Standards and Recommended Practices

Approved American National Standards

The American National Standards Institute approved four American National Standards on July 10, 1991: ANSI/SMPTE 249M-1991, Television Analog Recording – ½-in Type M-2 – Records; ANSI/SMPTE 250M-1991, Television Analog Recording – ½-in Type M-2 – Tapes and Cassettes; ANSI/SMPTE 251M-1991, Television Analog Recording – ½-in Type M-2 – Electrical Parameters of Video, Audio, Time and Control Code and Tracking Control; and ANSI/SMPTE 252M-1991, Television Analog Recording – ½-in Type M-2 – Pulse Code Modulation Audio. Copies of the standards are available from Society Headquarters for a nominal fee.

Approved SMPTE Recommended Practice

An SMPTE Recommended Practice was approved by the Society: RP 158-1991, Basic System and Transport Geometry Parameters for ½-in Type M-2 Format. The practice is available from Society Headquarters for $5.00.

Reaffirmed American National Standards

Reaffirmation of five American National Standards sponsored by the Society was approved by the American National Standards Institute on July 10, 1991: ANSI/SMPTE 139-1986 (R1991), Motion-Picture Film (35-mm) – Perforated KS; ANSI/SMPTE 146M-1986 (R1991), Motion-Picture Film – Determination of Speed – 16- and 8-mm Reversal Color Camera Films; ANSI/SMPTE 169-1986 (R1991), Motion-Picture Film (35-mm) – Perforated 8-mm Type S, 2R-1664 (1-0); ANSI/SMPTE 216-1985 (R1991), Motion-Picture Film (35-mm) – Recorded Characteristic of Magnetic Audio Records – Four-Track Striped Release Prints; and ANSI/SMPTE 217-1985 (R1991), Motion-Picture Film (70-mm) – Recorded Characteristic of Magnetic Audio Records – Striped Release Prints. Copies of ANSI/SMPTE 139, 169, 216, and 217 are available from Headquarters for $8.00 each and ANSI/SMPTE 146M for $20.00.

Withdrawn American National Standard

A recommendation for withdrawal of an American National Standard was approved by the American National Standards Institute on August 6, 1991: ANSI V98.34M-1984, Video Recording – ½-in Type G Cassette – Records. Withdrawal was approved because the standard was out of date and needed significant revision to cover the various format permutations presently in use.

—Sherwin H. Becker, Director of Engineering

SMPTE STANDARD

ANSI/SMPTE 249M-1991

for Television Analog Recording — 1/2-in Type M-2 — Records

1 Scope

This standard specifies the dimensions and locations of the video, audio, time code, and tracking-control records, as recorded by 1/2-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 ANSI/SMPTE 250M-1991. This standard also specifies the records for two different audio recording modes — common audio mode and pulse code modulation (PCM) audio mode.

2 General specifications

2.1 All dimensions are in the metric system.

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

2.3 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 kPa to 106 kPa
Tape tension	0.31 N ± 0.05 N

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

Environment	Established to the conditions specified in 2.3
Tape tension	Wound on a reel at a tension of 0.4 N ± 0.1 N
Condition time	24 hours

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

3 Tape speed

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

4 Record locations and dimensions

4.1 The locations and dimensions of the video and common audio mode records shall be as specified in figures 1 and 2 and table 1.

4.2 The locations and dimensions of the video and PCM audio mode records shall be as specified in figures 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.

4.3 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.

American National Standard

Approved
July 10, 1991

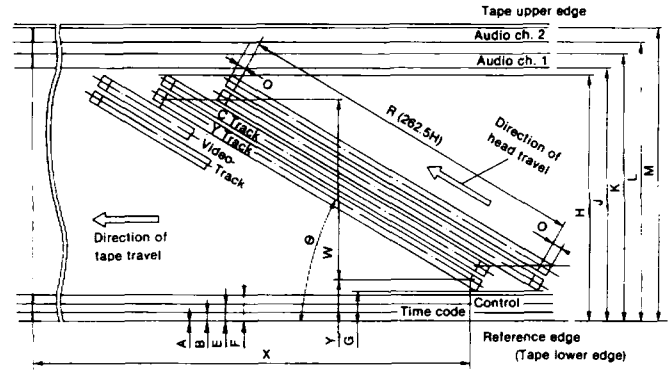

Figure 1 – Record locations and dimensions (common audio mode)

