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SMPTE STANDARD**SMPTE 264M-1998**Revision of
ANSI/SMPTE 264M-1993

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

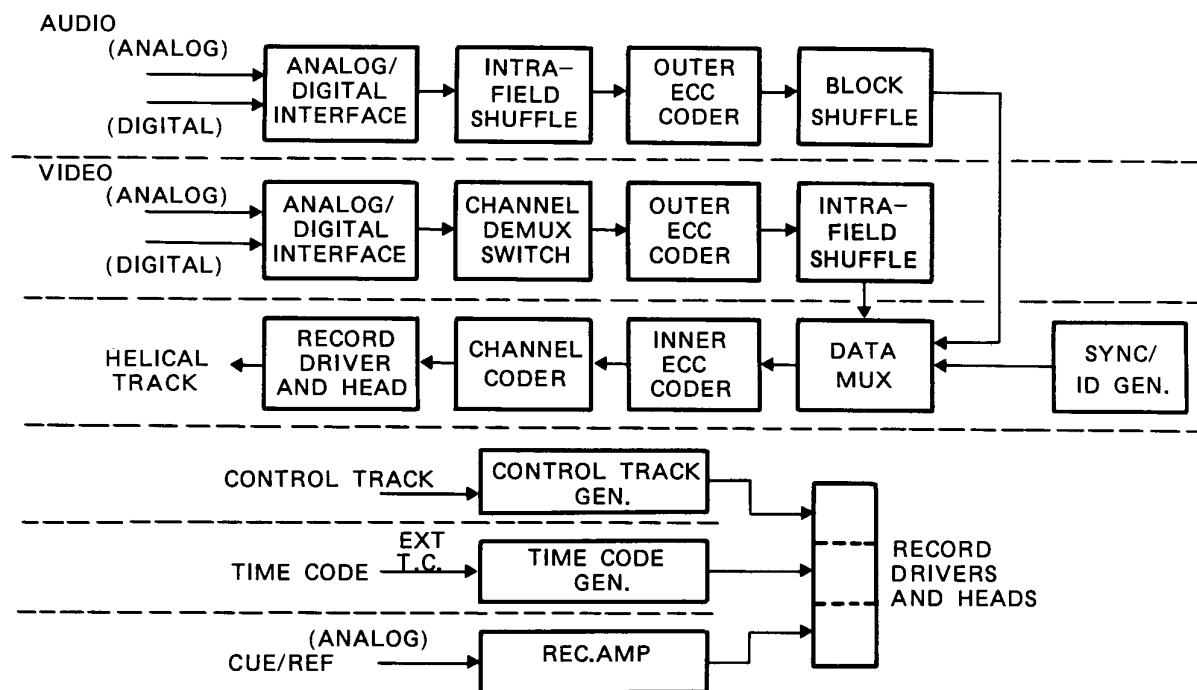


Figure 1 - Record block diagram

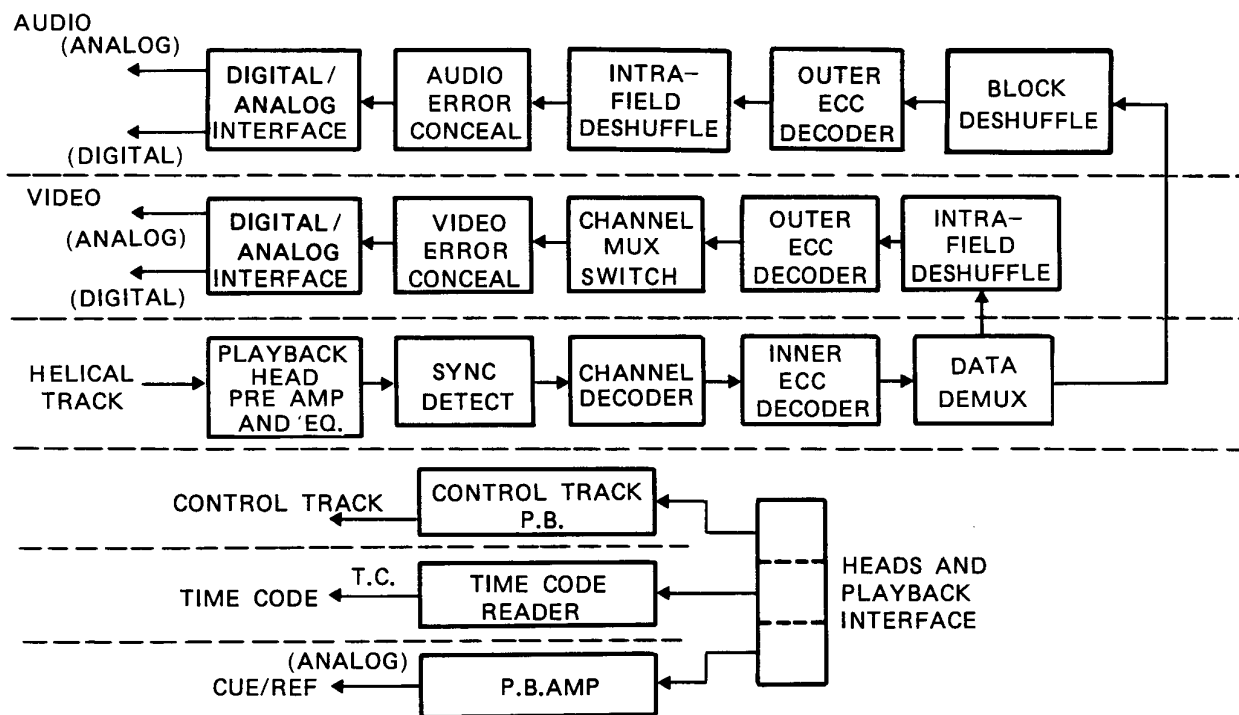


Figure 2 - Playback block diagram

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%.

