2. *Screen Brightness.* Is the picture brightness (screen luminance), contrast ratio, and color balance according to SMPTE Standards?

3. *Picture Steadiness.* Do the projectors provide picture steadiness (jump and weave) and freedom from "breathing" and "ghosting" in accordance with SMPTE Standards?

4. *Picture Sharpness.* Are lenses and lamphouses of modern design, and have they been properly matched to provide optimum image sharpness (acutance) according to SMPTE Standards?

5. *Sound System Characteristics.* Is the "B chain" of the sound system optimized for frequency response, wow and flutter, and distortion according to SMPTE Standards?

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Appendix

(This Appendix is not part of the SMPTE Engineering Guideline, but is included for information only.)

Some Representative Fields of Vision for Selected Viewing Distances Normalized for 2.35, 1.85, and 1.37 Aspect Ratios

Format	θ_H	θ_V	D		Remarks
2.35	37.6	16.1	3.45H	1.46W	Szabo, 1984
1.85	30.0	16.1	3.45H	1.86W	
1.37	22.5	16.1	3.45H	2.50W	
2.35	35.9	15.0	3.73H	1.59W	NIKFI, 1961[9]
1.85	27.8	15.0	3.73H	2.01W	
1.37	20.8	15.0	3.73H	2.72W	
2.35	28.0	12.0	4.70H	2.00W	Meister[2] and
1.85	22.3	12.0	4.70H	3.43W	Philips[10]
1.37	16.5	12.0	4.70H	3.43W	
2.35	26.4	11.3	5.00H	2.12W	Vivié, 1965[11]
1.85	21.0	11.3	5.00H	2.70W	
1.37	15.6	11.3	5.00H	3.65W	
2.35	19.5	8.35	6.81H	2.90W	Soulé, 1980[12]
1.85	15.5	8.35	6.81H	3.70W	
1.37	11.5	8.35	6.81H	5.00W	

Proposed American National Standard

for television analog recording —

½-in type M-2 — records

SMPTE 249M

1. Scope

This standard specifies the dimensions and locations of the video, audio, time code, and tracking-control records, as recorded by ½-in type M-2 helical-scan video tape recorders operating with video signals having a typical scanning structure of 525 lines, 59.94 fields/sec, 2:1 interlace, and utilizing the video cassettes specified in SMPTE 250M. This standard also specifies the records for two different audio recording modes — common audio mode and pulse code modulation (PCM) audio mode.

2. Referenced Documents

This standard is intended for use in conjunction with the following documents:

SMPTE 250M, Television Analog Recording — ½-in Type M-2 — Tapes and Cassettes

SMPTE 251M, Television Analog Recording — ½-in Type M-2 — Electrical Parameters of Video, Audio, Time and Control Code and Tracking Control

SMPTE 252M, Television Analog Recording — ½-in Type M-2 — Pulse Code Modulation Audio

SMPTE RP 158, Basic System and Transport Geometry Parameters for ½-in Type M-2 Format

3. General Specifications

3.1 All dimensions are in the metric system.

3.2 A basic dimension is a fundamental dimension to which no tolerance is applicable.

3.3 Tests and measurements made on the tape record to check the requirements of this standard shall be made under the following conditions unless otherwise specified:

Temperature	20°C ± 1°C
Relative humidity	50% ± 2%
Barometric pressure	86 to 106 kPa
Tape tension	0.31 N ± 0.05 N

3.4 Conditioning of the tape stock before recording and testing shall be as follows:

Environment	Established to the conditions specified in 3.3.
Tape tension	Wound on a reel at a tension of 0.4 N ± 0.1 N.
Condition time	24 hours.

3.5 The reference edge of the tape for dimensions specified in this standard shall be the lower edge as shown in Figs. 1 to 4. The magnetic coating, with the direction of tape travel as shown in Figs. 1 to 4, is on the side facing the observer.

4. Tape Speed

The tape speed shall be 67.693 mm/s, basic.

5. Record Locations and Dimensions

5.1 The locations and dimensions of the video and common audio mode records shall be as specified in Figs. 1 and 2 and Table 1.

5.2 The locations and dimensions of the video and PCM audio mode records shall be as specified in Figs. 3 and 4 and Table 2. The PCM records are recorded by the luminance and chrominance heads and only a single longitudinal audio record shall be available.

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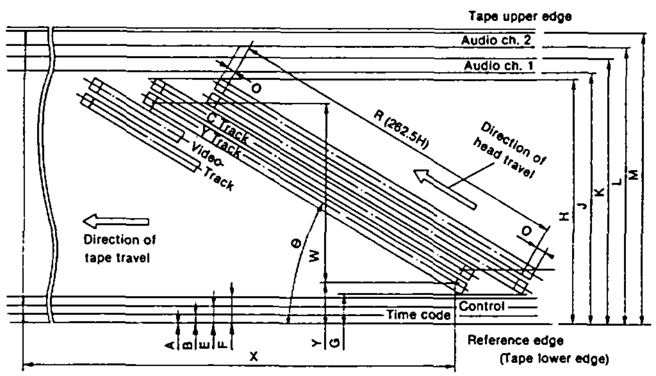


Fig. 1
Record Locations and Dimensions (Common Audio Mode)

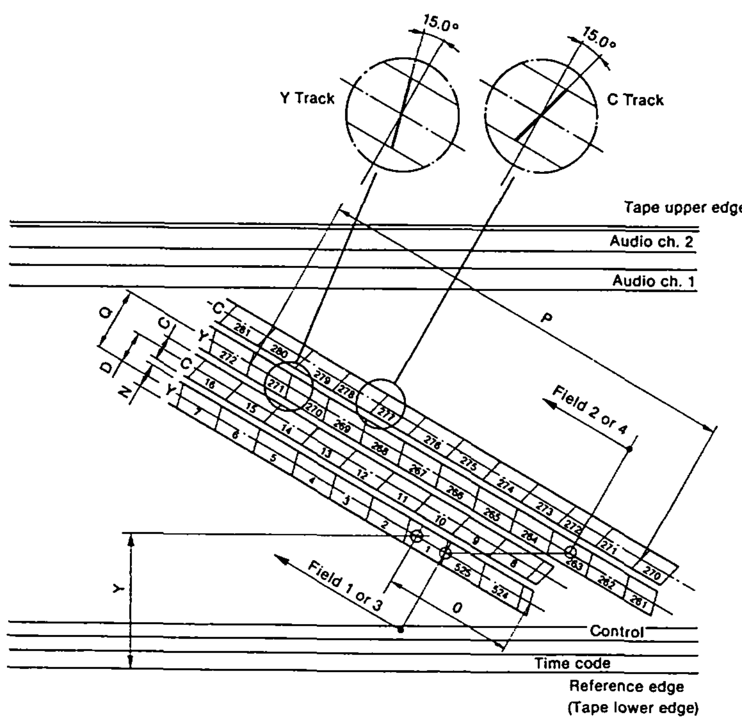


Fig. 2
Video Record Locations (Common Audio Mode)

Table 1
Record Locations and Dimensions (Common Audio Mode)

	Dimensions	Micrometers Minimum	Nominal	Maximum
A	Time code track lower edge	0	0	0
B	Time code track upper edge	400	450	500
C	Color track width	34	36	38
D	Y-C track pitch	40.7	42.2	43.7
E	Control track lower edge	850	900	950
F	Control track upper edge	1250	1300	1350
G	Video track lower edge	1469	1503	1537
H	Video track upper edge	10601	10634	10668
J	Audio 1 track lower edge	10830	10850	10870
K	Audio 1 track upper edge	11400	11450	11500
L	Audio 2 track lower edge	11900	11950	12000
M	Audio 2 track upper edge	12500	12550	12650
N	Y track width	42	44	46
O	Lead signal overlap		3H ref	
P	Y-C track offset		4505 (= 10H) ref	
Q	Video track pitch		84.5 ref	
R	Video track length		118254.3 (262.5H) ref	
W	Video area effective width		8847.1 ref	
X	Audio, time code and control track record offset		202000	
Y	Lower limit of W	1621	1626	1631
θ	Track angle		4.2906° (basic)	

Note: "Ref" indicates those measurements which are fixed by other parameters and are given for reference purposes only.

5.3 Dimensions O, P, Q, R, W, W', and PE are *shown for reference purposes only.* The actual value of these dimensions is determined by the tape speed, the transport parameters, and their tolerances.

The tape speed of 67.693 mm/s basic shall result in angle θ as shown. The nominal values given *are based on tensioned tape; therefore, direct* measurements without tension must take into account tape elasticity.

6. Video Record Curvature

The edge of any video record contained within an area defined by dimension W or the edge of any video and PCM audio record contained within an area defined by dimension W' shall be contained within two parallel straight lines 0.006 mm apart. (See Appendix.)

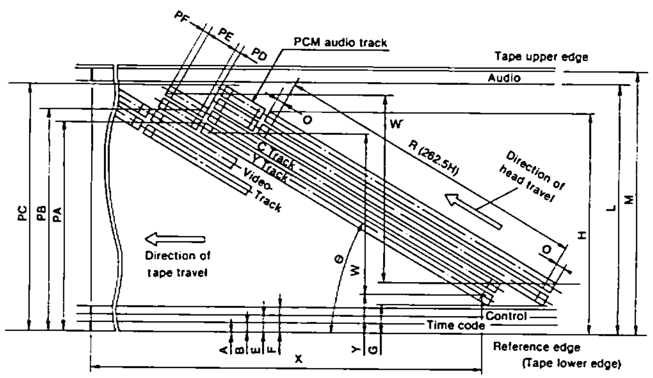


Fig. 3
Record Locations and Dimensions (PCM Audio Mode)

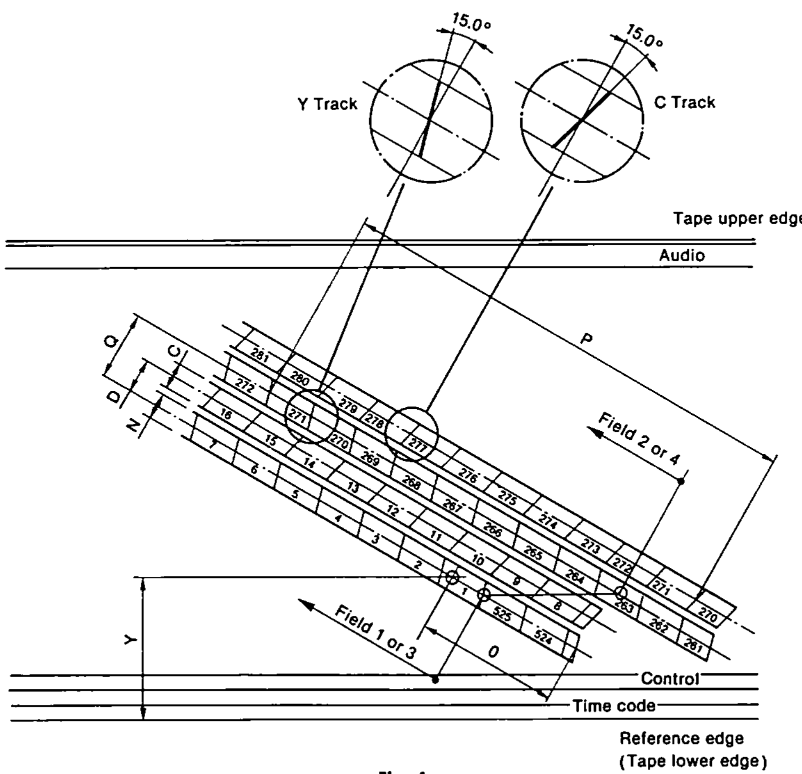


Fig. 4
Video Record Locations (PCM Audio Mode)

Table 2
Record Locations and Dimensions (PCM Audio Mode)

	Dimensions	Micrometers Minimum	Nominal	Maximum
A	Time code track lower edge	0	0	0
B	Time code track upper edge	400	450	500
C	Color track width	34	36	38
D	Y-C track pitch	40.7	42.2	43.7
E	Control track lower edge	850	900	950
F	Control track upper edge	1250	1300	1350
G	Video track lower edge	1469	1503	1537
H	Video track upper edge	10601	10634	10668
L	Audio track lower edge	11900	11950	12000
M	Audio track upper edge	12500	12550	12650
N	Y track width	42	44	46
O	Lead signal overlap		3H ref	
P	Y-C track offset		4505 (= 10H) ref	
Q	Video track pitch		84.5 ref	
R	Video track length		118254.3 (262.5H) ref	
W	Video area effective width		8847.1 ref	
W'	Video and PCM audio (CH6) area effective width		9973.5 ref	
X	Audio, time code and control track record offset		202000	
Y	Lower limit of W	1621	1626	1631
θ	Track angle		4.2906° (basic)	
PA	Effective PCM audio track lower edge (luminance head)	10676	10709	10743
PB	Effective PCM audio track lower edge (chrominance head)	10724	10758	10791
PC	PCM audio track upper edge (chrominance head)	11660	11693	11727
PD	Preamble	360	450	541
PE	PCM audio data area		11820 ref	
PF	Postamble	360	450	541

Note: "Ref" indicates those measurements which are fixed by other parameters and are given for reference purposes only.

7. Relative Positions of Signal Records

Video luminance, color difference, tracking-control, longitudinal audio, and time-code signals, with information intended to be time coincident, shall be positioned as shown in Figs. 1 to 4. PCM audio shall be positioned as shown in Figs. 3 and 4.

8. Gap Azimuth

8.1 The azimuth of the audio, tracking-control, and time code head gaps used to produce longitudinal track records shall be perpendicular to the direction of relative head-to-tape motion. (See Figs. 1 and 3.)

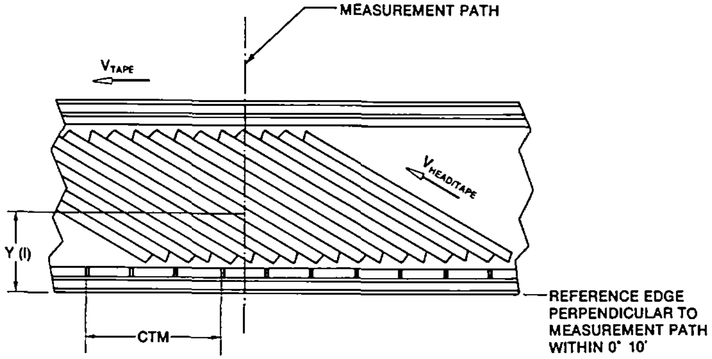
8.2 The azimuth of the video head gaps for the luminance signal shall be — 15.0° and for the color difference signals shall be + 15.0° to the perpendicular of the direction of head motion. (See Figs. 2 and 4.)

Appendix

(This Appendix is not part of the American National Standard, but is included for information only.)

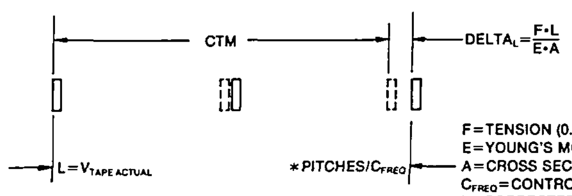
CROSS TAPE TRACK MEASUREMENT TECHNIQUE (PREFERRED)

MEASUREMENT TECHNIQUE



Y (I) MUST USE SAME HEAD FOR EACH MEASUREMENT (i.e. EVERY 2nd TRACK)
CTM = CONTROL TRACK PULSES (UNTENSIONED TAPE)

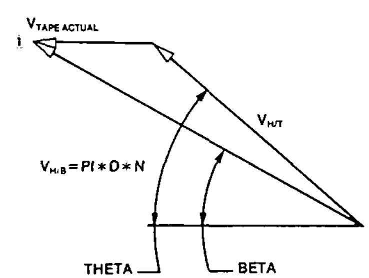
CORRECTION FACTORS ACTUAL TAPE SPEED, TENSION



F = TENSION (0.31 N)
E = YOUNG'S MODULUS (8000 N/mm²)
A = CROSS SECTIONAL AREA (THICKNESS × WIDTH)
C_{FREQ} = CONTROL TRACK FREQUENCY (59.94 Hz)
L = CORRECTED DISTANCE

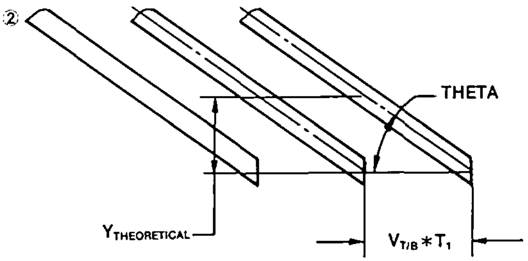
$$V_{TAPE\ ACTUAL} = CTM * C_{FREQ}/((1 - F/(E * A)) * PITCHES)$$

MODEL



$V_{H/B}$ = VELOCITY OF HEAD wrt BAND
$V_{TAPE\ ACTUAL}$ = ACTUAL VELOCITY of TAPE
$V_{H/T}$ = VELOCITY of HEAD wrt TAPE
D = EFFECTIVE SCANNER DIAMETER
N = SCANNER SPEED $(\frac{REV}{S})$
THETA = TRACK ANGLE
BETA = SCANNER HELIX ANGLE

②



T_1 = TIME BETWEEN HEAD PASSES

$$= \frac{1}{N * HPPR}$$

HPPR = HEAD PASSES per REVOLUTION

FROM ①

$$TAN\ (THETA) = \frac{PI * D * N * SIN\ (BETA)}{PI * D * N * COS\ (BETA) - V_{TAPE\ ACTUAL}}$$

FROM ②

$$TAN\ (THETA) = \frac{Y_{THEORETICAL}}{V_{TAPE\ ACTUAL} * T_1}$$

THEREFORE:

$$Y_{THEORETICAL} = \frac{PI * D * N * SIN\ (BETA)}{PI * D * N * COS\ (BETA) - V_{TAPE\ ACTUAL}} * V_{TAPE\ ACTUAL} * T_1$$

$$TRACK\ LOCATION\ ERROR = Y\ (I) - Y\ (I)_{THEORETICAL}$$

Proposed American National Standard

for television analog recording —

½-in type M-2 — tapes and cassettes

SMPTE 250M

1. Scope

This standard specifies tapes and cassettes for the ½-in type M-2 helical-scan video tape recording system.

2. General Specifications

2.1 Dimensions are in the metric system.

2.2 Tests and measurements for confirming the requirements of this standard shall be made under the following conditions unless otherwise specified:

Temperature	20°C ± 1°C
Relative humidity	50% ± 2%
Barometric pressure	86 to 106 kPa

2.3 Specimens shall be stored under the test conditions specified in 2.2 for 24 hours prior to the test.

3. Cassette Type

There are two cassette types which are identified by outside dimensions shown below:

Large cassette (L)	106 x 188 x 25 mm
Small cassette (S)	87 x 130 x 25 mm

4. Video Tape

The video tape shall have the following characteristics:

4.1 Type of video tape	Metal particle
4.2 Base material	Polyethylene terephthalate or its equivalent
4.3 Direction of particle orientation	Longitudinal direction of tape
4.4 Coercivity	Class 1500
4.5 Light transmissivity	5% or less (measured over the range of wavelengths 700 to 900 nm)
4.6 Total thickness	13.5 μm ± 0.5 μm
4.7 Width	12.65 mm ± 0.01 mm
4.8 Width fluctuation	6 μm or less

5. Leader Tape and Trailer Tape

The leader tape and trailer tape shall have the following characteristics:

5.1 Light transmissivity	50% or more (measured over the range of wavelengths 700 to 900 nm)
5.2 Length	for large cassette 170 mm ± 15 mm; for small cassette 140 mm ± 10 mm

Length of the leader and trailer tape is defined between the end of the leader or trailer tape to a point where this tape is attached by a splicing tape to the metal particle tape.