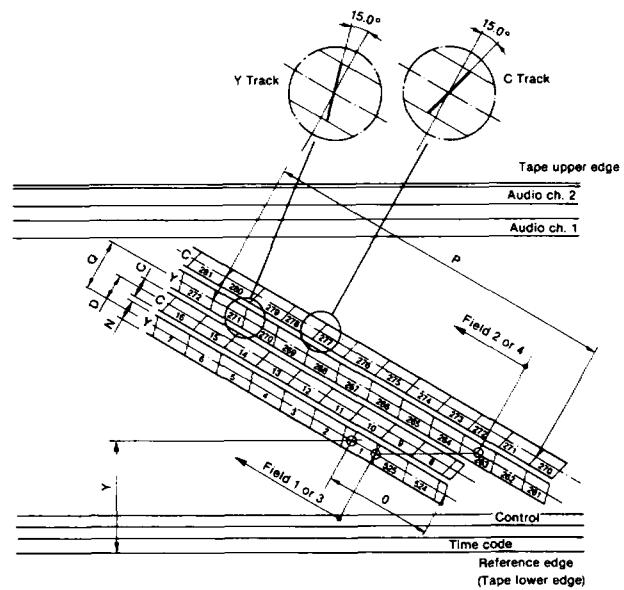

Figure 2 – Video record locations (common audio mode)

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 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 annex A.)

6 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 figures 1 to 4. PCM audio shall be positioned as shown in figures 3 and 4.

7 Gap azimuth

7.1 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 figures 1 and 3.)

7.2 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 figures 2 and 4.)

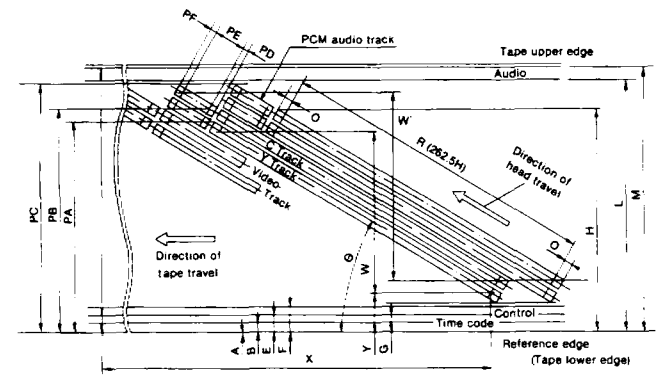

Figure 3 – Record locations and dimensions (PCM audio mode)

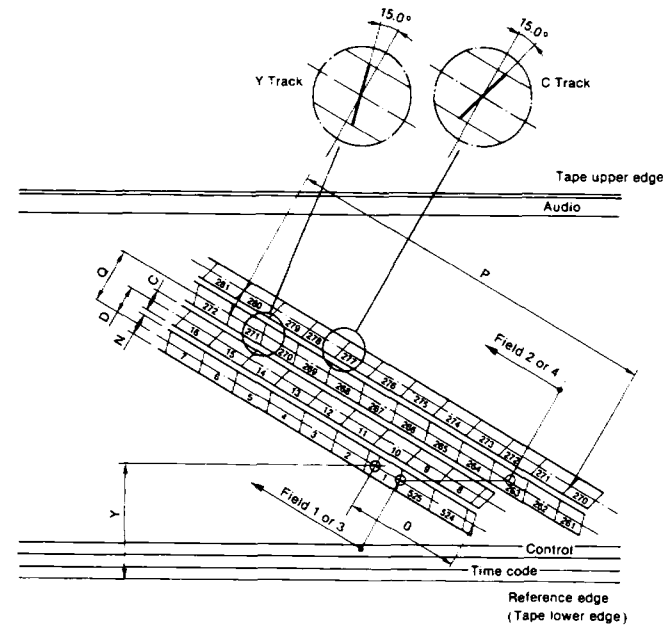

Figure 4 – Video record locations (PCM audio mode)

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.