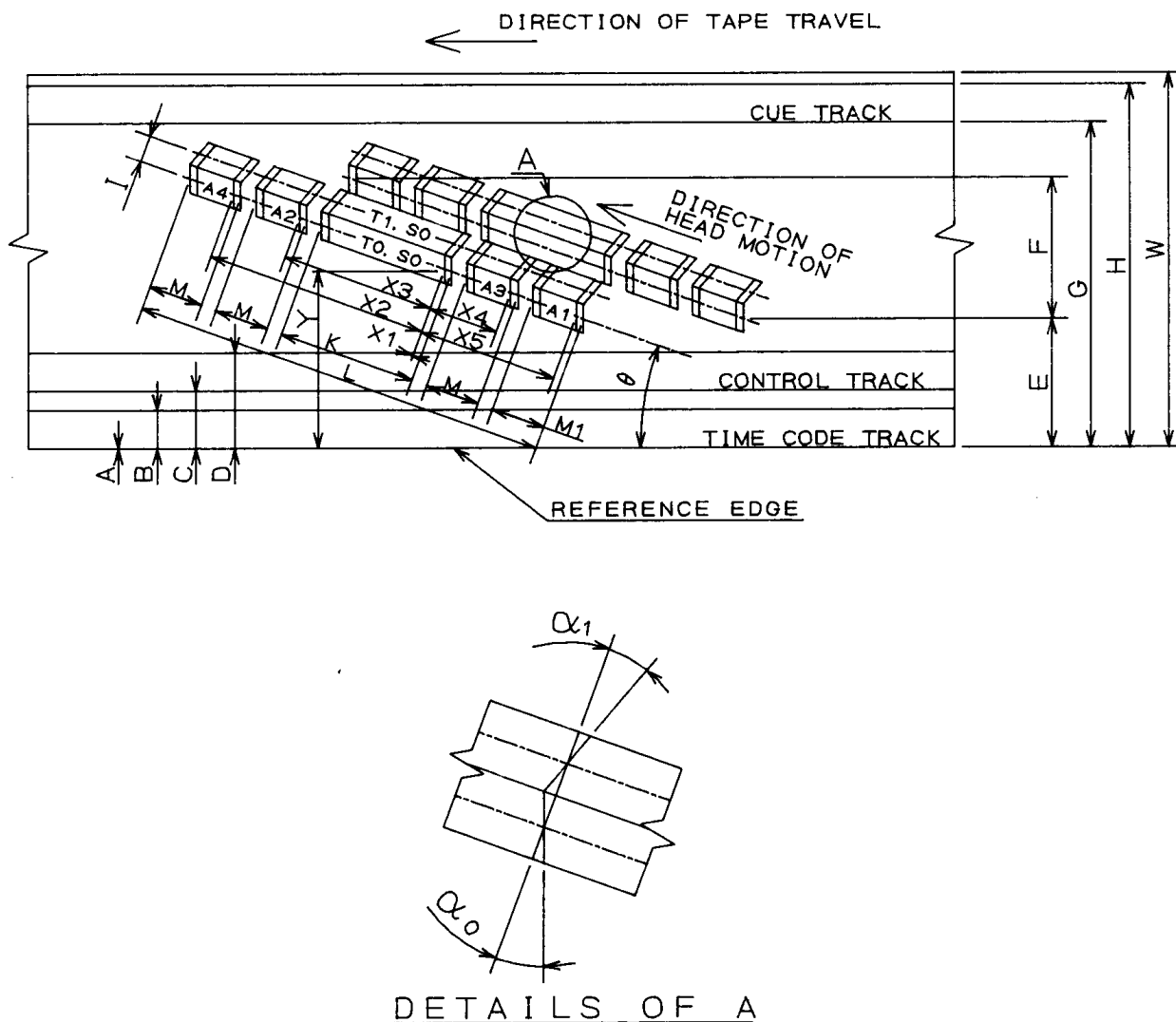
5.2 Record location and dimensions

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