5.3 Tape thickness	13 to 36 μm
5.4 Width	12.65 mm ± 0.02 mm
5.5 Splicing tape length	13 to 20 mm
5.6 Splicing tape thickness	25 μm or less
5.7 Splicing strength to reel hub	20 N or more
5.8 Splicing strength to video tape	20 N or more

5.9 Breaking strength of leader tape	30 N or more
5.10 Offset yield strength of leader tape	18 N or more

6. Video Tape Length and Record/Playback Time

Tape length and record/playback time specifications shall be as given in Tables 1 and 2.

Table 1
Definition of Play/Record Time for Large Cassette

Record/Play Time (min)	Tape Length (m)
95	389 $^{+3}_{0}$
65	267 $^{+3}_{0}$
35	145 $^{+3}_{0}$
23	96 $^{+3}_{0}$
12	51 $^{+3}_{0}$

Table 2
Definition of Play/Record Time for Small Cassette

Record/Play Time (min)	Tape Length (m)
23	96 $^{+3}_{0}$
12	51 $^{+3}_{0}$

7. Video Cassette

The video cassette shall be specified by the following descriptions:

7.1 Cassette Dimensions. Large cassettes shall conform to Figs. 1 to 8. Small cassettes shall conform to Figs. 9 to 20.

7.2 Cassette Datum System

7.2.1 Datum Holes. Datum holes shall be holes serving as a reference when loading a cassette in the video tape recorder, and shall also be the datum reference of the cassette dimensions. (See Figs. 2 to 4 and 10 to 12.)

7.2.2 Datum Plane Z. Datum plane Z shall be a plane containing three datum places, A, B, and C, on the cassette bottom. (See Figs. 4 and 12.)

7.2.3 Datum Plane X

7.2.3.1 Large Cassette. This plane shall be orthogonal to datum plane Z containing the centerlines of datum holes A and B. (See Figs. 2 to 4.)

7.2.3.2 Small Cassette. This plane shall be parallel to the long side face of the cassette and shall be orthogonal to datum plane Z, containing the centerline of datum hole A. (See Figs. 10 to 12.)

7.2.4 Datum Plane Y. Datum plane Y shall be a plane orthogonal to both datum planes Z and X, containing the centerline of datum hole A. (See Figs. 2 to 4 and 10 to 12.)

7.3 Window and Label Pasting Face. Large cassettes shall conform to Fig. 1 and small cassettes to Fig. 9.

7.4 Identification Holes. Multiple holes shall be provided for identifying the conditions of the cassette. (See Figs. 2 and 10.) Each hole may be set in a closed state or an opened state:

Closed state	The hole depth shall be 0 to 0.25 mm and shall withstand a force of 0.5 N.
Opened state	The hole diameter shall be 3 mm + 0.3 mm — 0.1 mm. The hole depth shall be 5 mm or more.

7.4.1 Record Lock-Out Identification Hole. Large cassettes shall be as specified in Fig. 2 and small cassettes as in Fig. 10.

The record lock-out identification hole shall be coupled to the record lock-out mechanism shown in Figs. 1 and 9, and may be changed between the closed state and the opened state. Each state shall be defined as follows:

Identification hole closed	Ready to record
Identification hole opened	Record lock out

7.4.2 Tape Type Identification Hole. Large cassettes shall be as specified in Fig. 2 and small cassettes as in Fig. 10.

The closed or opened state of the identification hole shall be defined as follows:

Identification hole closed	Metal particle tape (Coercivity class 1500)
Identification hole opened	Reserved

7.4.3 Tape Thickness Identification Hole. Large cassettes shall be as specified in Fig. 2 and small cassettes as in Fig. 10.

The closed or opened state of the identification hole shall be defined as follows:

Identification hole closed	Tape total thickness is 13.5 μm $\pm$ 0.5 μm
Identification hole opened	Reserved

7.4.4 Additional Identification Holes. These holes are provided for future usage. The positions of these reserved holes shall be as follows: Large cassettes shall be as specified in Fig. 2 (five holes) and small cassettes shall be as specified in Fig. 10 (two holes).

7.5 Dimensions of the reel shall conform to Figs. 6, 14, and 15.

7.6 The tape winding method and path shall conform to Figs. 7 and 16.

7.7 The E value shall be 1.0 mm or more. (See Note 4 of Fig. 5 and Note 5 of Fig. 13.)

7.8 The structure of the lid shall conform to Figs. 8 and 17. The lid shall be unlocked when a force of not more than 0.15 N for large cassettes or a force of not more than 0.30 N for small cassettes is applied to the unlocking clutch as shown in Note 8 of Fig. 1, Note 6 of Fig. 9, and Fig. 19.

7.9 The force necessary for opening the lid shown in Note 7 of Fig. 3 and Fig. 17 shall be 1 N or less.

7.10 The reel brakes shall be released by a force of not more than 0.7 N by means of a reel brake unlocking pin as shown in Note 4 of Fig. 3 and Note 3 of Fig. 11.

7.11 The cassette reels shall be pushed down by a reel spring with a force of 2.0 N $\pm$ 0.3 N for large cassettes and 1.5 N $\pm$ 0.3 N for small cassettes, as shown in Fig. 5b and Fig. 13b.

7.12 The minimum space required for the recorder and/or player loading mechanism shall be as shown in Fig. 18.

7.13 Screw Positions. Screw positions for assembling the upper and lower cassette halves should be as shown in Fig. 8 (large cassette) and Fig. 20 (small cassette). The diameter of the spot facing for the screw head should be within 3.8 to 6.2 mm. The diameter of the spot facing for the screw head described in Note 1 of Fig. 20 shall be 5.3 to 5.7 mm. No screw head shall protrude beyond the cassette surface.

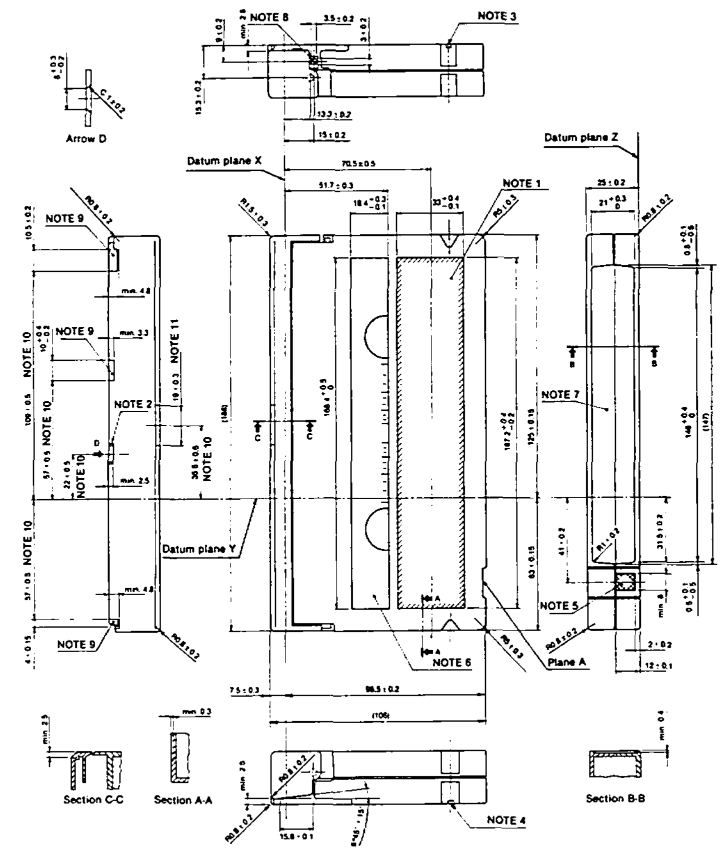


Fig. 1
Top and Side Views of Large Cassette

Notes:
1. Top Label Pasting Face. The label shall not protrude beyond the cassette height.
2. Guide groove A to prevent misinsertion. (Dimension at the lid is shown.)
3. Guide groove B to prevent misinsertion.
4. Guide groove C to prevent misinsertion.
5. Operation of Record Lock-Out Hole. When the record lock-out hole is open, recording should be impossible. The minimum hole depth is 2.9 mm from plane A. When the hole is closed, recording should be possible. The record lock-out mechanism shall be coupled with the identification hole shown in Note 9 of Fig. 2.
6. Window. This window shall not protrude beyond the cassette height.
7. Side Label Face. The label shall not protrude beyond the cassette side.
8. Lid unlocking clutch.
9. Cassette front positioning face.
10. These tolerances include a slight play of the lid.
11. Recess to prevent misinsertion.

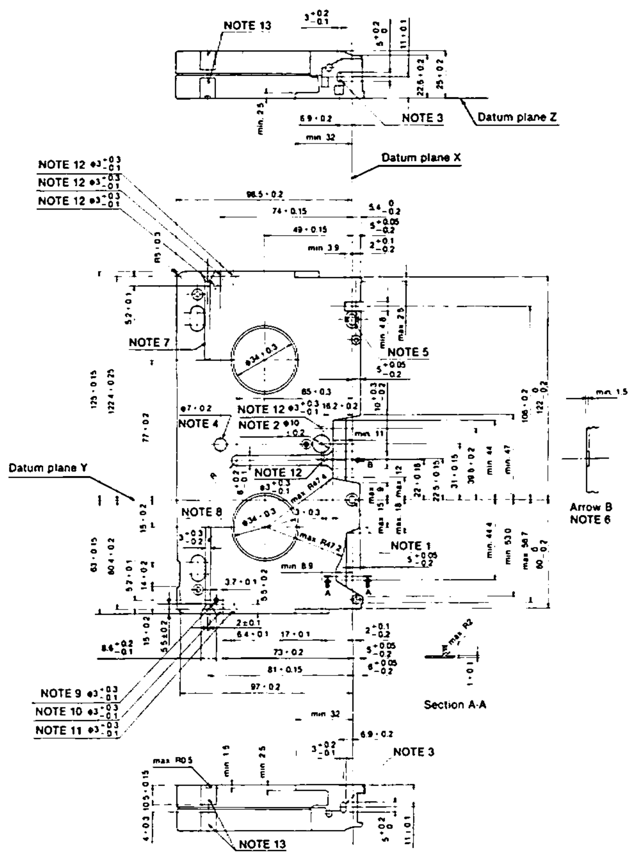


Fig. 2
Bottom View of Large Cassette

Notes:
1. Datum hole A.
2. Hole for the sensor lamp.
3. Holes for the sensor optical path.
4. Reel brake unlocking hole.
5. Datum hole B.
6. Guide groove A to prevent misinsertion.
7. Guide groove B to prevent misinsertion.
8. Guide groove C to prevent misinsertion.
9. Record lock-out identification hole.
10. Tape type identification hole.
11. Tape thickness identification hole.
12. Extra identification holes (five holes).
13. Grip for automatic loading machine

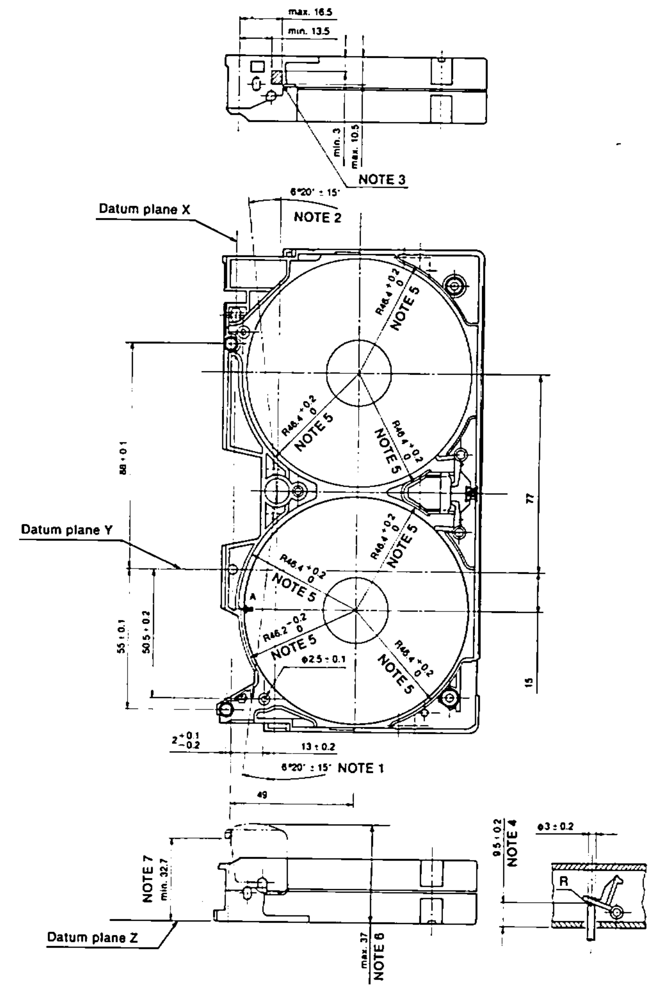


Fig. 3
Inner Structure of Large Cassette

Notes:
1. Supply side sensor optical path angle.
2. Take-up side sensor optical path angle.
3. Pushing position of the lid unlocking device.
4. Position of the brake unlocking pin of the recorder.
5. The space of this dimension shall be maintained throughout the entire circumference of the inner wall.
6. Maximum permissible height when the lid is opened.
7. The lid minimum opening dimension. This dimension shall be applied over the cassette front tape threading range. (See Fig. 7 for tape threading path.)

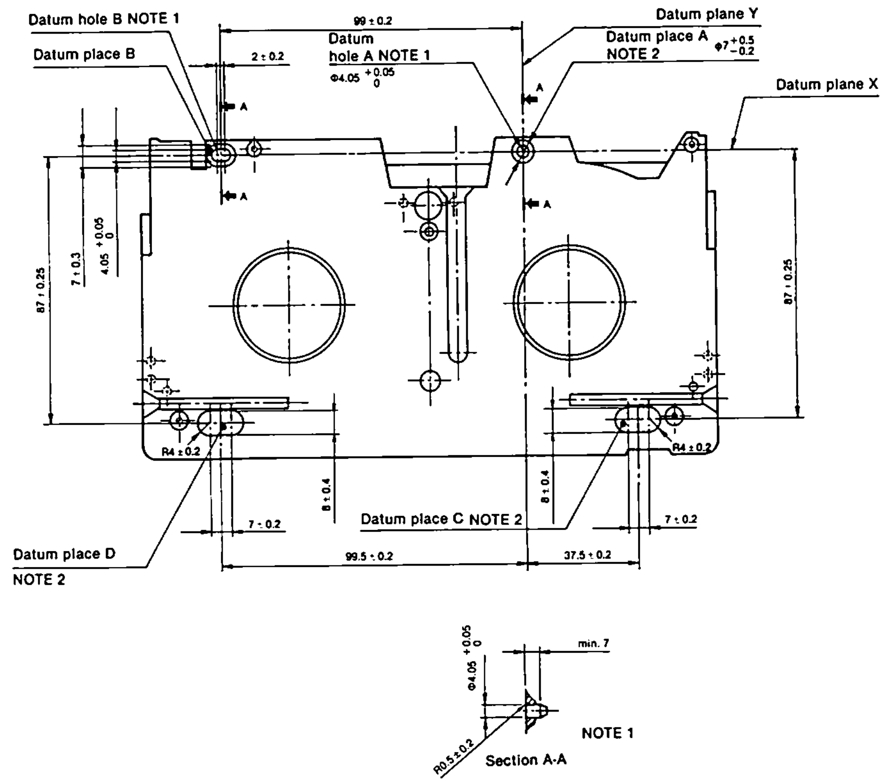
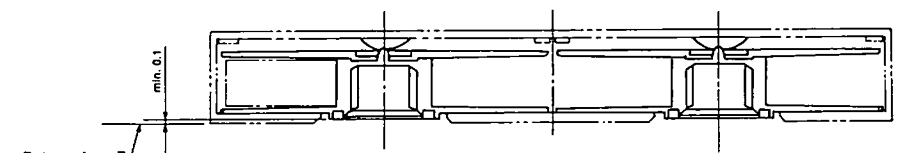


Fig. 4
Datum Places and Support Surfaces of Large Cassette

Notes:
1. The diameter of the datum hole in Section A-A shall be 4.05 mm + 0.05 mm — 0.00 mm and 7 mm in depth.
2. The flatness of the four datum places shall be 0.2 mm or less. The datum places are used as the supporting surfaces of the cassette.

(a) Condition off the machine



(b) Condition loaded on the machine

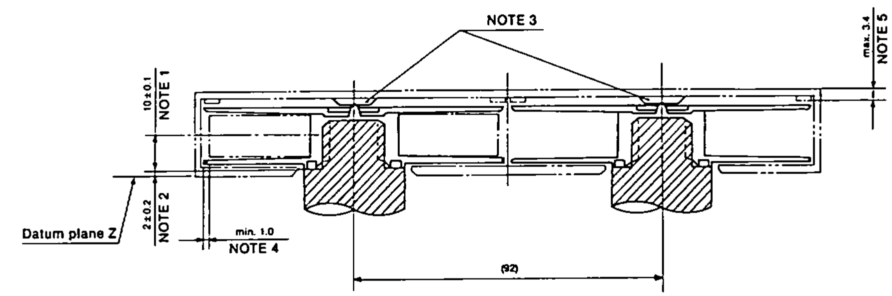


Fig. 5
Relationship Between Reels and Reel Stands for Large Cassette

Notes:
1. Centerline of tape.
2. Height of reel stand above cassette datum plane Z. The cassette tape reel shall be smoothly operated at a height of 2.0 mm ± 0.2 mm.
3. Reel springs.
4. E value (a margin between reel flange outside diameter and maximum wound tape diameter).
5. Reel stoppers to limit the play of the reel.