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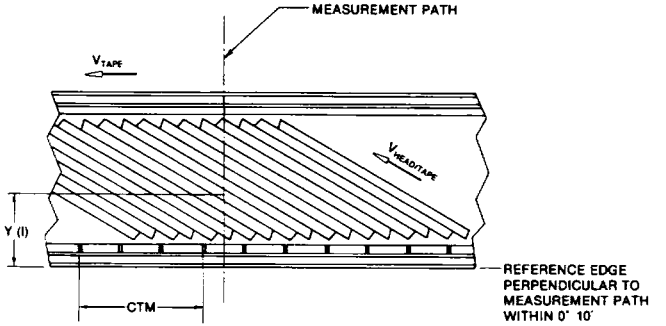
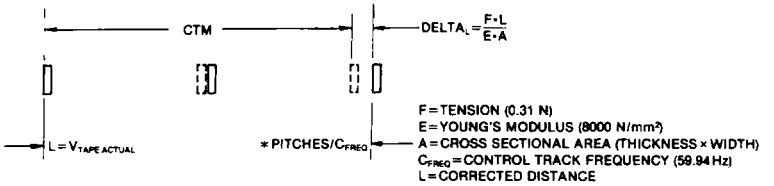
Annex A (normative)
Cross tape track measurement technique (preferred)

MEASUREMENT TECHNIQUE



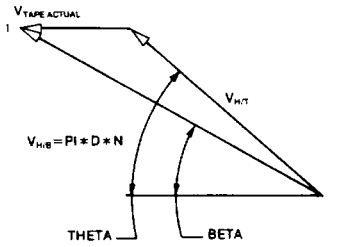
Y (I) MUST USE SAME HEAD FOR EACH MEASUREMENT (i.e. EVERY 2nd TRACK)
CTM = CONTROL TRACK PULSES (UNTENSIONED TAPE)

CORRECTION FACTORS ACTUAL TAPE SPEED, TENSION

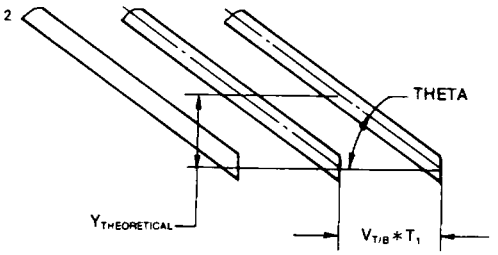


$$V_{TAPE\ ACTUAL} = CTM * C_{FREQ} / ((1 - F/(E * A)) * PITCHES)$$

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



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:

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

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

Annex B (informative)
Bibliography

ANSI/SMPTE 250M-1991, Television Analog Recording — 1/2-in Type M-2 — Tapes and Cassettes

ANSI/SMPTE 251M-1991, Television Analog Recording — 1/2-in Type M-2 — Electrical Parameters of Video, Audio, Time and Control Code and Tracking Control

ANSI/SMPTE 252M-1991, Television Analog Recording — 1/2-in Type M-2 — Pulse Code Modulation Audio

SMPTE RP 158-1991, Basic System and Transport Geometry Parameters for 1/2-in Type M-2 Format

SMPTE STANDARD

for Television Analog Recording — 1/2-in Type M-2 — Tapes and Cassettes

1 Scope

This standard specifies tapes and cassettes for the 1/2-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 kPa 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 types

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 nm 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 nm to 900 nm)

5.2 Length:

Large cassette	170 mm ± 15 mm
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 µm to 36 µm

5.4 Width: 12.65 mm ± 0.02 mm

5.5 Splicing tape length: 13 mm to 20 mm

5.6 Splicing tape thickness: 25 µm or less

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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.

7 Video cassette

The video cassette shall be specified by the following descriptions:

7.1 Cassette dimensions

Large cassettes shall conform to figures 1 to 8. Small cassettes shall conform to figures 9 to 20.

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	$51\ ^{+3}_{0}$

7.2 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 figures 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 figures 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 figures 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 figures 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 figures 2 to 4 and 10 to 12.)

7.3 Window and label pasting face

Large cassettes shall conform to figure 1 and small cassettes to figure 9.

7.4 Identification holes

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

Closed state	The hole depth shall be 0 mm 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 figure 2 and small cassettes as in figure 10.

The record lock-out identification hole shall be coupled to the record lock-out mechanism shown in figures 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 figure 2 and small cassettes as in figure 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 figure 2 and small cassettes as in figure 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 ± 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 figure 2 (five holes) and small cassettes shall be as specified in figure 10 (two holes).

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

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

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

7.8 The structure of the lid shall conform to figures 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 given in note 8 of figure 1, note 6 of figure 9, and figure 19.