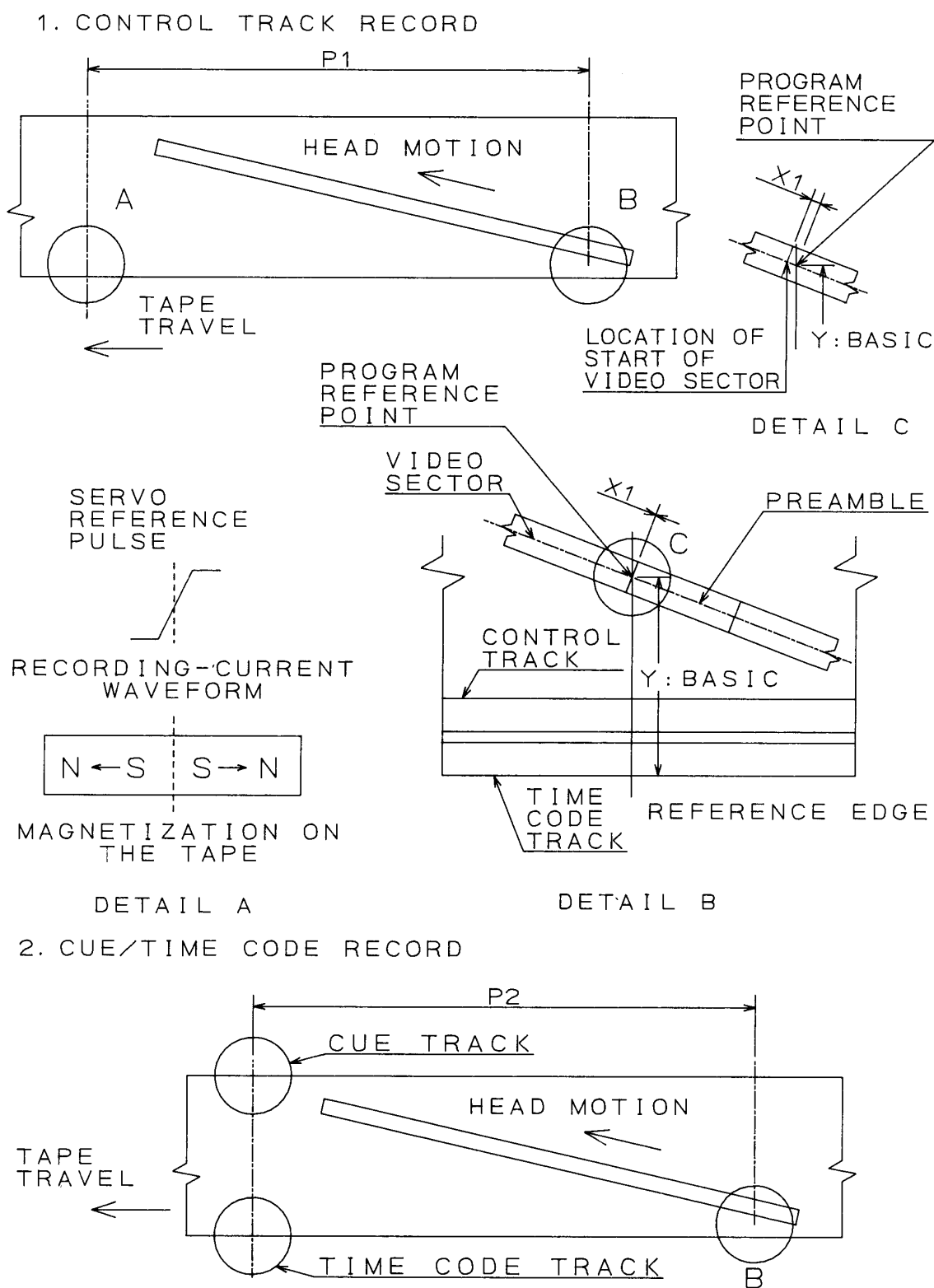


Figure 4 – Location of cue, time code and control track record

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.