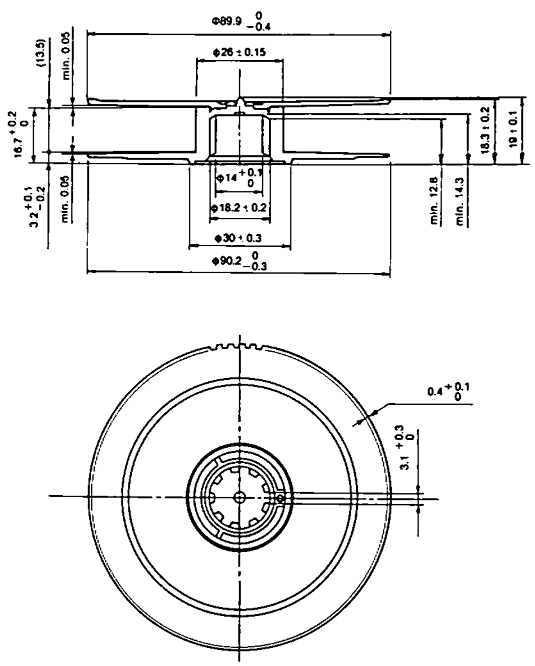


Fig. 6
Reel Dimensions of Large Cassette

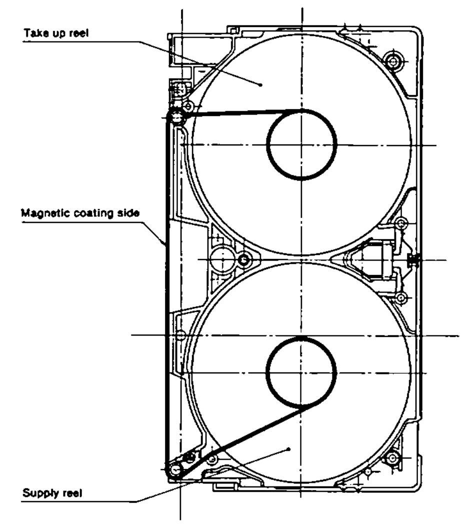


Fig. 7
Tape Path in Large Cassette

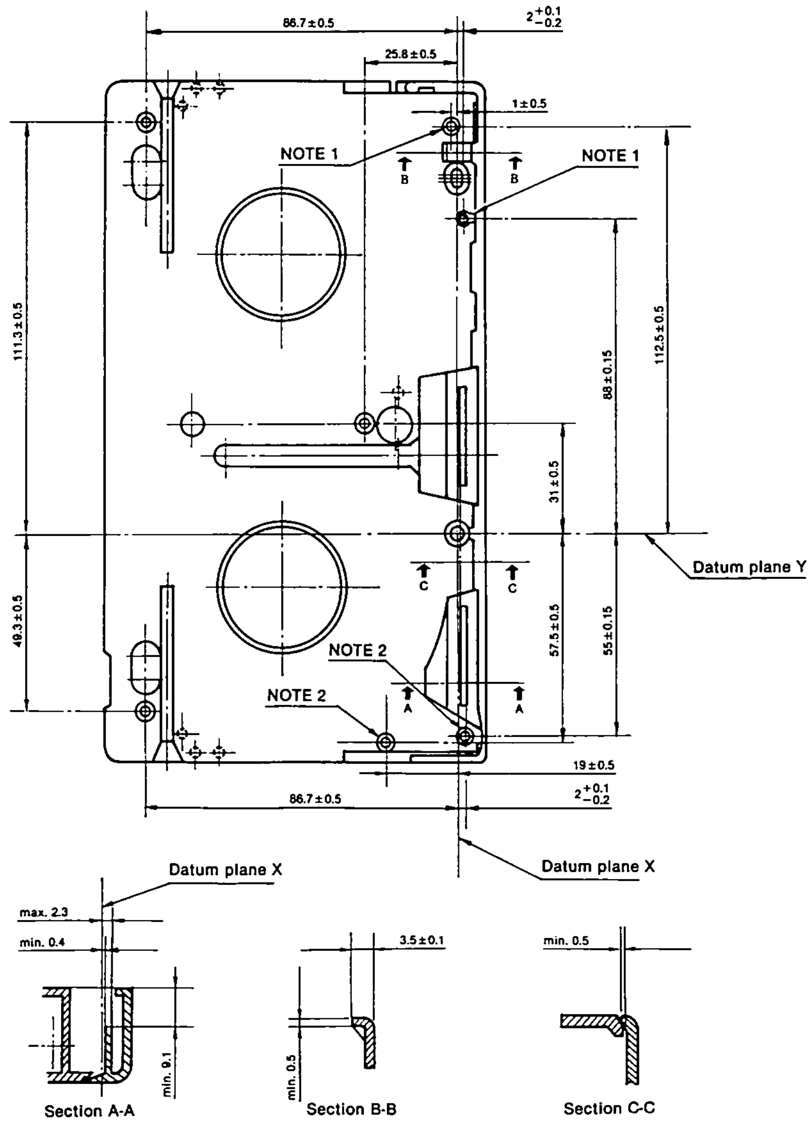


Fig. 8
Screw Positions and Lid Structure of Large Cassette

Notes:
1. Either one of two screw positions may be used.
2. Either one of two screw positions may be used.

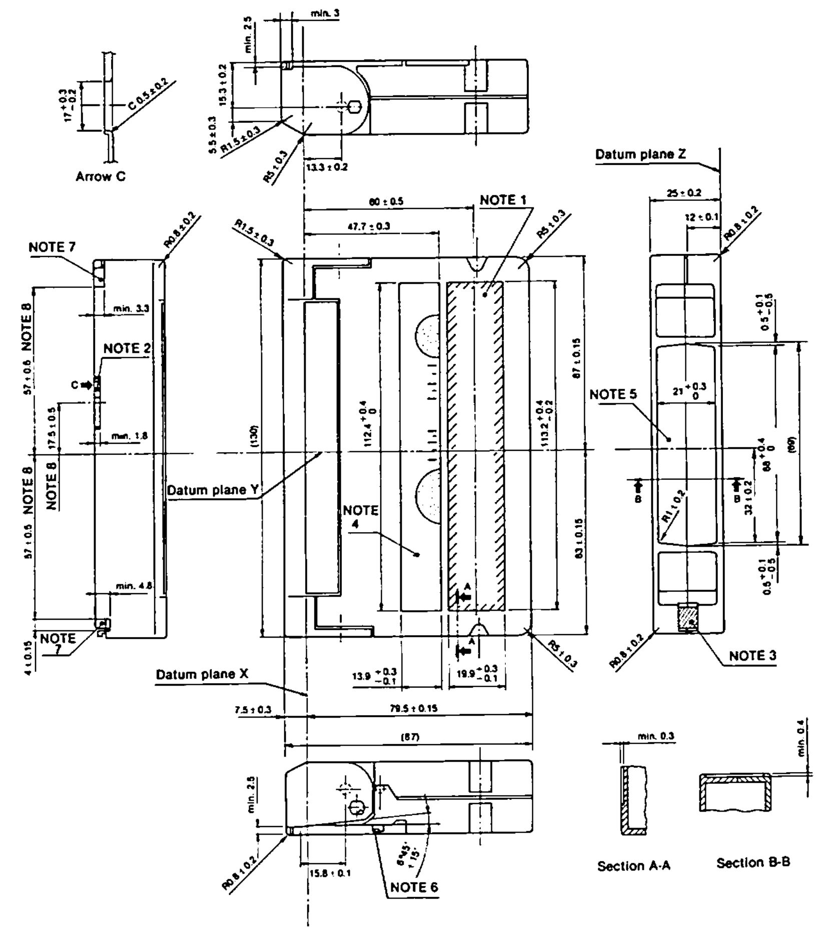


Fig. 9
Top and Side Views of Small Cassette

Notes:
1. Top Label Pasting Face. The label shall not protrude beyond the cassette height.
2. Guide groove to prevent misinsertion.
3. Operation of Record Lock-Out Hole. When the record lock-out hole is open, recording should be impossible. When the hole is closed, recording should be possible. The record lock-out mechanism shall be coupled with the identification hole shown in Fig. 10 (Note 6).
4. Window. This window shall not protrude beyond the cassette height.
5. Side Label Pasting Face. The label shall not protrude beyond the cassette side.
6. Lid unlocking clutch.
7. Cassette front positioning face.
8. These tolerances include a slight play of the lid.

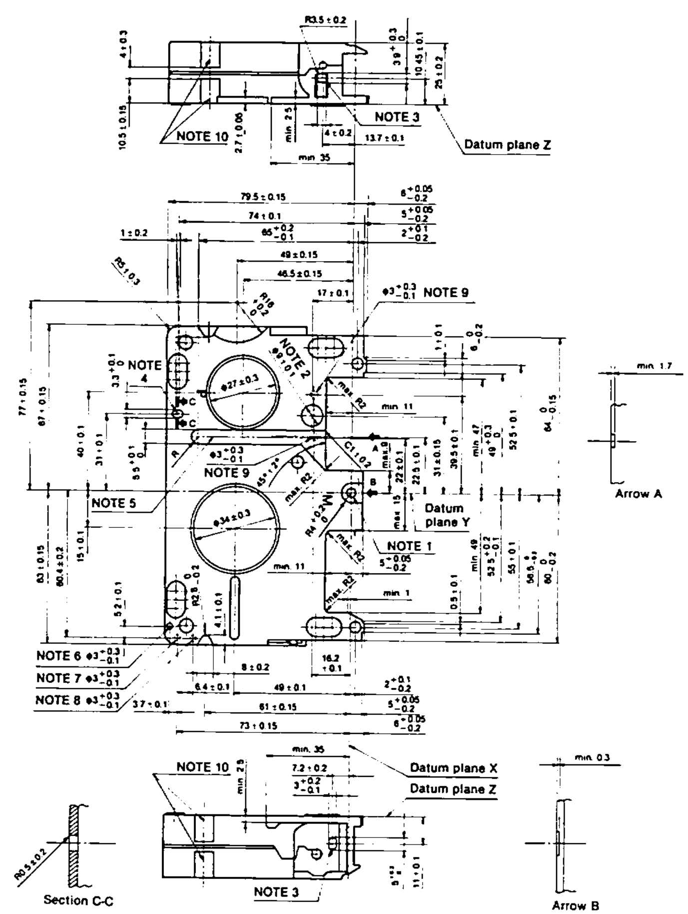


Fig. 10
Bottom View of Small Cassette

Notes:
1. Datum hole.
2. Hole for sensor lamp.
3. Holes for sensor optical path.
4. Reel brake unlocking hole.
5. Guide groove to prevent misinsertion.
6. Record lock-out identification hole.
7. Tape type identification hole.
8. Tape thickness identification hole.
9. Extra identification holes (two holes).
10. Grip for automatic loading machine.

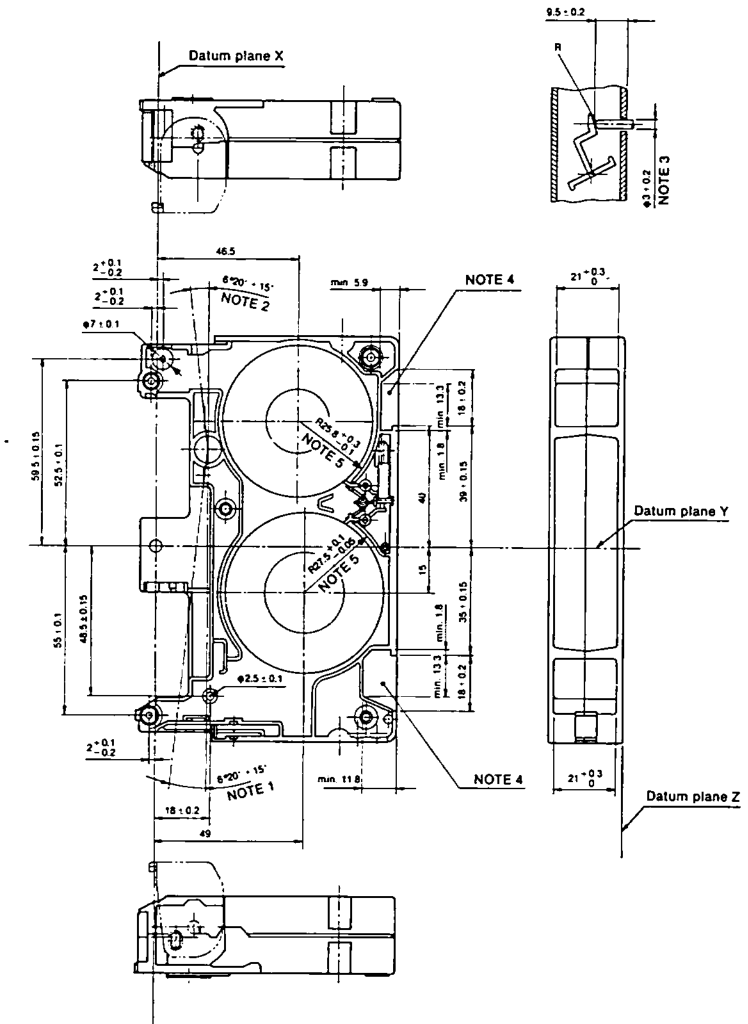


Fig. 11
Inner Structure of Small Cassette

Notes:
1. Supply side sensor optical path angle.
2. Take-up side sensor optical path angle.
3. Position of the brake unlocking pin of the recorder.
4. Finger hole.
5. This dimension shall be maintained throughout the entire circumference of the inner wall.

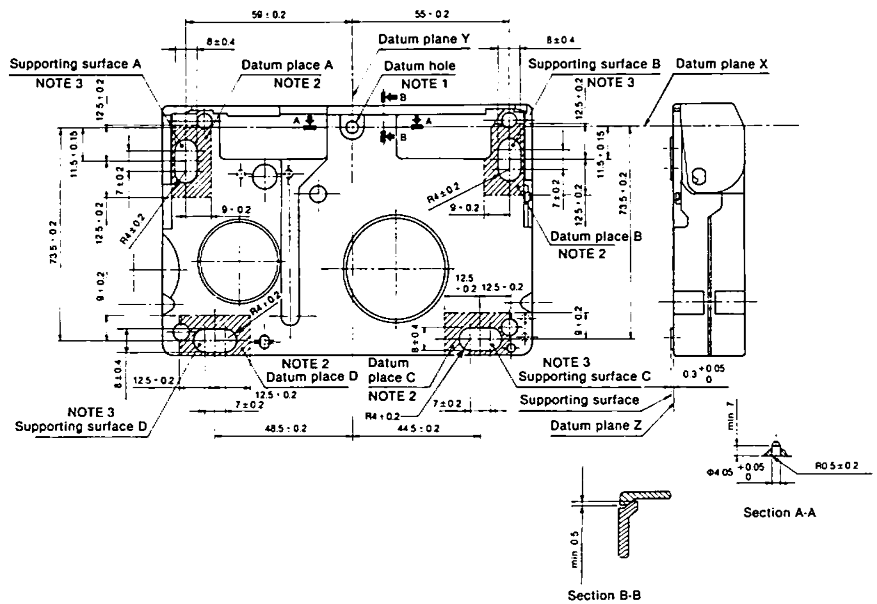
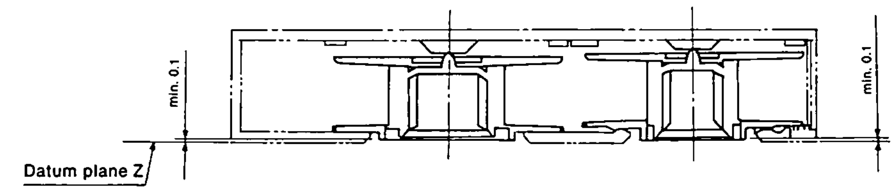


Fig. 12
Datum Places and Supporting Surfaces of Small Cassette

Notes:
1. The diameter of the datum hole in Section A-A shall be 4.05 mm + 0.05 mm — 0.00 mm and 7 mm in depth.
2. The flatness of the four datum places shall be 0.2 mm or less.
3. The flatness of the four supporting surfaces shall be 0.2 mm or less. The supporting surfaces are used as the cassette supporting surfaces for cassette loading.

(a) Condition off the machine



(b) Condition loaded on the machine

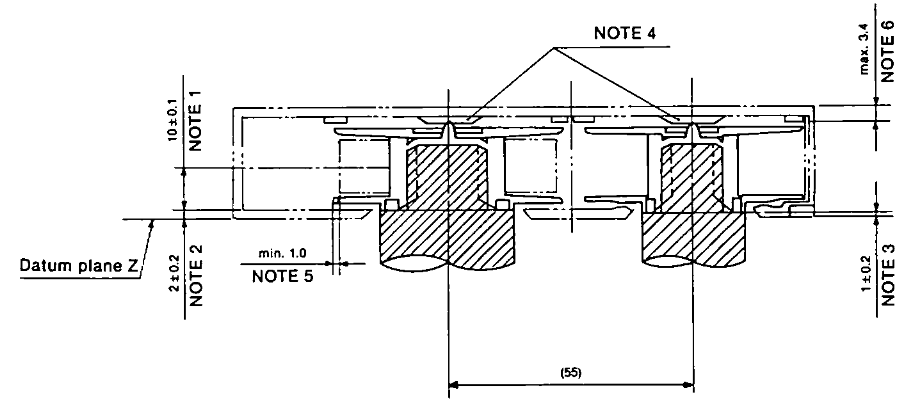


Fig. 13
Relationship Between Reels and Reel Stands of Small Cassette

Notes:
1. Centerline of tape.
2. Height of supply reel stand above cassette datum plane Z. The cassette shall operate smoothly at a height of 2.0 mm ± 0.2 mm.
3. Height of take-up reel stand above cassette datum plane Z. The cassette shall operate smoothly at a height of 1.0 mm ± 0.2 mm.
4. Reel springs.
5. E value (a margin between reel flange outside diameter and maximum wound tape diameter).
6. Reel stoppers to limit the play of the reel.

