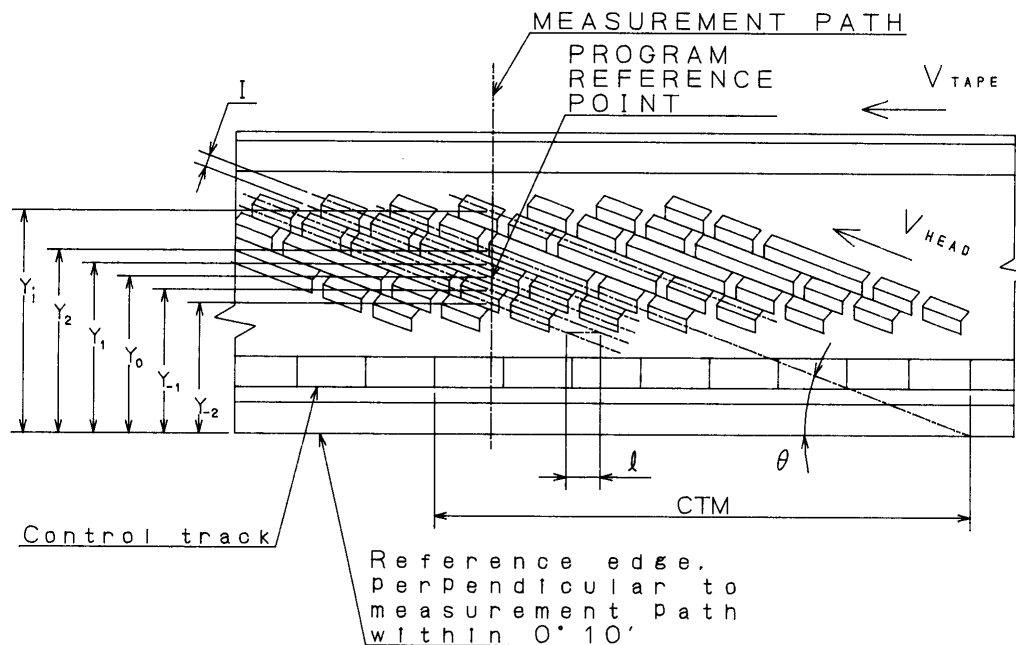
From a ferrofluid development, measurements are made of the actual track positions and the distance between a minimum of 200 control track pitches. All measurements shall be made under the environmental conditions described in 3.1, except that the measurements are made without tape tension (see table B.1). 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 shall be 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.1. The values for each fourth 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

Y_0	Program area reference (basic)	2.030 mm
θ	Track angle (basic)	4.9192°
T	Tension	0.31N
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	$CTM' = CTM \left(1 + \frac{T}{A \times E} \right)$
λ	Longitudinal track pitch	$\lambda = CTM' / 4n$
i	Track number, i = 0 for the track containing reference point	
Y_i	Measured position of track i at the recorded pattern	
ΔY	Cross-section track pitch	$\Delta Y = \lambda \times \tan \theta$
Y_{it}	Theoretical position of track i at the recorded pattern	$Y_{it} = Y_0 + i \times \Delta Y$
l	Track pitch	$l = \lambda \times \sin \theta$
TLE	Track location error	$TLE = Y_i - Y_{it}$
Z	Tolerance zone	Z2 = 0.004 mm Z1, Z3, Z4 = 0.006 mm
NOTE – For tolerance zone Z1, i = ... -4, 0, +4, +8, ... For tolerance zone Z2, i = ... -5, -1, +3, +7, ... For tolerance zone Z3, i = ... -6, -2, +2, +6, ... For tolerance zone Z4, i = ... -7, -3, +1, +5, ...		