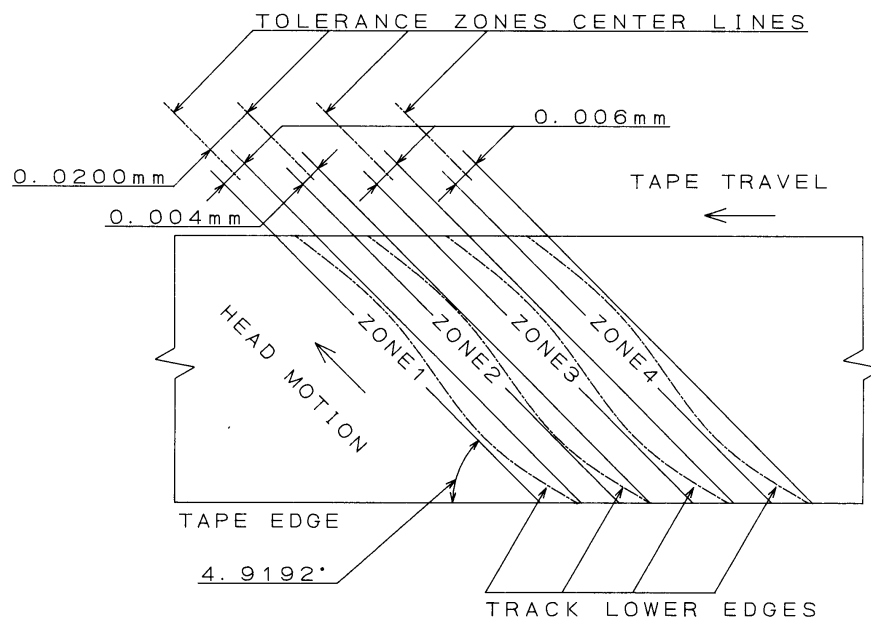


Figure 5 – Location and dimensions of tolerance zones of helical track record