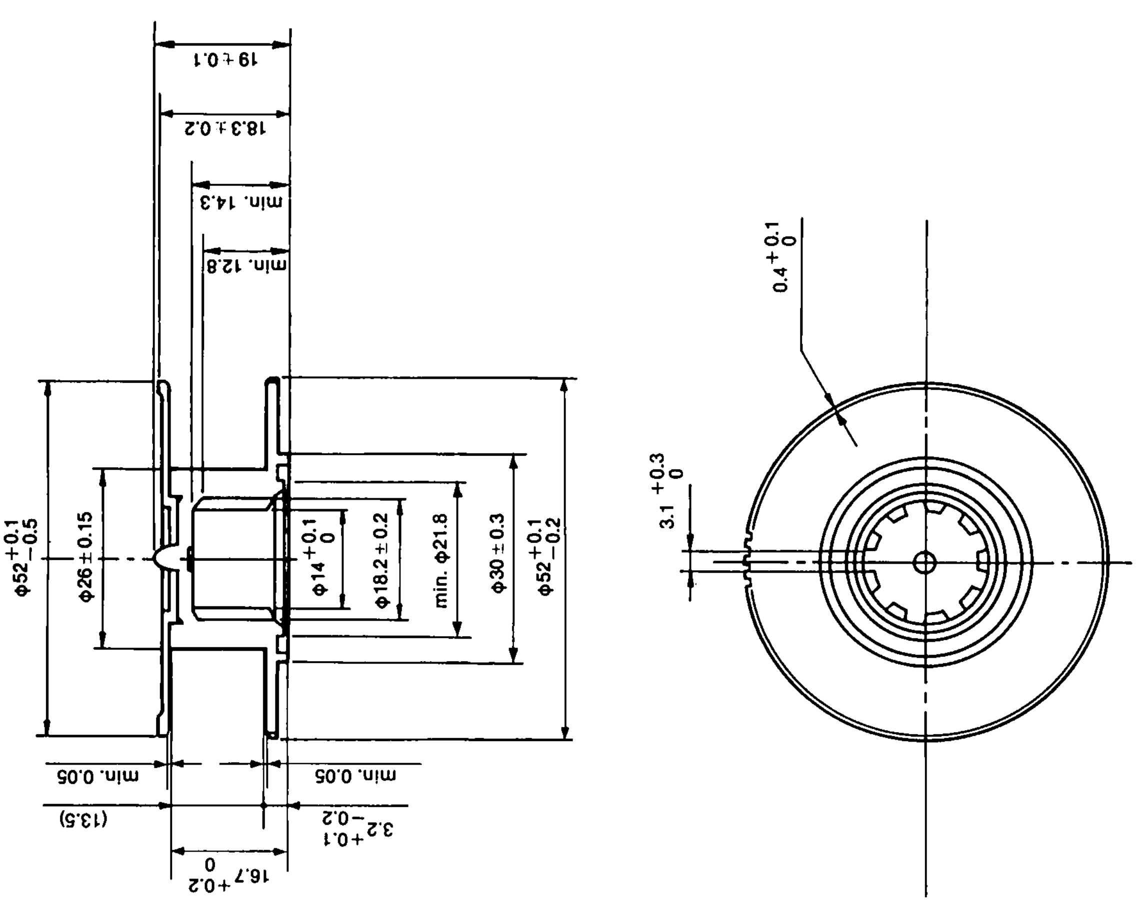


Fig. 14
Supply Reel Dimensions of Small Cassette

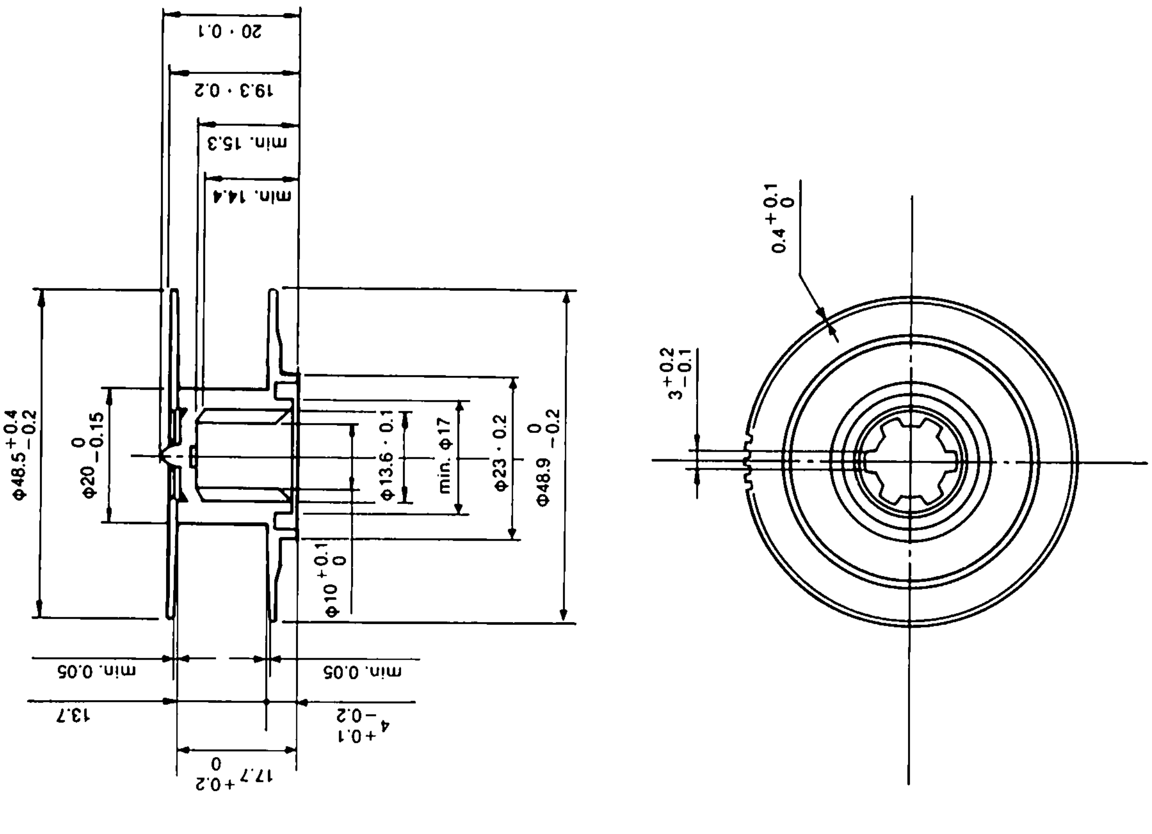


Fig. 15
Take-Up Reel Dimensions of Small Cassette

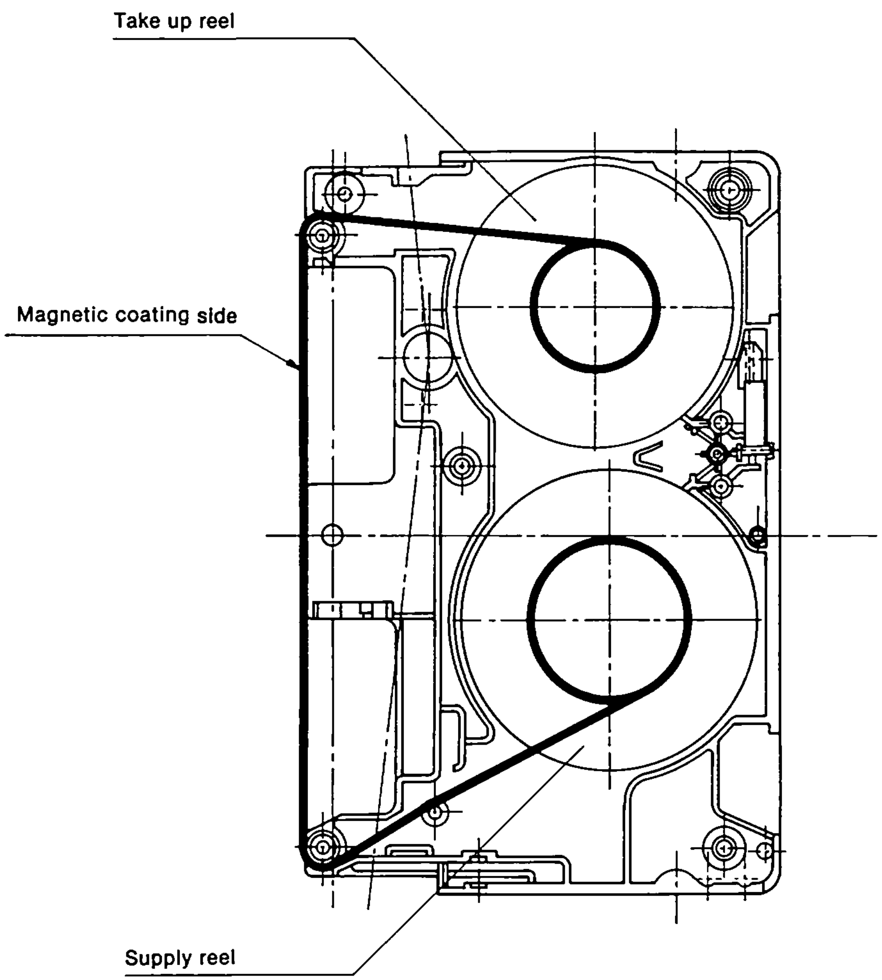


Fig. 16
Tape Path in Small Cassette

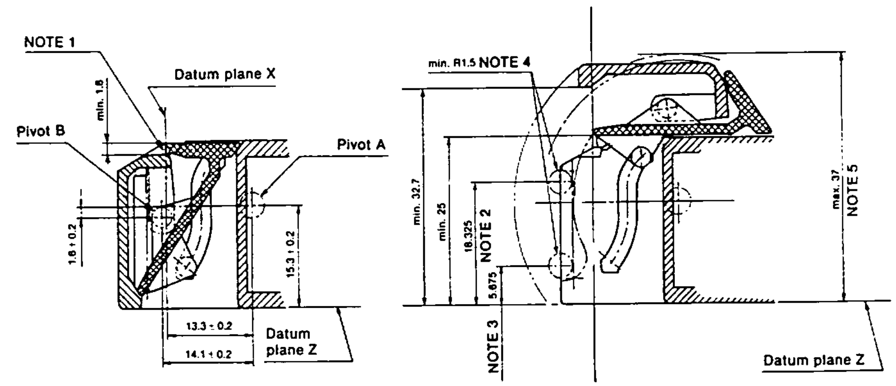


Fig. 17
Lid Structure of Small Cassette

Notes:
1. Recess to prevent misinsertion.
2. Tape upper edge position.
3. Tape lower edge position.
4. Margin for tape position changes shall be 1.5 mm or more.
5. Maximum permissible height when lid is opened.

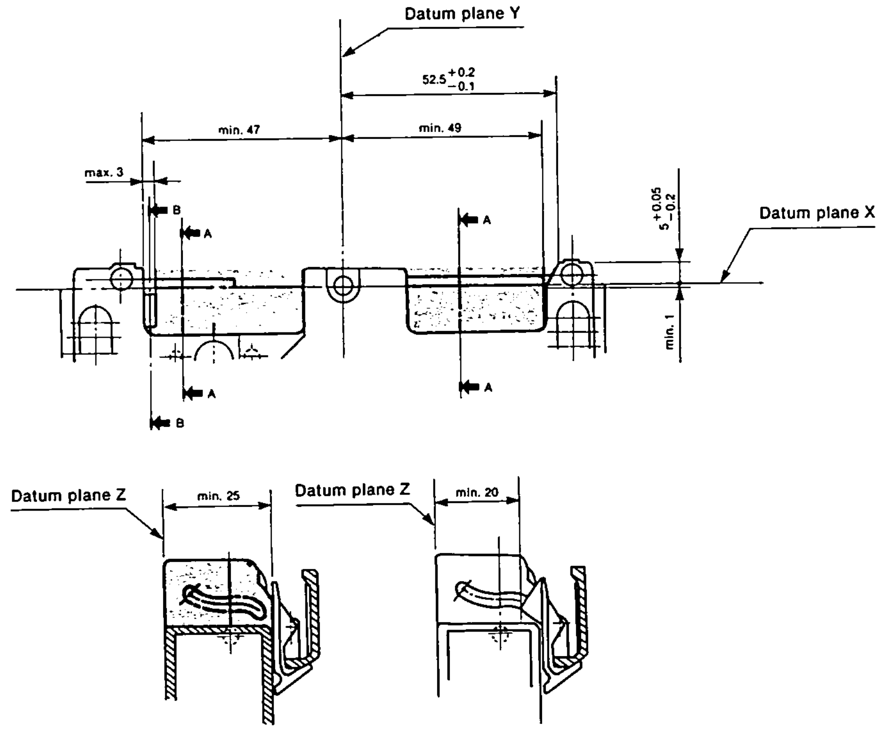


Fig. 18
Minimum Clearance for Recorder and Player Loading Mechanism

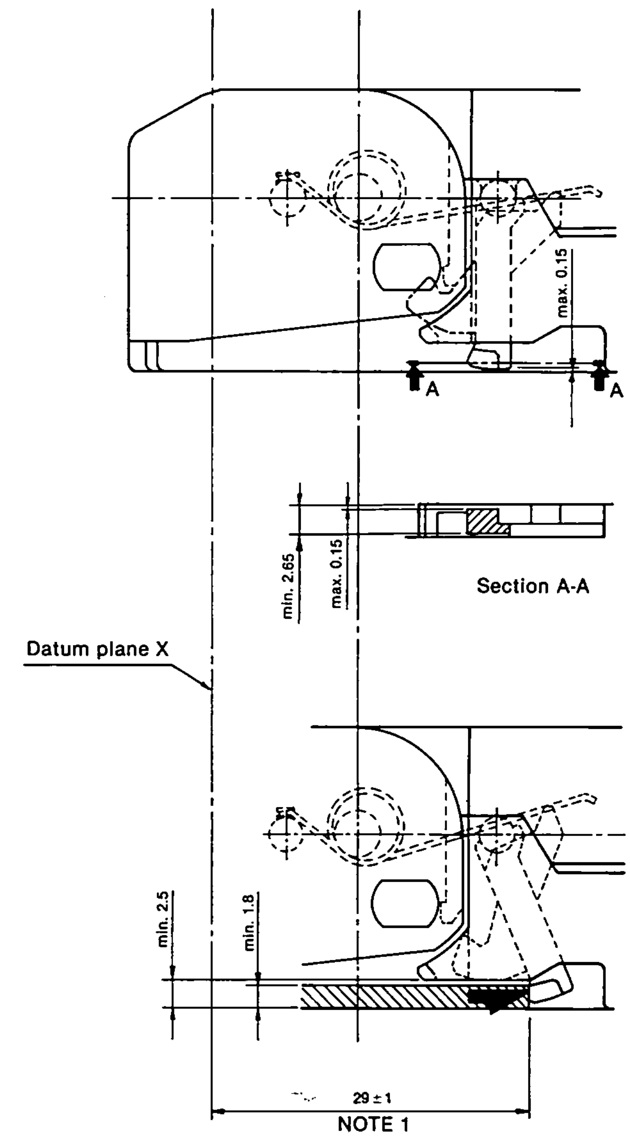


Fig. 19
Unlocking Structure of Lid

Note 1: Lid unlocking position.

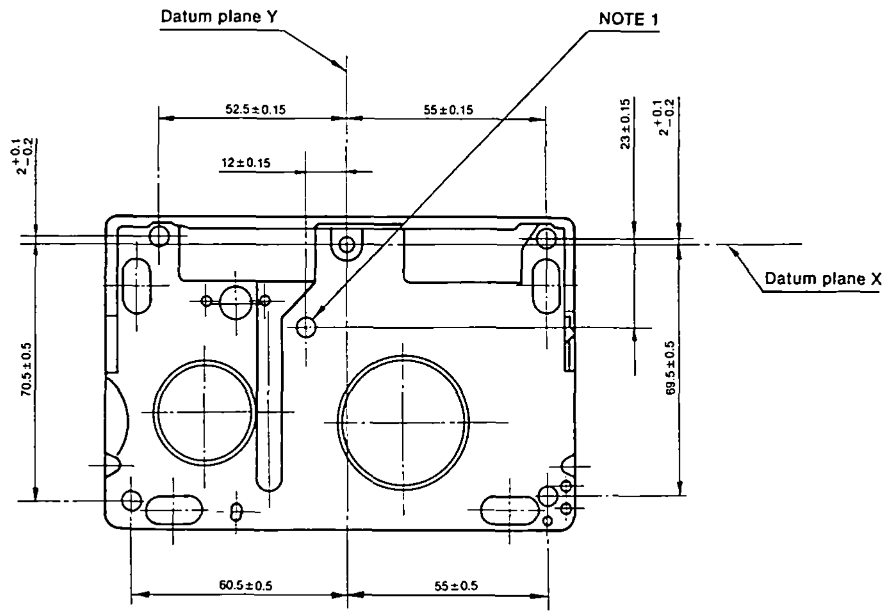


Fig. 20
Screw Positions of Small Cassette

Note 1: The screw position also serves as the positioning point for mounting a small cassette in video tape recorders. The diameter of the spot facing for the screw head of this portion is 5.3 to 5.7 mm, and the depth of the seat to the screw head is 3 mm or more.

Proposed American National Standard

for television analog recording —

½-in type M-2 — electrical parameters of video, audio, time and control code and tracking control

SMPTE 251M

1. Scope

1.1 This standard specifies the recording system for the video, audio, time and control code, and tracking-control signals for ½-in type M-2 helical-scan video tape recorders operating with video signals having a typical scanning structure of 525 lines, 59.94 fields/sec, 2:1 interlace, and utilizing the video cassettes specified in SMPTE 250M.

1.2 The audio frequency modulation (AFM) recording shown in this standard is optional. Pulse code modulation (PCM) audio recording mode with limited interchangeability, as defined in SMPTE 249M, is a secondary audio recording mode which is specified in SMPTE 252M.

1.3 Where nominal values are given without tolerances, the interchange performance will be limited by implementation accuracy.

2. Referenced Documents

This standard is intended for use in conjunction with the following documents:

ANSI/SMPTE 12M-1986, Television — Time and Control Code — Video and Audio Tape for 525-Line/60-Field Systems

SMPTE 249M, Television Analog Recording — ½-in Type M-2 — Records

SMPTE 250M, Television Analog Recording — ½-in Type M-2 — Tapes and Cassettes

SMPTE 252M, Television Analog Recording — ½-in Type M-2 — Pulse Code Modulation Audio

IEEE Std 152-1953, Volume Measurements of Electrical Speech and Program Waves

CCIR Report 624-3, Characteristics of Systems for Monochrome and Colour Television

IEC Publication 268-12 (1975), Circular Connectors for Broadcast and Similar Use

3. *Video Signal Recording*

Type M-2 video tape recorders shall record component video signals and are intended to operate interchangeably in an NTSC environment. This component video recording system shall provide independent signal channels for the luminance and chrominance signals. These component signals shall be recorded on two independent tracks on the video tape as frequency modulated signals. The two separate tracks shall be designated as the Y track for the luminance signals and the C track for the chrominance signals. The chrominance signals, in the form of R-Y and B-Y color-difference signals, shall be recorded in the form of a time compressed and time division multiplexed signal on the C track. (The AFM audio signal recording shall be recorded in the form of a frequency multiplexed signal together with the FM color-difference signal on the C track.) The PCM audio signal shall be recorded using the luminance and chrominance heads on the luminance and chrominance tracks.

3.1 Luminance Channel

3.1.1 Signal Processing. A signal processing system, as specified in this standard, shall contain the following elements in the order of signal flow:

(1) Means for adding a timing burst signal to the luminance signal

(2) Means for adding vertical interval subcarrier when appropriate

(3) A luminance nonlinear preemphasis circuit

(4) A luminance preemphasis network

(5) Means for clipping the preemphasized luminance signal to the amplitude of the modulating frequencies

(6) A linear frequency modulator having constant deviation with respect to the amplitude of the modulating frequencies

(7) A circuit for mixing the PCM audio CH5 signal to the frequency modulated luminance signal

(8) The recording current amplifier for the Y track video heads

3.1.2 Burst Signal Addition. The resultant waveforms when the burst signal is added to the luminance signal shall be as shown in Figs. 1 to 3. Burst frequency (2.25 MHz) is locked to horizontal line frequency.