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.1 – Cross-tape measurement technique

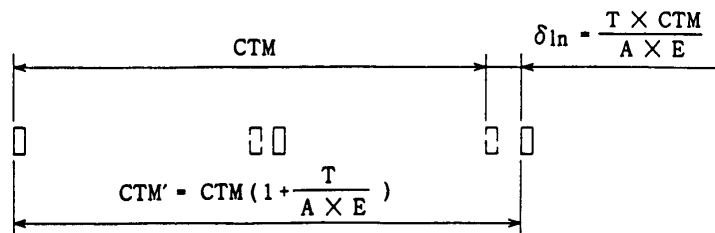


Figure B.2 – Correction factors (actual tape speed and tension)

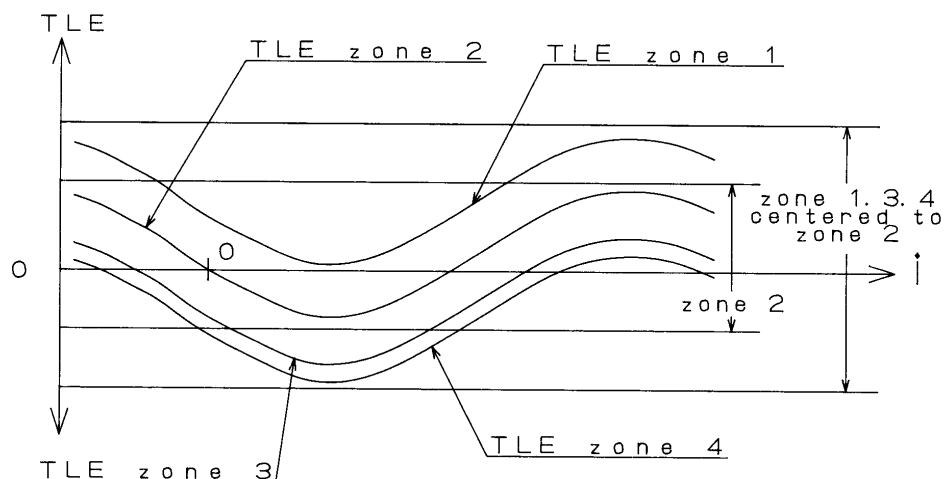


Figure B.3 – Track location error plot (example)

Annex C (normative)

Mathematically processed measured tape data

To obtain the reference edge of the tape and the position of the track, the coordinates of all measured points, P_m , may be mathematically corrected as follows (refer to figure C.1).

The X_m coordinate of Pm is found by measuring in the direction parallel to two fixed points along the edge of the tape 170 mm apart, the distance from the first fixed point.

The Y_m coordinate of P_m is found by measuring in the direction perpendicular to the two fixed points along the edge of the tape, the distance from the edge of the tape at the X_m coordinate.

A correction in the Y direction is calculated from the rebending function:

$$\Delta Y_m = 4 \times \delta_1 \times [(X_m/S)^2 - (X_m/S)]$$

where

δ_1 is the distance from the straight line joining the two fixed points along the edge of the tape to the tape edge, at a point midway between the two fixed points;

S is the distance between the two fixed points along the edge of the tape (170 mm).

A correction in the X direction is calculated from the tension displacement function:

$$\Delta X_m = (T/(A \times E)) \times X_m$$

where

T is the tape tension (0.31 N at the center of the scanner);

A is the cross-sectional area of the tape;

E is Young's modulus (8000 N/mm²).

The corrections are applied as follows to obtain corrected coordinates of the point, P_c :

$$X_c = X_m + \Delta X_m:$$

$$Y_c = Y_m + \Delta Y_m;$$

NOTE – The same results may be achieved by the procedure described in annex B.