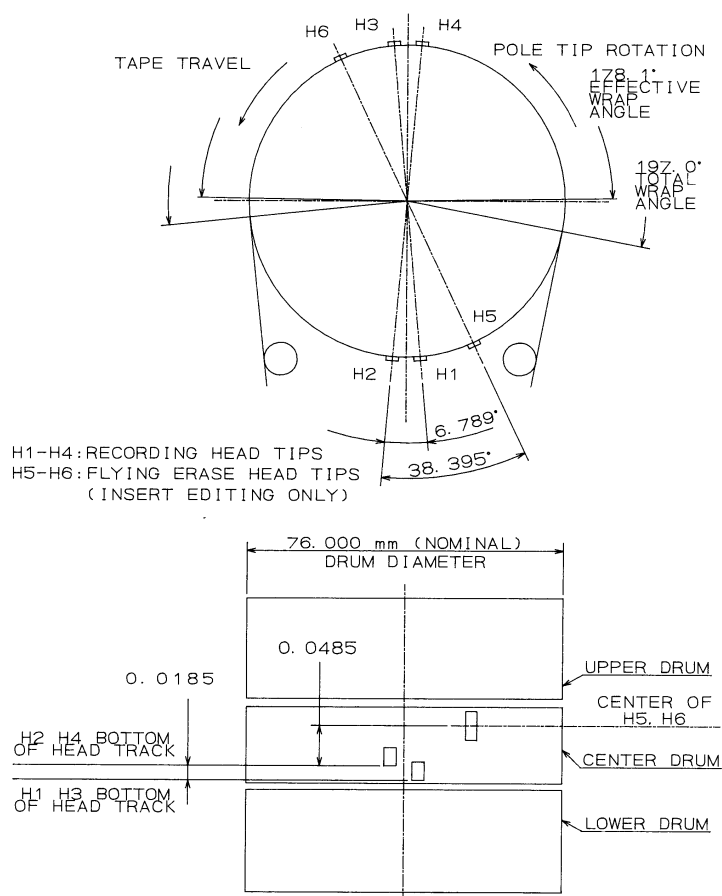
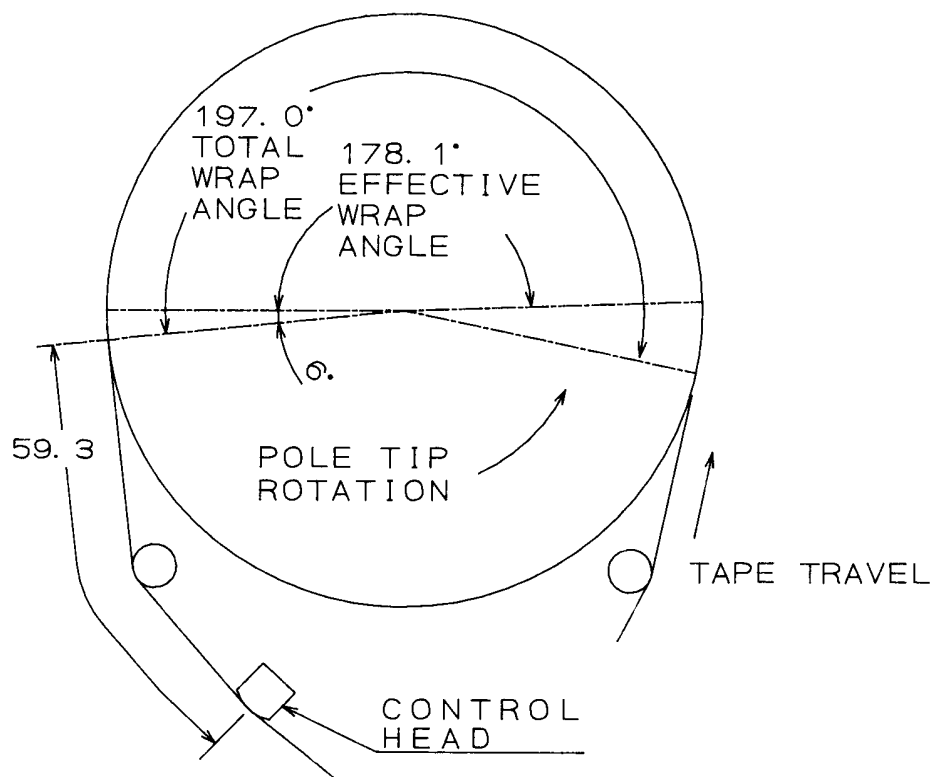
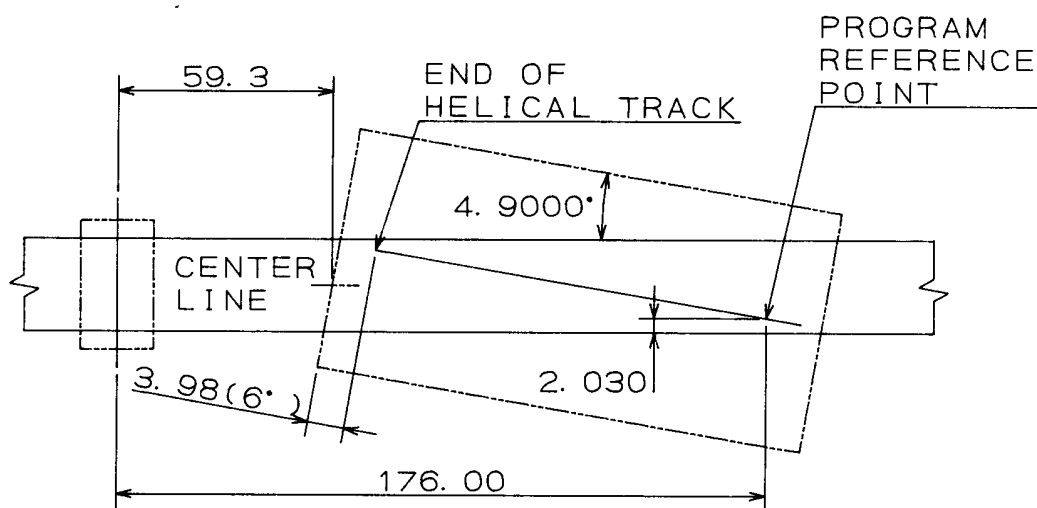