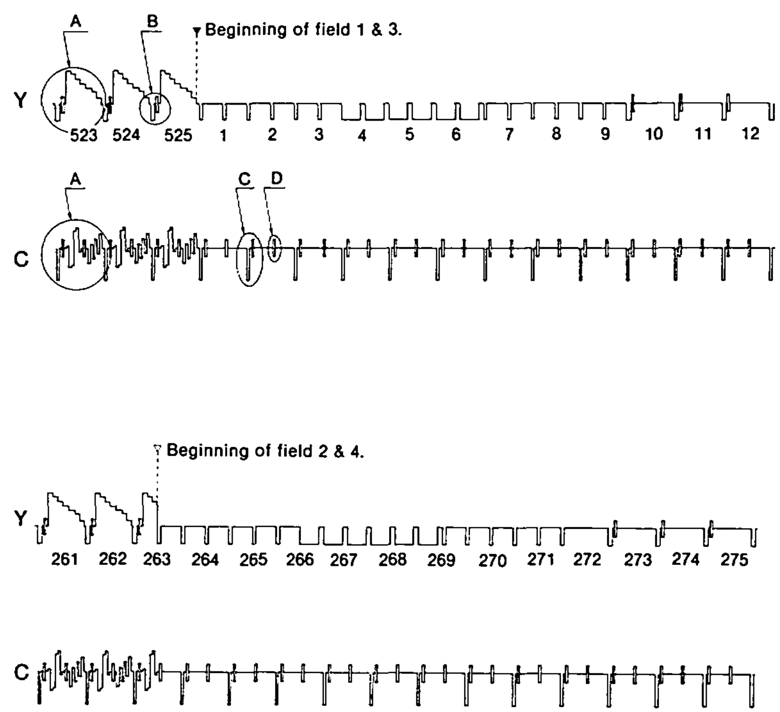


Fig. 1
Waveform of Burst Mixed Luminance and Burst and Sync Added Chrominance Signals

Note: No burst signals are mixed during the 9H period of Y vertical blanking.

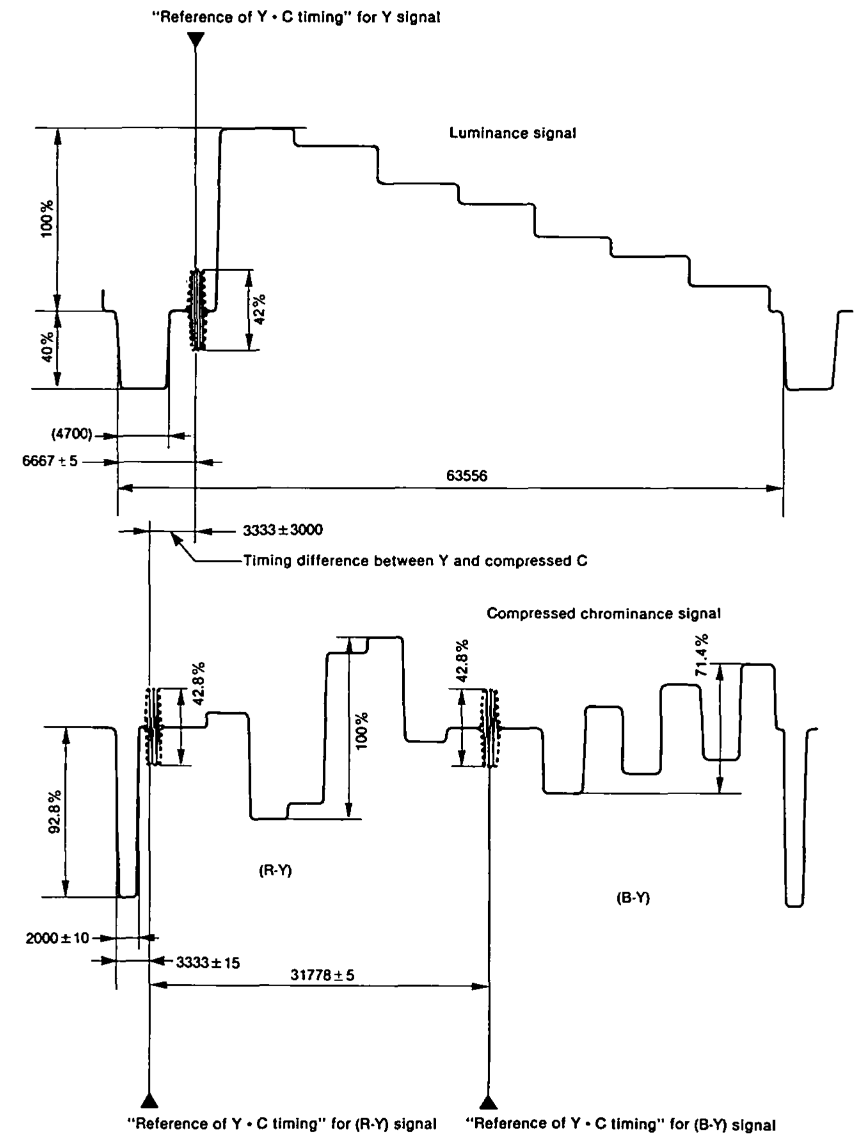


Fig. 2
Luminance Signal and Compressed Chrominance Signals for 100/7.5/77/7.5 Color Bars (Details of Fig. 1A)

Note: Time base in nanoseconds.

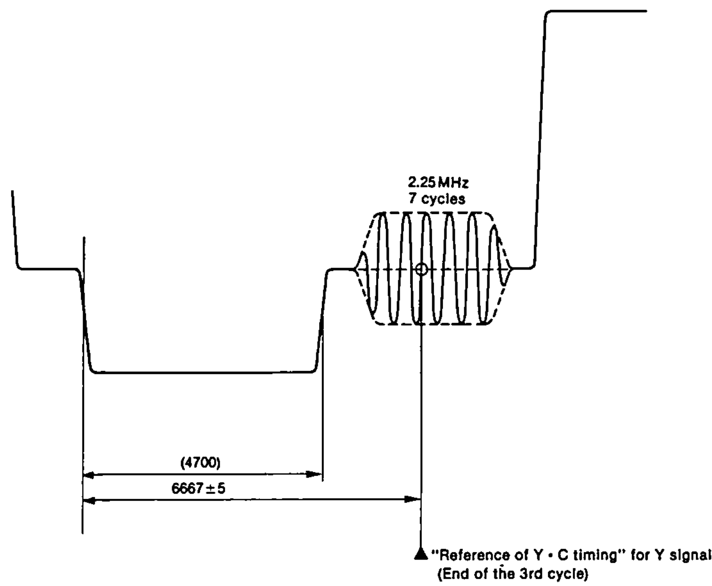


Fig. 3
Details of Fig. 1B

Note: Time base in nanoseconds.

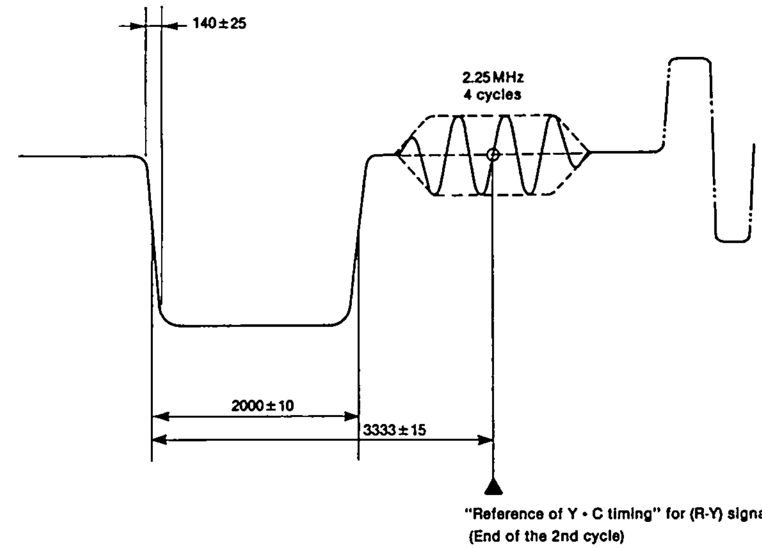


Fig. 4
Details of Fig. 1C

Note: Time base in nanoseconds.

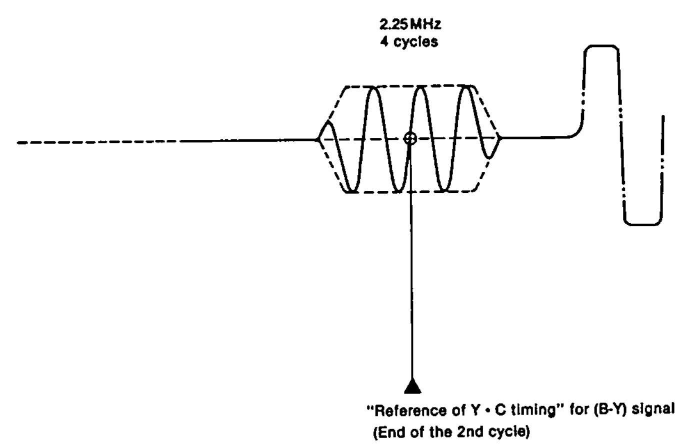


Fig. 5
Details of Fig. 1D

Note: Time base in nanoseconds.

3.1.3 Luminance Nonlinear Preemphasis. The typical frequency characteristics of the nonlinear preemphasis circuit output signal are as shown in Table 1.

Table 1
Luminance Nonlinear Preemphasis Circuit Output Signal

Frequency (MHz)	Relative Input Level (dB) 0	—10	—20
0.01	0	0	0
0.1	—0.1	—0.2	0.1
0.2	—0.4	0.1	0.4
0.5	—0.7	1.1	1.7
1.0	0	3.0	4.0
2.0	0.9	4.8	6.1
3.0	1.3	5.5	6.8
5.0	1.7	6.1	7.2

Notes: 1. A block diagram of a nonlinear preemphasis circuit is shown in Fig. 6.
2. Values are in decibels.

3.1.4 Luminance Preemphasis. The network and circuit parameters shall be as shown in Fig. 7.

3.1.5 Amplitude Clipping. For an input signal where blanking is at 0% and peak white at 100%, any positive or negative amplitude excursion exceeding the limits shown below shall be clipped:

Positive excursion limit	+ 338% (nominal) + 348% (maximum)
Negative excursion limit	— 190% (nominal) — 200% (maximum)

3.1.6 FM Carrier Frequency. Carrier frequencies corresponding to the reference video level shall be as follows:

100% white	7.70 MHz (nominal)
50% level	6.95 MHz (nominal)
Blanking	6.20 MHz ± 0.05 MHz
Sync tip	5.60 MHz (nominal)
Video deviation	1.50 MHz ± 0.05 MHz

3.1.7 Y Track Record Head Current

3.1.7.1 The amplitude of the record current for the Y track shall be such that the maximum level of remanent flux on the tape is produced when recording a Y signal with 50% average picture level.

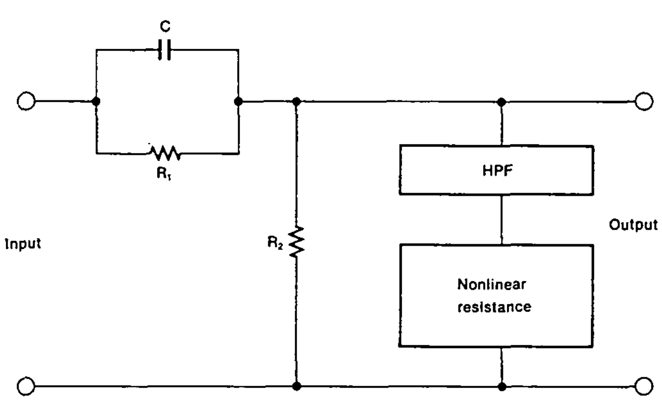
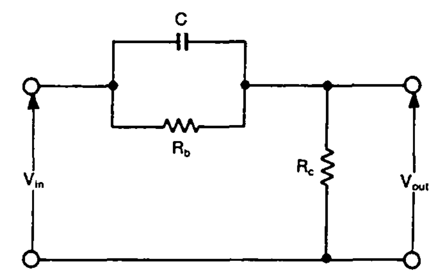


Fig. 6
Luminance Nonlinear Preemphasis Circuit

Note: The input signals are fed from the zero impedance source, and the output signals are applied to the infinite impedance load.



$T_Y = CR_b = 1.34\,\mu s$

$X_Y = R_b/R_c = 2.5$

$$\frac{V_{out}}{V_{in}} = \frac{1 + j\omega T_Y}{1 + X_Y + j\omega T_Y}$$

Fig. 7
Luminance Preemphasis Network

Note: Input source impedance = 0; output load impedance = ∞.

3.1.7.2 The amplitude of the Y track record current shall decrease with increasing frequency according to a straight line in the range of 2 to 10 MHz contained within limit lines as shown in Fig. 11.

3.2 Chrominance Channel

3.2.1 Signal Processing. A signal processing system, as specified by this standard, shall contain the following elements in the order of the signal flow:

(1) Means for adding a horizontal sync pulse and the timing burst signals to the chrominance signal

(2) Means to individually adjust the R-Y and B-Y levels in the ratio specified

(3) Means to perform the time compression and time-division multiplexing of the R-Y and B-Y color difference signals

(4) A chrominance nonlinear preemphasis circuit

(5) A chrominance preemphasis network

(6) Means for clipping the preemphasized chrominance signal

(7) A linear frequency modulator having constant deviation with respect to the amplitude of the modulating frequencies

(8) A high-pass filter to reduce the amplitude of low-frequency components to allow for the mixing of the optional AFM signals

(9) A circuit to mix the optional AFM signals with the chrominance signal

(10) A circuit for mixing the PCM audio CH6 signal to the frequency modulated chrominance signal

(11) A recording current amplifier for the C track video heads

3.2.2 Addition of Burst and Sync Signals. Resultant signal waveforms shall be as shown in Figs. 1, 2, 4, and 5.

3.2.3 Time Compression and Multiplexing. The time compression factor shall be one half. The time compressed R-Y and B-Y signals shall be multiplexed alternately as shown in Fig. 8. The compressed and multiplexed R-Y and B-Y signals shall be delayed by one horizontal line with respect to the luminance signal.

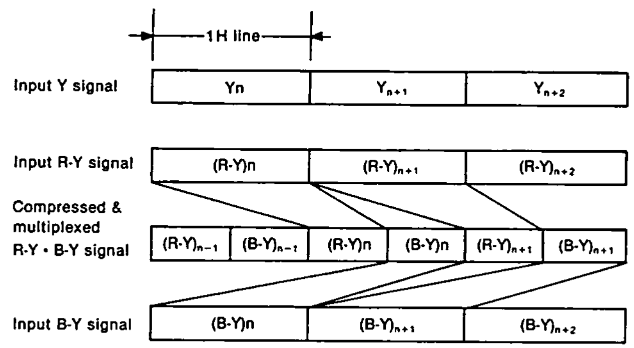


Fig. 8
Time-Base Compression and Multiplexing

3.2.4 Chrominance Nonlinear Preemphasis. A block diagram of a nonlinear preemphasis circuit is shown in Fig. 9. The typical frequency characteristics of this nonlinear preemphasis circuit output signal are as shown in Table 2.

3.2.5 Chrominance Preemphasis. The network and circuit parameters shall be as shown in Fig. 10.

3.2.6 Amplitude Clipping. For an input signal of "100/7.5/77/7.5" color bars (100% level), any positive or negative amplitude excursion exceeding the limits shown below shall be clipped:

Table 2
Chrominance Nonlinear Preemphasis Circuit Output Signal

Frequency (MHz)	Relative Input Level (dB) 0	—10	—20
0.01	0	0	0
0.1	—0.3	—0.3	—0.1
0.2	—0.5	—0.1	0.2
0.5	—0.2	1.1	1.6
1.0	0.6	3.0	3.9
2.0	1.5	4.8	6.0
3.0	1.9	5.5	6.6

Note: Values are in decibels.

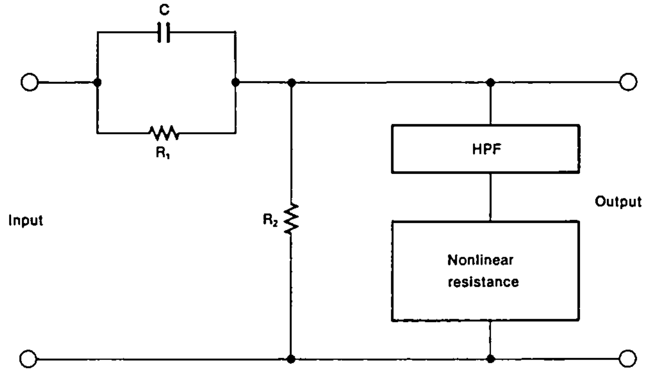
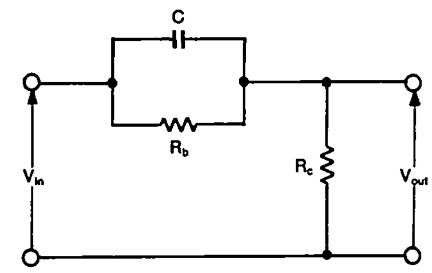


Fig. 9
Chrominance Nonlinear Preemphasis Circuit

Note: The input signals are fed from the zero impedance source and the output signals are applied to the infinite impedance load.



$T_c = CR_b = 0.60\ \mu s$

$X_c = R_b/R_c = 2.5$

$$\frac{V_{out}}{V_{in}} = \frac{1 + j\omega T_c}{1 + X_c + j\omega T_c}$$

Fig. 10
Chrominance Preemphasis Network

Note: Input source impedance = 0; output load impedance = ∞.

Positive excursion limit	+ 147.7% (nominal)	
	+ 157.7% (nominal)	
Negative excursion limit	—180.2% (nominal)	
	—190.2% (maximum)	

3.2.7 FM Carrier Frequency. Carrier frequencies corresponding to reference video levels shall be as shown in Table 3.

Table 3
Carrier Frequencies and Reference Video Levels

	100/7.5/77/7.5 Color Bar Signal R-Y	B-Y
Peak of positive excursion	6.20	6.00
Peak of negative excursion	4.80	5.00
Blanking	5.50	5.50
Sync-tip	4.20	—
Maximum p-p deviation	1.40	1.00
Deviation p-p tolerance	± 0.02	± 0.015
Blanking carrier tolerance	± 0.05	± 0.05

Note: Frequency in megahertz.

3.2.8 C Track Record Head Current

3.2.8.1 The amplitude of the record current for the C track shall be such that the maximum level of remanent flux on the tape is produced when recording the chrominance blanking level.

3.2.8.2 The amplitude of the C track record current shall decrease with increasing frequency according to a straight line in the range of 2 to 10 MHz contained within limit lines as shown in Fig. 11.

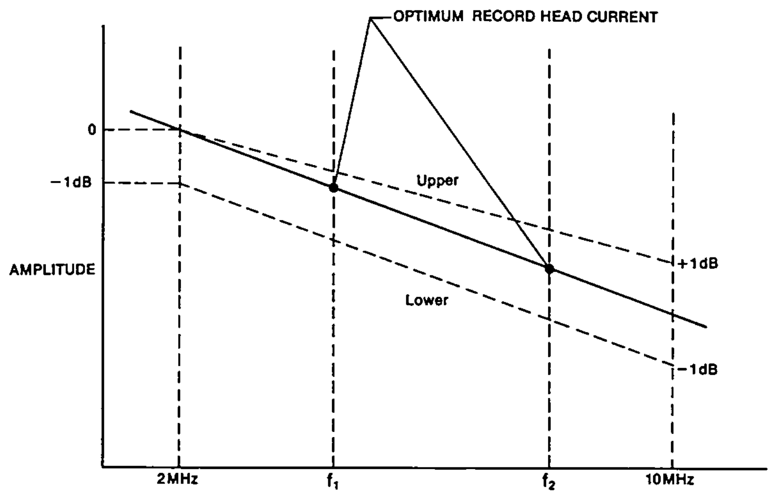
3.2.9 The frequency characteristics of the recording current shall be as shown in Table 4.