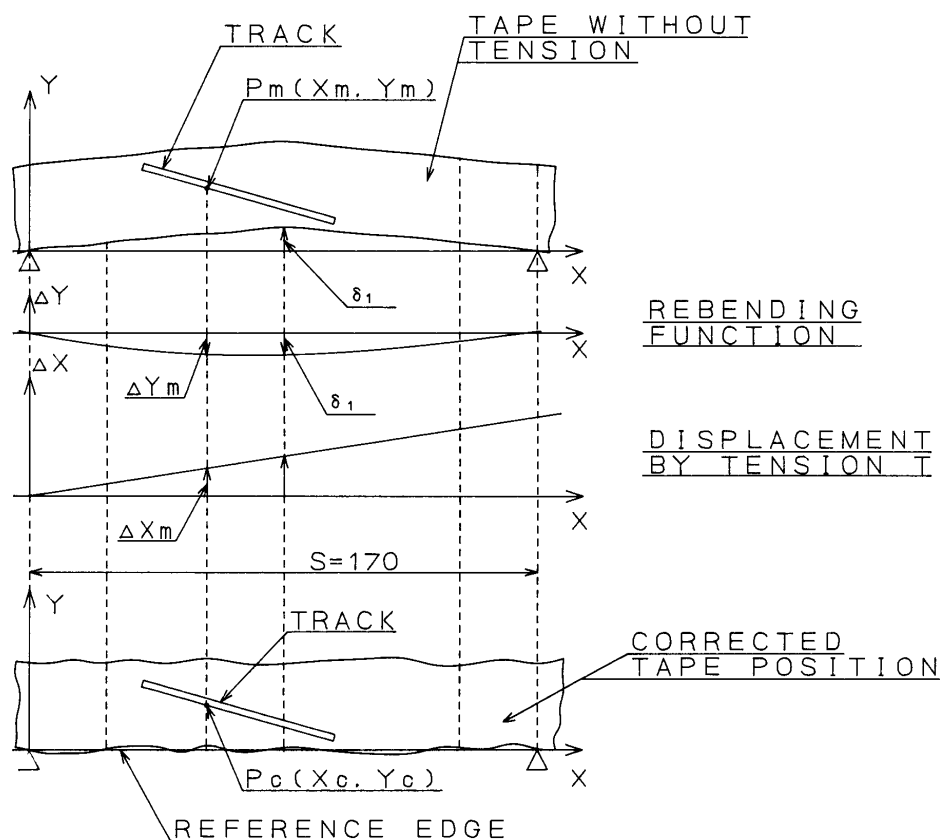
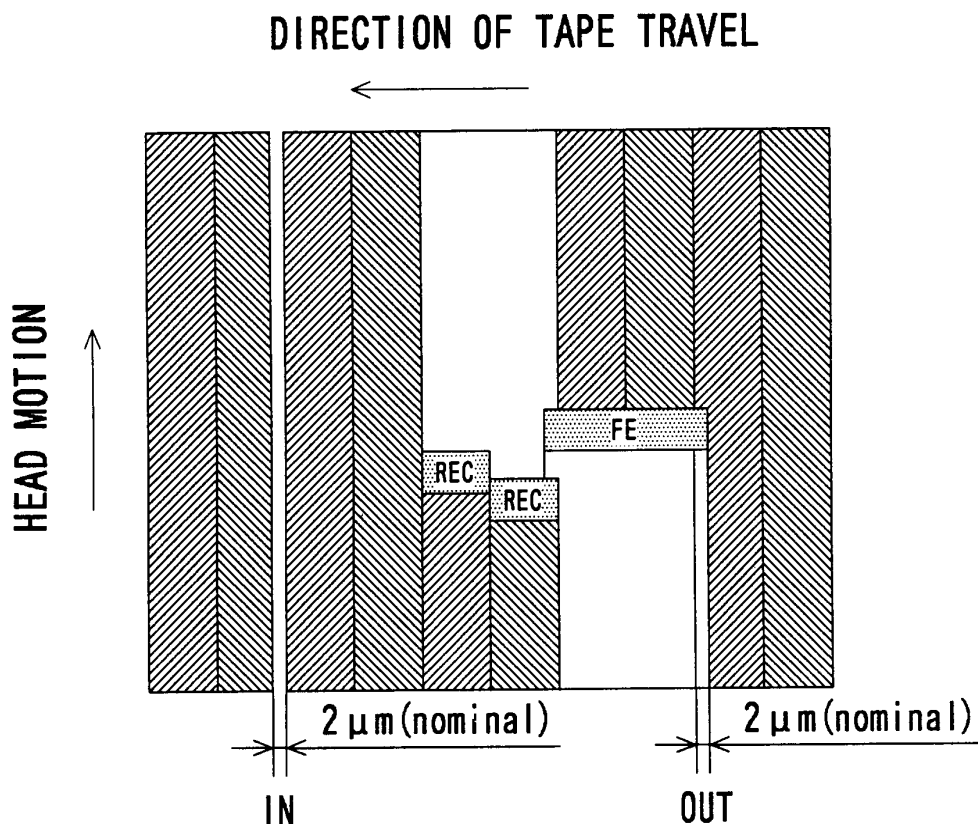


Figure C.1 – Mathematically processed measured tape data

Annex D (normative)

Track pattern during insert editing

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



NOTES

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

Figure D.1 – A typical track pattern during insert editing

Annex E (informative)

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