Figure 6 – A possible scanner configuration



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

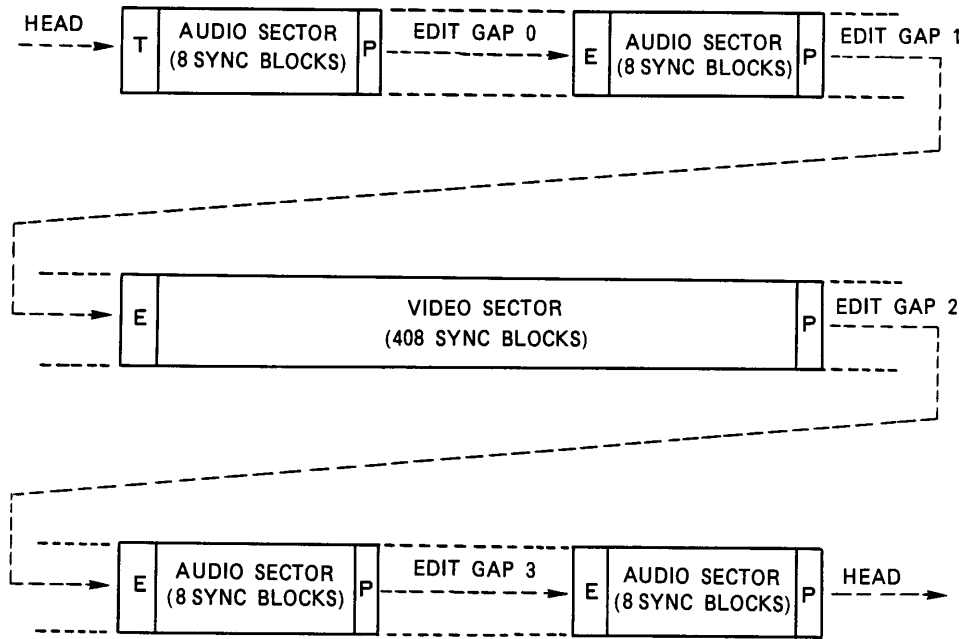
(a) Length: 16 bits (2 bytes).

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

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

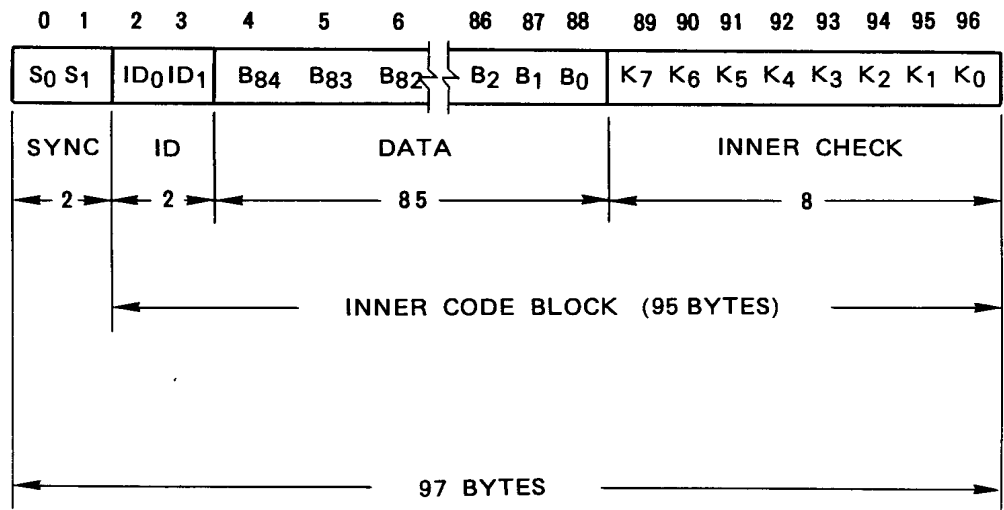


Figure 9 – Sync block format

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 80_h 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 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 $x^{86}D(x)$ 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: $ID_0x^{94} + ID_1x^{93} + B_{84}x^{92} + B_{83}x^{91} + \dots + B_1x^9 + B_0x^8 + K_7x^7 + K_6x^6 + \dots + K_2x^2 + K_1x + K_0$.