Table 4
Recording Current Characteristics

Frequency (MHz)	Relative Level (dB)
0.4	Less than —30
0.7	Less than —30
2.0	0

3.3 Y-C Timing

3.3.1 Reference of Y-C Timing. The timing difference between the Y signal, the R-Y, and the B-Y signal before time compression shall not be more than 5 ns as shown in Fig. 12.



Luminance Channel	Chrominance Channel
f_1 Blanking frequency	Minimum chroma frequency
f_2 100% white frequency	Maximum chroma frequency

Fig. 11
Record Equalization

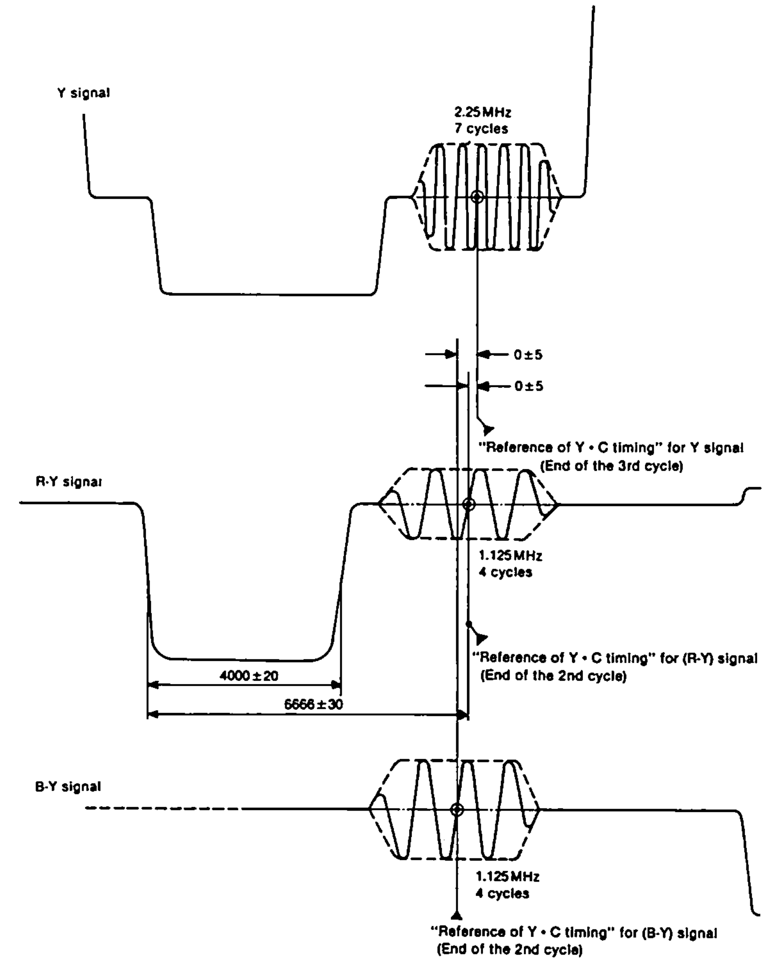


Fig. 12
Reference of Y-C Timing

Notes:
1. Time base in nanoseconds.
2. Reference of Y-C timing shown displaced for illustrative purposes.

3.3.2 Tolerance of Compressed Y-C Timing. The timing difference between the luminance and the compressed chrominance signals shall be the value as shown in Fig. 2.

3.4 Vertical Interval Subcarrier (VISC)

3.4.1 VISC shall consist of one line of subcarrier inserted into each field of the Y signal as shown in Fig. 13. This signal shall only be present when the signal to be recorded is the result of decoding a composite NTSC signal with coherent subcarrier.

3.4.2 The frequency of the VISC signal shall be equal to the frequency of the subcarrier of the NTSC video signal.

3.4.3 The phase of VISC signal shall be within ± 5° of the burst phase of the NTSC signal prior to decoding.

4. Longitudinal Audio Signal Recording

4.1 Recording Method. Recordings shall be made by the anhysteretic (bias) method.

4.2 Recording/Reproducing Reference Levels

4.2.1 Recording/Reproducing Level Indicator. The audio recording and reproducing levels of this recorder shall be determined by using a

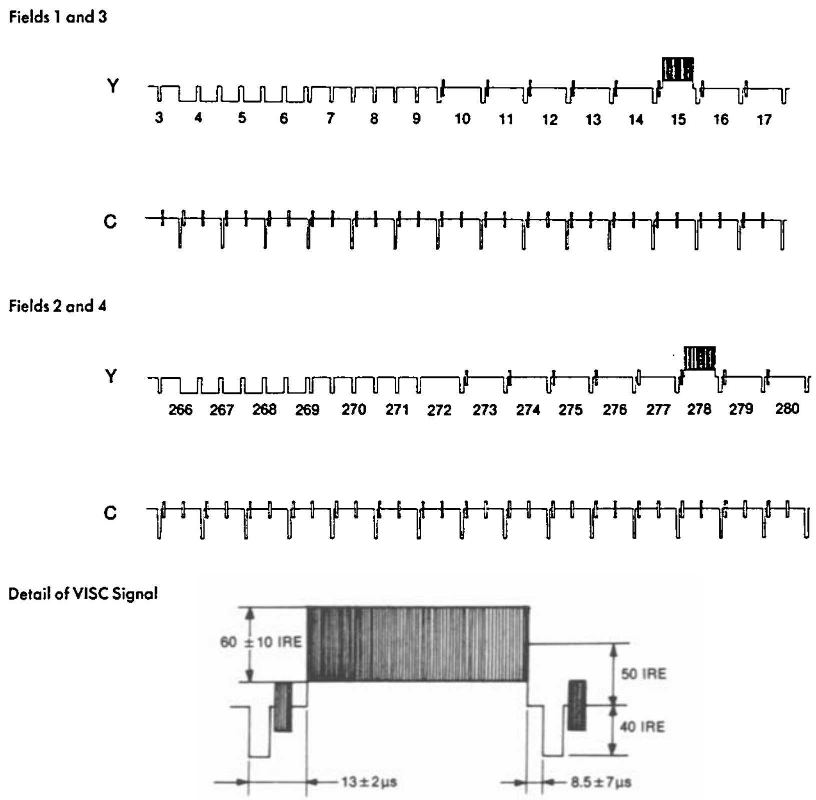


Fig. 13
Waveforms of VISC Signal

standard volume indicator or its equivalent as specified in IEEE Std 152-1953.

4.2.2 Recorder Reference Level. For a 1-kHz sinusoidal signal recording which yields an rms short circuit tape flux per unit track width on the record of 100 nWb/m ± 3 nWb/m, the recording volume indicator shall indicate its reference level scale mark.

4.2.3 Reproducer Reference Level. For the reproduction of 1-kHz tape record which yields an rms short circuit tape flux per unit track width of 100 nWb/m, the reproducing volume indicator shall indicate its reference level scale mark.

4.3 Frequency Characteristics

4.3.1 Record Flux Versus Frequency Characteristics. When a tape is recorded from a constant voltage applied to the input terminals, the short circuit tape flux level in the record versus frequency characteristics, $L_\phi(f)$, shall be expressed by the following equation:

$$L_\phi(f) = 10 \log_{10} \frac{1 + (F_1/f)^2}{1 + (f/F_h)^2} \text{ (dB)}$$

where
$L_\phi(f)$ is the relative tape flux level
f is the frequency at which the response is calculated
F_1 is the low-frequency transition frequency, 50 Hz
F_h is the high-frequency transition frequency, 4681 Hz

4.3.2 Reproduced Flux Versus Frequency Characteristics. When a tape record having a short-circuit tape flux level versus frequency characteristics given by 4.3.1 is reproduced, the output voltage level of the reproducer versus frequency characteristics shall remain constant.

4.3.3 Noise Reduction Characteristics. A noise reduction process, if applied, shall have the static encoding characteristics shown in Table 5.

Table 5
Longitudinal Audio Frequency Response of Noise Reduction Encoding Level

Frequency (Hz)	Input Level (dB) 0	—10	—20	—30	—40	—50	—60
100	0.2	0.9	2.7	2.9	2.9	2.9	2.9
200	0.1	1.5	5.3	8.0	8.1	8.1	8.1
300	0	1.6	6.1	10.7	12.0	12.0	12.0
500	0	1.7	6.3	11.8	15.6	16.2	16.2
1k	—0.3	1.5	5.9	11.4	16.2	19.4	19.6
3k	—1.6	—0.1	3.7	9.2	13.9	19.2	20.7
5k	—2.3	—0.6	2.9	8.4	13.5	18.7	20.4
10k	—3.5	—1.4	2.6	8.2	13.6	18.1	19.2
15k	—6.3	—3.3	1.5	7.3	12.2	15.0	15.0

Notes: 1. Input level is 0 dB, the reference input level at 1 kHz.
2. Encode level is 0 dB, the recorded reference level specified by 4.2.2.
3. Values are in decibels.

4.4 Track Usage (Common Audio Mode)

4.4.1 Nonstereo Audio. The primary program audio channel shall be recorded on the audio 1 track.

4.4.2 Stereo Audio. When separate channels are used for stereo audio, the left channel shall be recorded on the audio 1 track, and the right channel on the audio 2 track.

4.5 Program Audio Head Phasing. When the same signal is recorded on audio 1 and audio 2 tracks, the tracks shall be so phased that, when reproduced with a head wide enough to sense the recorded flux on both records, the result will be additive.

4.6 Recording Polarity. When a positive-going waveform is present on pin-2 of the input connector, as defined in IEC Publication 268-12

(1975), the audio head gap shall produce the magnetic flux which flows out of the north pole and into the south pole. This flux flow shall be in the direction of tape movement.

5. AFM Signal Recording (Optional)

Audio signals of two channels shall frequency modulate two carriers. These frequency modulated carriers shall be located in the frequency region below the lower side band of the frequency modulated chrominance signal, which is specified by 3.2, in order to produce a frequency multiplex signal. The resultant multiplex signal shall be recorded on the chrominance track.

5.1 Signal Processing. A signal processing system as specified by this standard shall contain the following elements:

5.1.1 An audio noise-reduction scheme incorporating compression

5.1.2 A linear frequency modulator having constant deviation with respect to the amplitude of the modulating frequencies

5.1.3 A means for adding the AFM signals to the chrominance signal in the ratios specified

5.2 Recording/Reproducing Reference Levels

5.2.1 Recording/Reproducing Level Indicator. The audio recording and reproducing levels of this recorder shall be determined by using a standard volume indicator or its equivalent as specified in IEEE Std 152-1953.

5.2.2 Recorder Reference Level. When a 1-kHz sinusoidal signal recording is made with the reference deviation defined in 5.5.2, the recording volume indicator shall be adjusted to deflect to its reference level scale mark.

5.2.3 Reproducer Reference Level. When a 1-kHz tape record with the reference deviation defined in 5.5.2 is reproduced, the reproducing volume indicator shall deflect to its reference level scale mark.

5.3 Noise Reduction

5.3.1 Noise Reduction Circuit. A noise reduction circuit or its equivalent shall be as shown in Fig. 14.

5.3.2 Compression Ratio. The compression ratio shall be 2:1 in the logarithmic scale.

5.3.3 Transient Response. The transient response shall be such that an attack time is 9.0 ms ± 3 ms and a recovery time is 90 ms± 30 ms. Dynamic characteristics shall be as shown in Fig. 15.

5.4 Preemphasis. The output signal of the noise-reduction circuit specified in 5.3 shall be preemphasized before the frequency modulation by a network as shown in Fig. 16.

5.5 Frequency Modulation

5.5.1 Carrier Frequency. The left channel (CH3) signal frequency shall be 400 kHz ± 5 kHz. The right channel (CH4) signal frequency shall be 700 kHz ± 5 kHz.

5.5.2 Frequency Deviation. The reference level deviation shall be 35 kHz ± 0.7 kHz at 1 kHz. The maximum deviation shall not exceed ± 105 kHz.

5.6 Recording Head Current. The recording head current level shall be adjusted at 20 dB ± 1 dB below the chrominance recording level defined in 3.2.8. The amplitude of the recording head current shall be constant over the frequency range from 300 to 800 kHz.

6. Time and Control Code Signal Recording

6.1 Designated Track for Time and Control Code. The longitudinal track identified as the time and control code track shall be used for recording the code specified in ANSI/SMPTE 12M-1986.

6.2 Recording Method. The recording shall be made by the anhysteretic (bias) method.

6.3 Recording Level. The recording level, as expressed in peak-to-peak short circuit tape flux per unit track width, shall be 250 nWb/m ± 50 nWb/m.

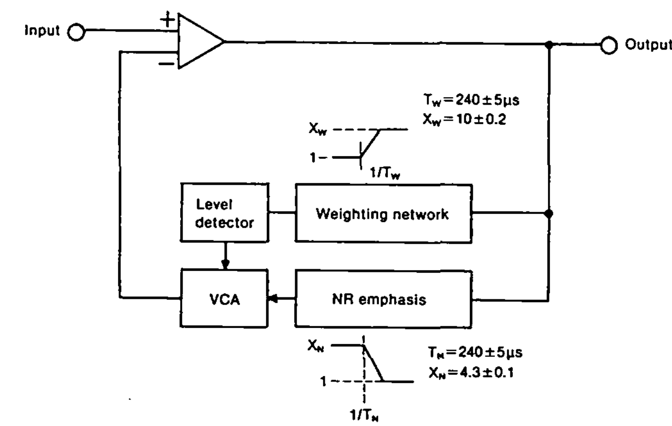


Fig. 14
Noise Reduction Circuit for AFM Signals
Note: VCA is voltage controlled amplifier.

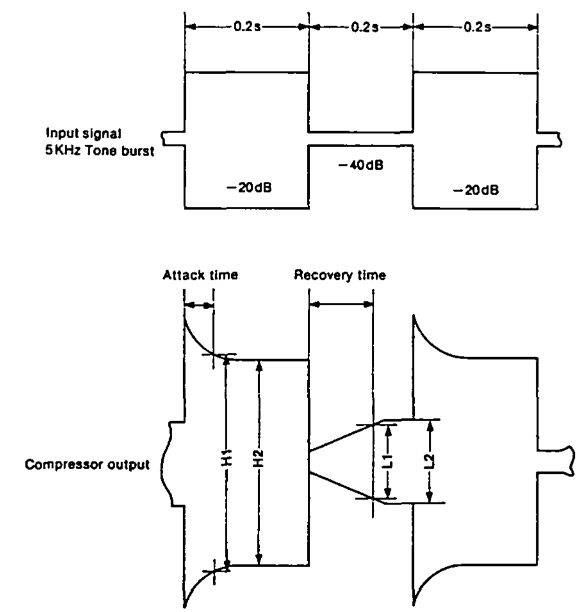
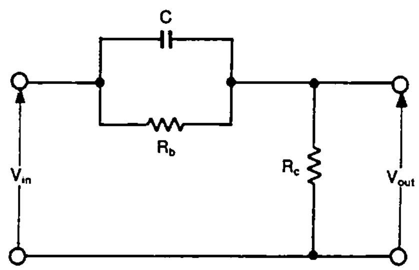


Fig. 15
Transient Response of Compressor for AFM Noise Reduction

Notes: 1. 0 dB is input level corresponding to reference level.
2. $H_1 = H_2 + 2dB$. $L_1 = L_2 - 2$ dB.



$$T_D = CR_b = 56.0\,\mu s$$

$$X_D = \frac{R_b}{R_C} = 1.80$$

$$\frac{V_{out}}{V_{in}} = \frac{1 + j\omega T_D}{1 + X_D + j\omega T_D}$$

Fig. 16
Audio Preemphasis Network

Note: Input source impedance = 0; output load impedance = ∞.

7. Tracking Control Signal Recording

7.1 Waveform and Level. The recording waveform and level shall be a series of constant flux levels alternating in polarity at a field rate and completing one cycle per frame on the longitudinal track identified as shown in Fig. 17.

7.2 Polarity of Remanent Magnetization. During the time interval that video channel 1 is recording, the polarity of the tracking-control record flux shall be such that the S pole of the magnetic domain represents the direction of the tape travel.

7.3 Timing and Period. The polarity of the flux described in 7.2 shall change to the opposite polarity when the recording of the next field is started by the channel 2 video heads. This opposite polarity interval shall continue until the beginning of the subsequent field recorded by the channel 1 video heads as shown in Fig. 17.

7.4 Optional Framing Information. If implemented, the color framing information shall be carried out by changing the timing of the polarity transition of the control signal recording as shown in Fig. 18.

7.5 Magnetization Level. The magnitude of the tracking control recorded flux shall be at least 30 dB above the residual flux of any previous recordings.

7.6 Rise Time. The rise time shall be the value shown in Fig. 17.

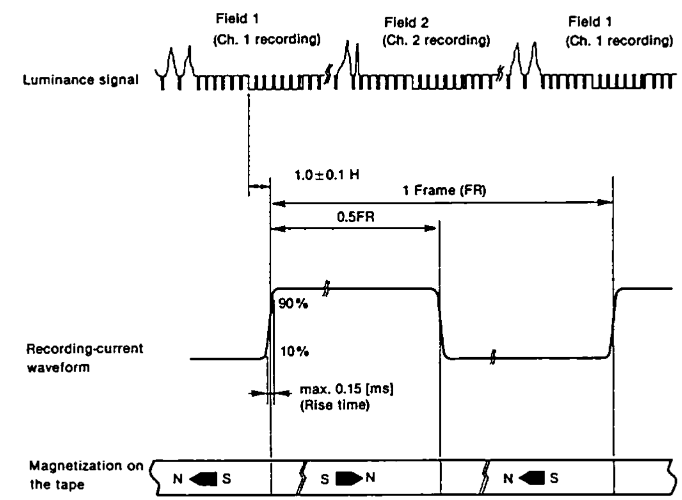


Fig. 17
Control Track Signal Waveforms and Timing for Component Signal

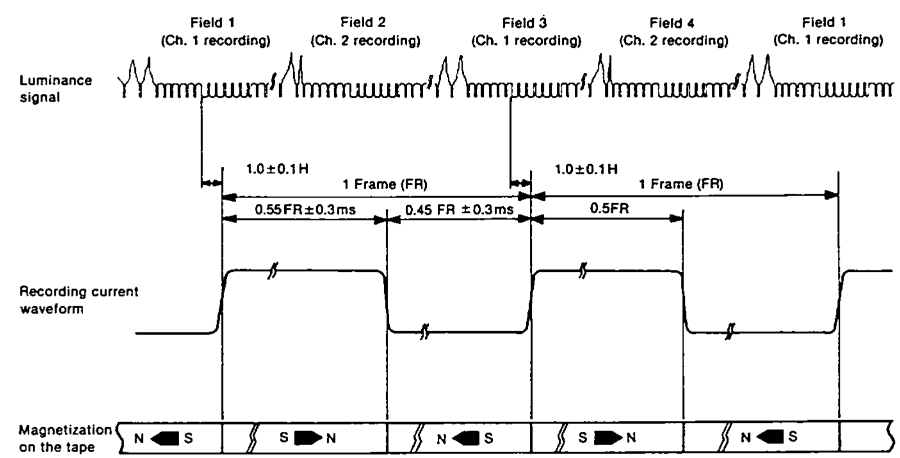


Fig. 18
Waveforms and Timing of Control Track Signal with Color Framing Information

Proposed American National Standard
for television analog recording—
½-in type M-2–pulse code modulation audio

SMPTE 252M

1. Scope

This standard specifies the pulse code modulation (PCM) audio mode of encoding and recording system utilizing a ½-in type M-2 helical-scan video tape recorder operating with video signals having a typical scanning structure of 525 lines, 59.94 fields/sec, 2:1 interlace, and the cassettes specified in SMPTE 250M.

2. Referenced Documents

This standard is intended for use in conjunction with the following documents:

SMPTE 249M, Television Analog Recording — ½-in Type M-2 — Records

SMPTE 250M, Television Analog Recording — ½-in Type M-2 — Tapes and Cassettes

SMPTE 251M, Television Analog Recording — ½-in Type M-2 — Electrical Parameters of Video, Audio, Time and Control Code and Tracking Control

SMPTE RP 155, Audio Levels and Indicators for Digital Audio Records on Digital Television Tape Recorders

SMPTE RP 158, Basic System and Transport Geometry Parameters for ½-in Type M-2 Format

3. Recording Location

The PCM audio signal is recorded on tape regions PD, PE, and PF, located on the video track as shown in SMPTE 249M. Since the recording area for longitudinal audio CH1 is allocated for the PCM recording, longitudinal audio recording can be accomplished only on one channel (CH2).

4. Audio Signal Recording

The recording of PCM audio signals in each of two channels is accomplished by using the luminance and chrominance heads provided for video signal recording as shown in Fig. 1.

The recording is accomplished beyond the overlap area on the tape produced by making the wrap angle on the scanner more than 180°. Direct recording of time compressed digital modulation is employed.

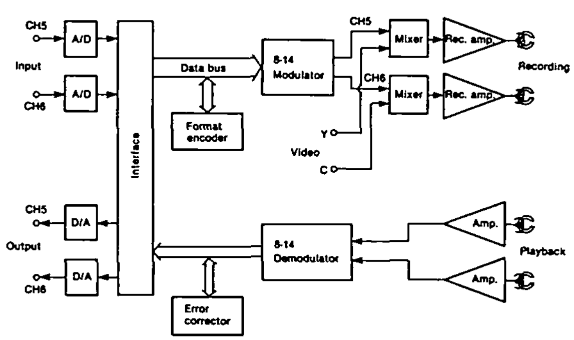


Fig. 1
Block Diagram of PCM Audio Recording System

4.1 Source Coding. The source data consists of the audio data and the ID (identification) data.

4.1.1 Audio Data Specifications

Number of channels	Two channels (CH5 and CH6).
Reference level	The input required to give — 20 dB full-scale at A/D converter (at 1 kHz) shall be the reference level and its digital value shall be as specified in SMPTE RP 155.
Track allocation	CH5 shall be recorded by the luminance head. CH6 shall be recorded by the chrominance head.
Stereo mode	CH5 is the left channel. CH6 is the right channel.

4.1.2 Audio Data Coding

Sampling frequency	48 kHz (synchronous with video signal).
Sampling order	CH5, CH6 simultaneous.
Quantization	16-bit linear.
Coding	Two's complement binary code.

4.1.3 ID Data Coding

Data capacity	6-byte or 8-byte/field as shown in Tables 1 and 2.
Coding	NRZ

4.1.4 Source Data Arrangement. The source data arrangement within one audio field period is shown by Tables 1 and 2. The 16-bit audio samples shown in Tables 1 and 2 are each divided into upper and lower 8-bit samples which are arranged in an order starting from suffix 0. However, in this five audio field periodic sequence, the data D 800U and D 800L are available in the audio fields 0, 1, 2, and 3, but the data in audio field 4 shall be replaced by ID6 and ID7.

Table 1
Source Data Arrangement for Fields 0, 1, 2 and 3

BLOCK NUMBER	#0	#1	#2	#3	#4	#31	#32	#33	#34	#35	#63	#64	#65	#66
	D 0U	D 2U	D 4U	D 6U	D 8U	D 62U	D 64U	D 66U	D 1U	D 3U	D 59U	D 61U	D 63U	D 65U
	D 0L	D 2L	D 4L	D 6L	D 8L	D 62L	D 64L	D 66L	D 1L	D 3L	D 59L	D 61L	D 63L	D 65L
	D 67U	D 69U	D 71U	D 73U	D 75U	D 129U	D 131U	D 133U	D 68U	D 70U	D 126U	D 128U	D 130U	D 132U
DATA SYMBOL														
	D 737U	D 739U	D 741U	D 743U	D 745U	D 799U	ID 0	ID 4	D 738U	D 740U	D 796U	D 798U	D 800U	ID 2
	D 737L	D 737L	D 741L	D 743L	D 745L	D 799L	ID 1	ID 5	D 736L	D 740L	D 796L	D 798L	D 800L	ID 3

Note: U stands for the upper 8 bits, and L for the lower 8 bits.

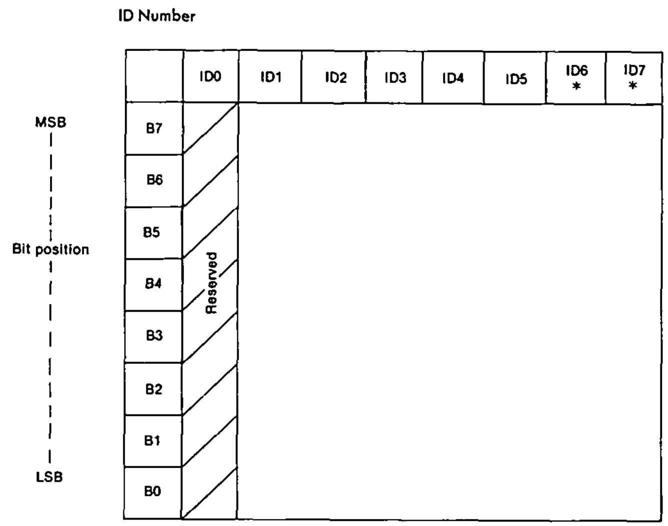
Table 2
Source Data Arrangement for Field 4

BLOCK NUMBER	#0	#1	#2	#3	#4	#31	#32	#33	#34	#35	#63	#64	#65	#66
	D 0U	D 2U	D 4U	D 6U	D 8U	D 62U	D 64U	D 66U	D 1U	D 3U	D 59U	D 61U	D 63U	D 65U
	D 0L	D 2L	D 4L	D 6L	D 8L	D 62L	D 64L	D 66L	D 1L	D 3L	D 59L	D 61L	D 63L	D 65L
	D 67U	D 69U	D 71U	D 73U	D 75U	D 129U	D 131U	D 133U	D 68U	D 70U	D 126U	D 128U	D 130U	D 132U
DATA SYMBOL														
	D 737U	D 739U	D 741U	D 743U	D 745U	D 799U	ID 0	ID 4	D 738U	D 740U	D 796U	D 798U	ID 6	ID 2
	D 737L	D 737L	D 741L	D 743L	D 745L	D 799L	ID 1	ID 5	D 736L	D 740L	D 796L	D 798L	ID 7	ID 3

Note: U stands for the upper 8 bits, and L for the lower 8 bits.

4.1.5 ID Data Specification. The ID data region is available for the user, and its contents are shown in Fig. 2 and Tables 1 and 2.

4.2 Signal Processing. The 800 or 801 audio data samples per field are divided into 67 blocks, and the block sync signal (SYNC), block address signal (ADDRESS), block address error detecting code (CRCC), and the error correction code (ECC2 and ECC1) are added to each block. The signal format is shown in Fig. 3 where the recording order for each data sample is MSB first.



Reserved Region:

Field Address	B_0	B_1	B_2	B_3	B_4	B_5	B_6	B_7
0	0	0	0					
1	1	0	0					
2	0	1	0	Not specified				
3	1	1	0					
4	0	0	1					

Fig. 2
ID Data Content and Reserved Region for Field Address

Note: Not available in fields 0, 1, 2, 3

Block Address →

Recording Direction ↓

SYNC	SYNC	SYNC	SYNC		SYNC	SYNC		SYNC	SYNC
ADDRESS	ADR0	ADR1	ADR2		ADR33	ADR34		ADR65	ADR66
CRCC	CRCC	CRCC	CRCC		CRCC	CRCC		CRCC	CRCC
DATA	D 0U	D 2U	D 4U		D 66U	D 1U		D 63U	D 65U
	D 0L	D 2L	D 4L		D 66L	D 1L		D 63L	D 65L
	D 67U	D 69U	D 71U		D 133U	D 68U		D 130U	D 132U
	⋮	⋮	⋮		⋮	⋮		⋮	⋮
	D 737U	D 739U	D 741U		ID 4	D 738U		*	ID 2
	D 737L	D 739L	D 741L		ID 5	D 738L		**	ID 3
ECC2	ECC2 0	ECC2 1	ECC2 2		ECC2 33	ECC2 34		ECC2 65	ECC2 66
ECC1	ECC1 0	ECC1 1	ECC1 2		ECC1 33	ECC1 34		ECC1 65	ECC1 66

*ID 6 or D 800U
**ID 7 or D 800L

Fig. 3
PCM Signal Format

4.2.1 PCM Signal Construction. The PCM signal construction is shown in Fig. 4.

Preamble area — Length: One horizontal line (63.5 μsec)
Content: A single frequency signal of 5.0625 MHz (basic)

Phase continuity to the beginning of the sync block shall be established.

Postamble area — Length: One horizontal line (63.5 μsec)
Content: A *single frequency* signal of 5.0625 MHz (basic)

Phase continuity to the end of the data block shall be established.

(Note: A basic dimension is a *fundamental* dimension to which no tolerance is applicable.)

SYNC: Specified in 4.2.4.

ADDRESS: Started from "00" by the sequential address for the identification of each of the 67 blocks.

CRCC: CRCC is used for block ADDRESS error detection; this detected error pointer is referred to data error correction. The error detection method is based upon a CRC code containing 8 bits and its generator polynominal G1(x) is as follows:

$G1(x) = X^8 + 1$ (preset all "1")

DATA: Data shall be arranged in the order shown in Tables 1 and 2 and Fig. 3.

ECC2, ECC1: *Specified in* 4.2.2.

Transmission data rate: 11.57 Mbps per channel.

4.2.2 Error Correction Codes. The *error detection* and correction system (ECC) shall be based on the Reed-Solomon code which contains *the elements of Galois Field* 2^8, *and its generator* polynominal G2(x) and primitive polynominal G3(x) are given by:

$$G2(x) = \prod_{i=0}^{3} (x - a^i)$$

$$G3(x) = X^8 + X^4 + X^3 + X^2 + 1$$

The generation scheme of error correction codes ECC1 and ECC2 is shown *in Fig. 5.*

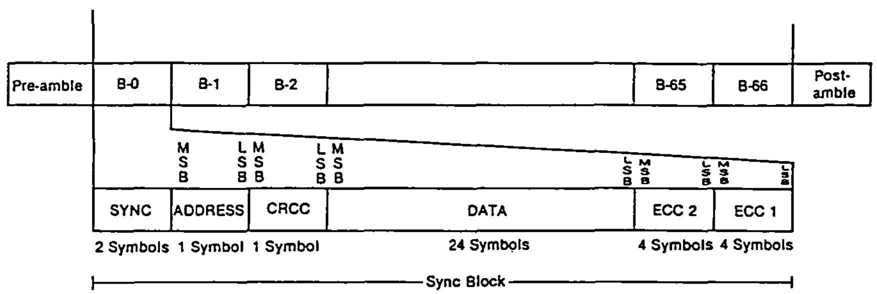


Fig. 4
PCM Signal Construction

Note: 1 symbol = 8 bits.

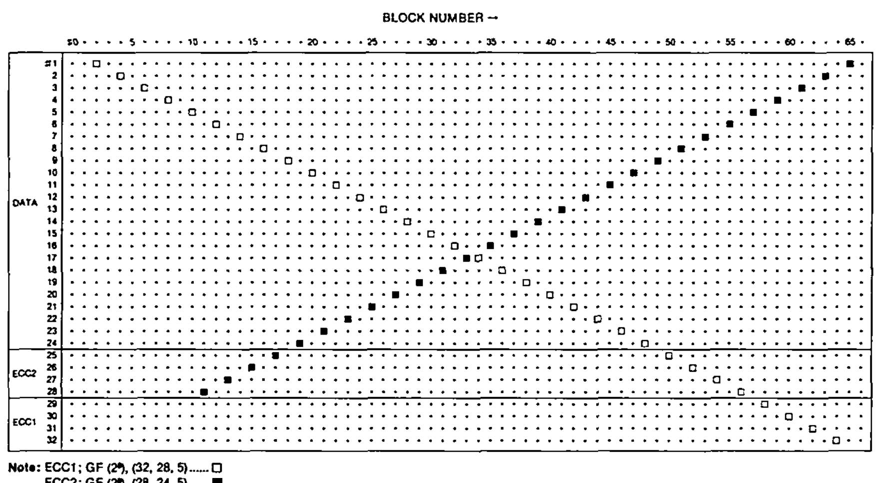


Fig. 5
Error Correction Format

Note: ECC1: GF(2^8), (32, 28, 5) ..... □
ECC2: GF(2^8), (28, 24, 5) ..... ■

4.2.3 Channel Coding. The channel code shall conform to the 8-14 modulation method. (See Fig. 6 and Tables 3 and 5.) This method is based on an algorithm where the DC component is minimized when the 8-bit data is converted to a 14-bit code. The data converted by the 8-14 modulation method shall be further transformed by NRZI conversion process before it is recorded.

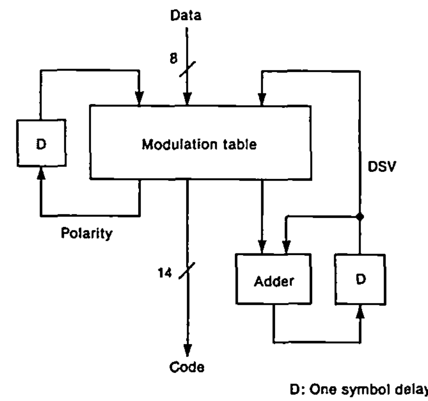


Fig. 6
Block Diagram for 8-14 Modulation

Table 3
Selection of Modulation Code

Preceding DSV	Preceding Polarity	Selection of Modulation Code
Positive Polarity	Positive	Select group A
	Negative	Select group B
Zero	—	Select small absolute value of CDS
Negative Polarity	Positive	Select group B
	Negative	Select group A

Notes:
1. DSV. DSV is an abbreviation for digital sum value and indicates the integral value which is counted from the beginning of the NRZI-modulated waveform, taking high level = 1 and low level = —1.
2. CDS. CDS is an abbreviation for code word digital sum and indicates the DSV of one symbol modulation code where NRZI modulation starts from the low level.
3. Polarity. Positive polarity indicates a high level of the NRZI modulated waveform. Negative polarity indicates a low level of the NRZI-modulated waveform.

4.2.4 Sync Pattern. The sync pattern shall be constructed as shown in Fig. 7.

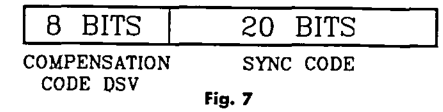


Fig. 7
Sync Pattern

The sync code shall be defined as follows:

00100000001000000010

Compensation code DSV shall be chosen in such a way as to compensate the DC component of the last block. Table 4 shows this compensation code.

Table 4
Compensation Code

DSV	Polarity Positive	Polarity Negative
—4	00101000	01000001
—2	01010001	00100001
0	00001000	00001000
2	00100001	01010001
4	01000001	00101000

4.2.5 Record Physical Offset. The physical offset between the two PCM audio channels shall be as shown in Fig. 8 due to the Y/C head offset as shown in Table 2 of SMPTE 249M.

4.2.6 Recording Video and Audio Timing. The recording timing between video and audio signals shall be as shown in Fig. 9.

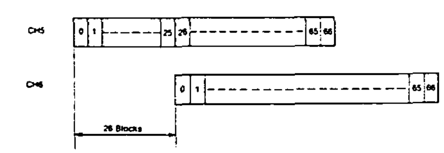


Fig. 8
Physical Offset Between Two Audio Channels

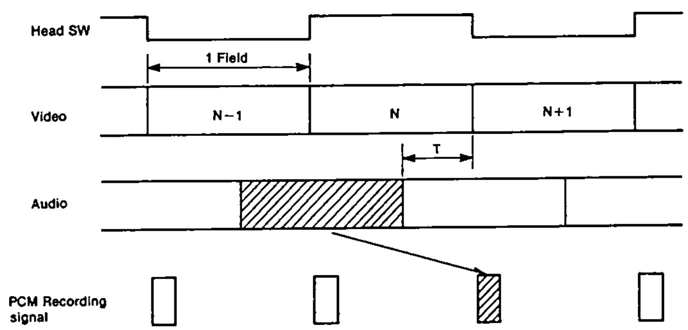


Fig. 9
Recording Video and Audio Timing

Note: $T = 3.0 \pm 0.2$ ms.

Table 5
8-14 Modulation

Data	Group A (Positive)		Group B (Negative)	
	Code	CDS	Code	CDS
00	01001010101010	0	01001010101010	0
01	01010100101010	0	01010100101010	0
02	01010101010010	0	01010101010010	0
03	10010010101010	0	10010010101010	0
04	10010101001010	0	10010101001010	0
05	10010101010100	0	10010101010100	0
06	10100100101010	0	10100100101010	0
07	10100101010010	0	10100101010010	0
08	10101001001010	0	10101001001010	0
09	10101001010100	0	10101001010100	0
0A	10101010010010	0	10101010010010	0
0B	10101010100100	0	10101010100100	0
0C	01001001010010	0	01001001010010	0
0D	01010010010010	0	01010010010010	0
0E	01010010100100	0	01010010100100	0
0F	01001001000100	0	01001001000100	0
10	10001000100100	0	10001000100100	0
11	10001001001000	0	10001001001000	0
12	10010001000100	0	10010001000100	0
13	10010010001000	0	10010010001000	0
14	01001000101010	0	01001000101010	0
15	01001010100010	0	01001010100010	0
16	01010001001010	0	01010001001010	0
17	01010001010100	0	01010001010100	0
18	01010100100010	0	01010100100010	0
19	01010101000100	0	01010101000100	0
1A	10010001010010	0	10010001010010	0
1B	10010010100010	0	10010010100010	0
1C	10100010010010	0	10100010010010	0
1D	10100010100100	0	10100010100100	0
1E	10100100100010	0	10100100100010	0
1F	10100101000100	0	10100101000100	0
20	01000100010010	0	01000100010010	0
21	01000100100100	0	01000100100100	0
22	01000101001000	0	01000101001000	0
23	01001000100010	0	01001000100010	0
24	01001010001000	0	01001010001000	0
25	01010010000100	0	01010010000100	0
26	10000100010100	0	10000100010100	0
27	10000100101000	0	10000100101000	0
28	10001000010010	0	10001000010010	0
29	10001010010000	0	10001010010000	0
2A	10010000100010	0	10010000100010	0
2B	10010100010000	0	10010100010000	0
2C	10100010000100	0	10100010000100	0
2D	10100100001000	0	10100100001000	0

Data	Group A (Positive)		Group B (Negative)	
	Code	CDS	Code	CDS
2E	10010000101010	0	10010000101010	0
2F	10010101000010	0	10010101000010	0
30	10100001001010	0	10100001001010	0
31	10100001010100	0	10100001010100	0
32	10101001000010	0	10101001000010	0
33	10101010000100	0	10101010000100	0
34	01000010001010	0	01000010001010	0
35	01000010010100	0	01000010010100	0
36	01000010101000	0	01000010101000	0
37	01010001000010	0	01010001000010	0
38	01010100001000	0	01010100001000	0
39	10000100001010	0	10000100001010	0
3A	10000101010000	0	10000101010000	0
3B	10100001000010	0	10100001000010	0
3C	10101000010000	0	10101000010000	0
3D	01000100000100	0	01000100000100	
3E	01001000001000	0	01001000001000	0
3F	01000010000010	0	01000010000010	0
40	01010000010000	0	01010000010000	0
41	10001000000100	0	10001000000100	0
42	10010000001000	0	10010000001000	0
43	10000100000010	0	10000100000010	0
44	10100000010000	0	10100000010000	0
45	01001001010100	2	00010100100100	−4
46	01001010100100	2	00100100010100	−4
47	01010100100100	2	00101000100100	−4
48	10001001010010	2	01001000101000	−4
49	10010010010010	2	01010010010000	−4
4A	10000100100010	4	00010101010010	−2
4B	00100010010000	4	00101010100010	−2
4C	10000010000100	4	01010010100010	−2
4D	01010100001010	4	00001000101010	−2
4E	10000101010010	4	00010001010100	−2
4F	10100101010000	4	00010101000100	−2
50	10100100010010	2	00001010010010	−4
51	10100101001000	2	00100100001010	−4
52	10000100010010	2	00101000010010	−4
53	00010001001000	2	01001001010000	−4
54	00100100010000	2	10010000101000	−4
55	10101000101010	2	10100001001000	−4
56	01000101000010	4	00101000100010	−2
57	10000101000100	4	01000100010100	−2
58	10001010000100	4	01001000010010	−2
59	00100010101010	2	00001010000100	−4
5A	00010001010000	4	01010001000100	−2
5B	01000010001000	4	10001000101000	−2
5C	00101010001010	2	01001000001010	−4

Data	Group A (Positive)		Group B (Negative)	
	Code	CDS	Code	CDS
5D	01000100101010	2	10010000010100	−4
5E	01000001010010	4	10010010010000	−2
5F	10000001001010	4	00001000100010	−2
60	10010010000010	4	00010010000100	−2
61	01010010001010	2	00010010000010	−4
62	00010000010100	4	00010000010000	−2
63	01000001000100	4	01010000101010	−2
64	01010100010010	2	10010000001010	−4
65	10001010100010	2	00100100000010	−4
66	10010100100010	2	01001000000010	−4
67	10100010001010	2	10010000000010	−4
68	10100010101000	2	00010100010100	−6
69	10101010001000	2	00101000101000	−6
6A	10001010001010	6	10100101000010	−2
6B	01000100100010	2	00001010010100	−6
6C	10000010001010	2	00010100001010	−6
6D	10001000100010	2	00101000010100	−6
6E	10010010000100	2	01010000101000	−6
6F	00010000100100	2	10100001010000	−6
70	10001010101000	6	01000100001010	−2
71	10010100101000	6	01010000100010	−2
72	10000010001000	6	10001001010000	−2
73	10000101010100	6	10100001000100	−2
74	10010101010000	6	00010001000010	−2
75	10101001010000	6	00100100000100	−2
76	00100001010000	6	10101010000010	−2
77	00100001000100	2	01010000010100	−6
78	01000010010000	6	10001000001010	−2
79	01001000010000	2	00001010000010	−6
7A	10101000001010	6	00101000001000	−2
7B	10001000001000	2	01010000001010	−6
7C	00100101000010	2	00010100000010	−6
7D	00100000101000	6	01010000001000	−2
7E	01000010010010	2	10100000001010	−6
7F	10000000100010	6	10001000000010	−2
80	01001001000010	2	01010000000010	−6
81	01000010100100	2	00101000000010	−6
82	01000001001000	6	10010000000100	−2
83	10001010000010	6	01000100000010	−2
84	00100001010010	2	10100000010100	−6
85	10000010100010	6	01001000000100	−2
86	10000010101010	6	00100010000010	−2
87	10000001000100	6	10100000100010	−2
88	01000100001000	2	10100000101000	−6
89	00010010010000	2	00101000001010	−6
8A	10000101000010	6	10100000101010	−2
8B	10101000010100	6	00010100001000	−2

Data	Group A (Positive)		Group B (Negative)	
	Code	CDS	Code	CDS
8C	10010100001010	6	00001010001000	−2
8D	10000101001010	6	10010000010010	−2
8E	10101000101000	6	10001000010100	−2
8F	10010100010100	6	01000101010000	−2
90	10001010010100	6	00001010100010	−2
91	00001000101000	2	01010001010000	−6
92	10001010001000	2	00101001010000	−6
93	10000100100100	2	00010101010000	−6
94	01000101000100	2	00001010101000	−6
95	00100010100010	2	00001010001010	−6
96	10000100010000	6	10100001010010	−2
97	10101000100010	2	00010100101000	−6
98	10100010010100	2	10100000000100	−4
99	10010101000100	2	01010000000100	−4
9A	10010001010100	2	00101000000100	−4
9B	10001000101010	2	10100000010010	−4
9C	10000000010000	4	01010101000010	−2
9D	00100000010010	4	00001010101010	−2
9E	01010010101000	2	00010100000100	−4
9F	10010100000100	4	00001000001000	−2
A0	10000010100100	4	00001001000100	−2
A1	01001010000010	4	10100010001000	−2
A2	01000101010010	2	10100000100100	−4
A3	00101010101000	2	01010000010010	−4
A4	10000001000010	4	10010000100100	−2
A5	00100000100100	4	01010100010000	−2
A6	00010000101000	4	01001010010000	−2
A7	10101010100010	2	00001001000010	−4
A8	10001001000010	4	01000100101000	−2
A9	10000010010010	4	00101010001000	−2
AA	01000010100010	4	00100010101000	−2
AB	10001010101010	2	10010001010000	−4
AC	00100010001000	2	01010000100100	−4
AD	10001001000100	2	01001000010100	−4
AE	10101001000100	2	00100101010000	−4
AF	10100100100100	2	00001010100100	−4
B0	10101000010010	4	00100010001010	−2
B1	10100100001010	4	00010100100010	−2
B2	01010101010000	4	00001001010010	−2
B3	01000010101010	4	10100010100010	−2
B4	01000100010000	4	01010001010010	−2
B5	00100001001000	4	00101000101010	−2
B6	10010010100100	2	10100010010000	−4
B7	10010001001010	2	01010001001000	−4
B8	01010101001000	2	00101010010000	−4
B9	01010010010100	2	00100100101000	−4
BA	01001010010010	2	00010101001000	−4

Data	Group A (Positive)		Group B (Negative)	
	Code	CDS	Code	CDS
BB	01001001001010	2	00010100010010	−4
BC	00101010010100	2	00010010101000	−4
BD	00100101010100	2	00010010001010	−4
BE	00100101001010	2	00001001010100	−4
BF	10101001010010	2	00001001001010	−4
C0	10101010010000	4	00010100101010	−2
C1	10101000100100	4	10101010101000	−2
C2	10100100101000	4	10101010001010	−2
C3	10100100010100	4	10100010101010	−2
C4	10010100010010	4	10100100010000	−2
C5	10010010101000	4	10010001001000	−2
C6	10010010001010	4	01010010001000	−2
C7	10001010100100	4	01001001001000	−2
C8	10001010010010	4	01001000100100	−2
C9	10000100101010	4	00101001000100	−2
CA	01010100101000	4	00100101001000	−2
CB	01010100010100	4	00100100010010	−2
CC	01001010101000	4	00100010010100	−2
CD	01001010001010	4	00010010100100	−2
CE	01000101010100	4	00010010010010	−2
CF	01000101001010	4	00010001001010	−2
D0	10001000010000	4	00101001010010	−2
D1	10000100001000	4	10101010010100	−2
D2	10010101010010	2	00101001001000	−4
D3	10010100101010	2	00010010010100	−4
D4	10101001001000	4	10100101010100	−2
D5	10010101001000	4	10100101001010	−2
D6	10010100100100	4	01010101010100	−2
D7	10010010010100	4	01010101001010	−2
D8	10001001010100	4	01010010101010	−2
D9	10001001001010	4	00101010101010	−2
DA	01001010010100	4	00100100100100	−2
DB	10101010101010	2	00001000010000	−4
DC	00100000010000	0	00100000010000	0
DD	00001000000100	0	00001000000100	0
DE	00010000001000	0	00010000001000	0
DF	00101000010000	0	00101000010000	0
E0	00100001000010	0	00100001000010	0
E1	00001010010000	0	00001010010000	0
E2	00101010000100	0	00101010000100	0
E3	00101001000010	0	00101001000010	0
E4	00100001010100	0	00100001010100	0
E5	00010101000010	0	00010101000010	0
E6	00010000101010	0	00010000101010	0
E7	00100100001000	0	00100100001000	0
E8	00100010000100	0	00100010000100	0
E9	00010100010000	0	00010100010000	0

Data	Group A (Positive)		Group B (Negative)	
	Code	CDS	Code	CDS
EA	00010000100010	0	00010000100010	0
EB	00001001001000	0	00001001001000	0
EC	00001000010010	0	00001000010010	0
ED	00100101000100	0	00100101000100	0
EE	00100100100010	0	00100100100010	0
EF	00100010100100	0	00100010100100	0
F0	00100001001010	0	00100001001010	0
F1	00010010100010	0	00010010100010	0
F2	00010001010010	0	00010001010010	0
F3	00010101010100	0	00010101010100	0
F4	00010101001010	0	00010101001010	0
F5	00010010001000	0	00010010001000	0
F6	00010001000100	0	00010001000100	0
F7	00001000100100	0	00001000100100	0
F8	00100010010010	0	00100010010010	0
F9	00101010100100	0	00101010100100	0
FA	00101010010010	0	00101010010010	0
FB	00101001010100	0	00101001010100	0
FC	00101001001010	0	00101001001010	0
FD	00100101010010	0	00100101010010	0
FE	00100100101010	0	00100100101010	0
FF	00010010101010	0	00010010101010	0

PROPOSED

SMPTE RECOMMENDED PRACTICE — RP 158

Basic System and Transport Geometry Parameters for ½-in Type M-2 Format

1. *Scope*

This practice specifies the video recording system, scanner parameters, and test conditions for ½-in type M-2 helical-scan video tape recorders operating with video signals having a typical scanning structure of 525 lines, 59.94 fields/sec, 2:1 interlace, and utilizing the cassettes specified in SMPTE 250M. The parameters described in this practice are for reference purposes only and should not be taken as the only method available to attain the specifications as defined in SMPTE 249M.

2. *Referenced Documents*

This practice is intended for use in conjunction with the following documents:

SMPTE 249M, Television Analog Recording—½-in Type M-2—Records

SMPTE 250M, Television Analog Recording—½-in Type M-2—Tapes and Cassettes

SMPTE 251M, Television Analog Recording—½-in Type M-2—Electrical Parameters of Video, Audio, Time and Control Code and Tracking Control

SMPTE 252M, Television Analog Recording—½-in Type M-2—Pulse Code Modulation Audio

3. *Definitions*

Scanner: A mechanical assembly containing a drum, rotating pole tips, and tape-guiding elements used to record and reproduce video and PCM audio mode signals.

Drum: A cylindrical column around which the tape is at least partially wrapped in order to form the head-to-tape interface of a video tape recording system.

Upper Drum: The part of the drum which is not in contact with the reference edge of the tape. (See Fig. 1.)

Lower Drum: The part of the drum which contacts the reference edge of the tape and provides tape-guiding functions. (See Fig. 1.)

Effective Drum Diameter: The value of drum diameter which yields the actual video and PCM audio record dimensions in a theoretical calculation. This value is equal to or greater than the actual drum diameter.

Helix Angle: The angle formed between the path of the rotating pole tips and the tape reference edge guiding system.

Track Angle: The angle formed between the video record and the reference edge of the tape.

Center Span Tension: A calculated value of the tape tension at a point midway between the tape entrance and exit guides of the scanner in a video tape recording system.

Wrap Angle: The angle at the center of the drum rotation subtended by the lines of contact between the drum and the reference edge of the tape.

Lead Signal Overlap: That portion of the helical record which is required to provide a duplicate (overlap) recording.

4. *General Specifications*

4.1 Dimensions are in the metric system.

4.2 A basic dimension is a fundamental dimension to which no tolerance is applicable.

4.3 Tests and measurements made on the recorder to check the parameters specified in this standard shall be made under the following atmospheric conditions:

Temperature for drum diameter	20°C ± 0.5°C
Temperature for all other tests	20°C ± 1.0°C
Relative humidity	50% ± 2%
Barometric pressure	86 to 106 kPa
Conditioning time before testing	24 hours

5. *Tape Speed*

The tape speed shall be 67.693 mm/s, basic.

6. *Representative Scanner Parameters*

6.1 Drum Diameter and Structure. The effective drum diameter, tape tension, helix angle, and tape speed taken together completely determine the track angle. Different methods of design and/or minor variations in drum diameter and tape tension will produce equivalent recordings for interchange purposes.

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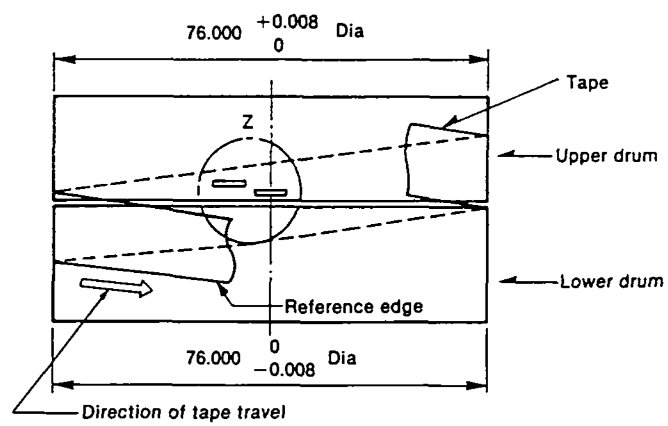
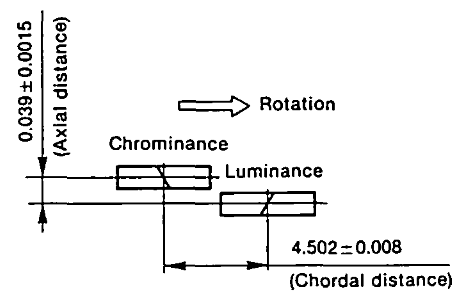


(a) Drum and Tape Wrap



(b) Details of Zone Z

Fig. 1
Side View of Chrominance and Luminance Pole Tips

6.1.1 Actual Upper Drum Diameter. The actual upper drum diameter *shall be 76.000 mm +* 0.008 mm — 0.000 mm.

6.1.2 Actual Lower Drum Diameter. The actual lower drum diameter shall be 76.000 mm + 0.000 mm — 0.008 mm.

6.1.3 Upper Drum Section. The upper drum section shall rotate together with the video heads.

6.1.4 Center Span Tension. The center span tension shall be 0.31 N ± 0.05 N.

6.1.5 Helix Angle. The helix angle formed by the scanner and all associated tape guides shall be 4.250° ± 0.001°.

6.2 Scanner Pole Tips. Four circumferential pole tips shall be located as shown in Fig. 2.

6.2.1 Pole Tip Projection. Each pole tip should project radially 0.035 mm (nominal value) above the upper drum surface.

6.2.2 Luminance Pole Tips. Two pole tips circumferentially arranged 180° ± 0.003° apart shall be provided for the luminance signal.

6.2.3 Chrominance Pole Tips. Each luminance pole tip shall have an associated pole tip for the time compressed chrominance signal and the FM audio signals. The chrominance pole tips shall be located at a chordal distance of 4.502 mm ± 0.008 mm in a counterrotational direction from the associated luminance pole tips, and are axially displaced from the associated luminance pole tips by 0.0390 mm ± 0.0015 mm in a direction away from the reference edge of the tape. (See Fig. 1b.)

6.2.4 Channel Identification. Suitable means, such as a pulse generator producing one pulse per drum revolution, shall be provided for identifying the one head pair which records field 1. This pair is identified as channel 1, and the other pair is identified as channel 2.

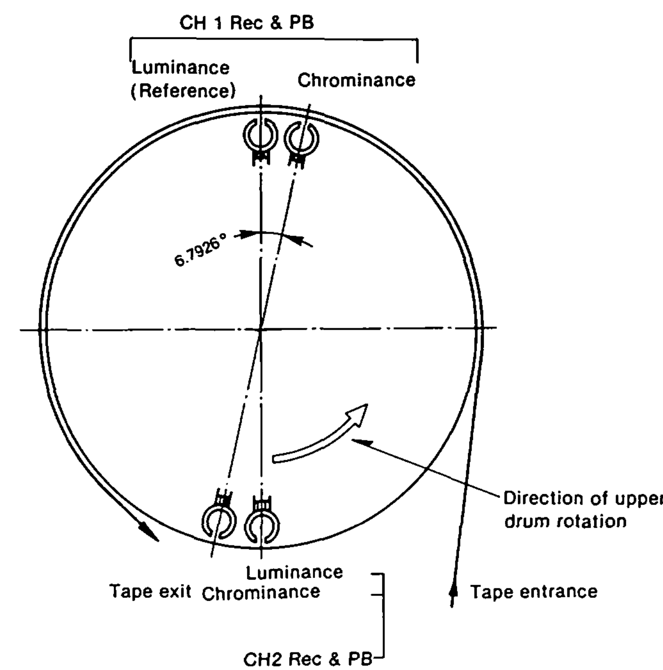


Fig. 2
Top View of Chrominance and Luminance Pole Tips