7.9 The force necessary for opening the lid given in note 7 of figure 3 and figure 17 shall be 1 N or less.

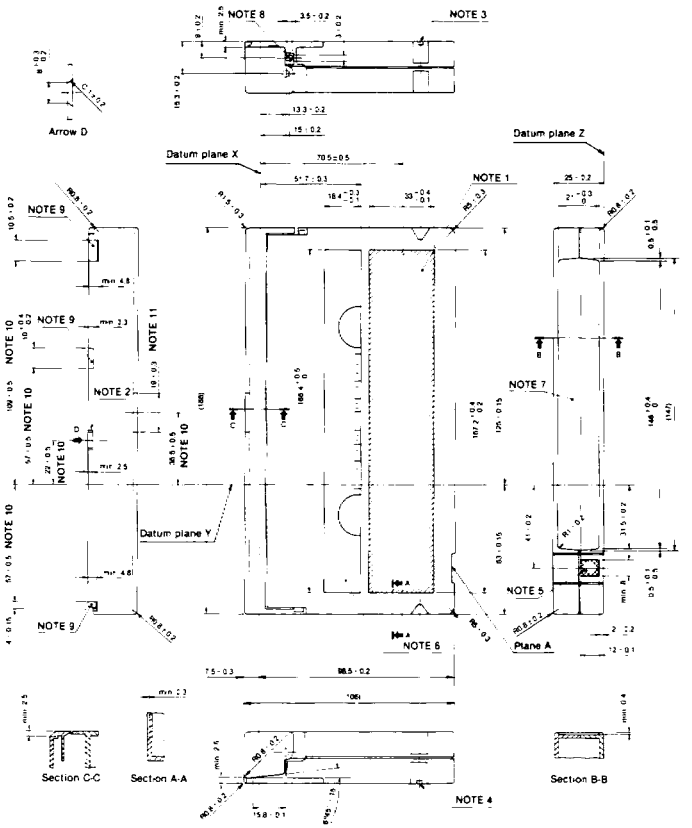
7.10 The reel brakes shall be released by a force of not more than 0.7 N by means of a reel brake unlocking pin as given in note 4 of figure 3 and note 3 of figure 11.

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

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

7.13 Screw positions

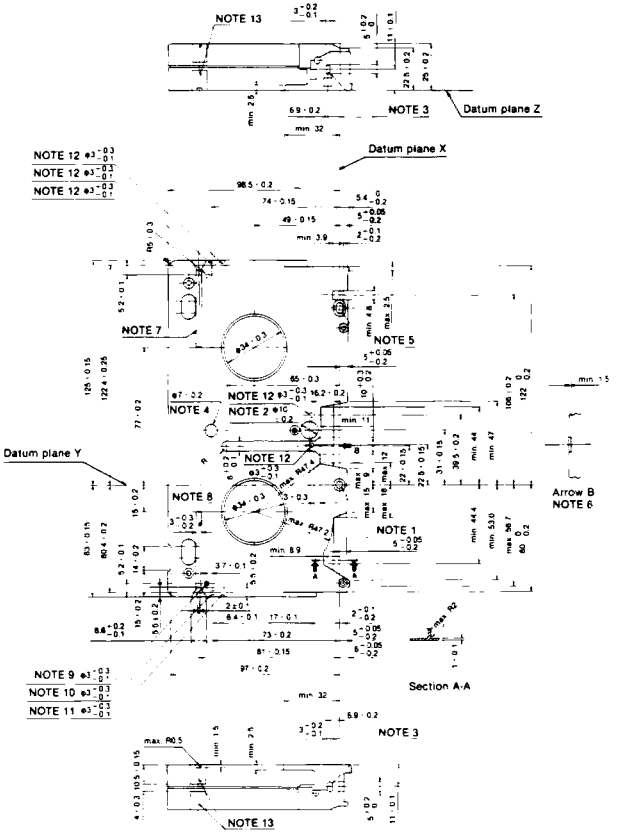
Screw positions for assembling the upper and lower cassette halves should be as shown in figure 8 (large cassette) and figure 20 (small cassette). The diameter of the spot facing for the screw head should be within 3.8 mm to 6.2 mm. The diameter of the spot facing for the screw head described in note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



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 given in note 9 of figure 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.

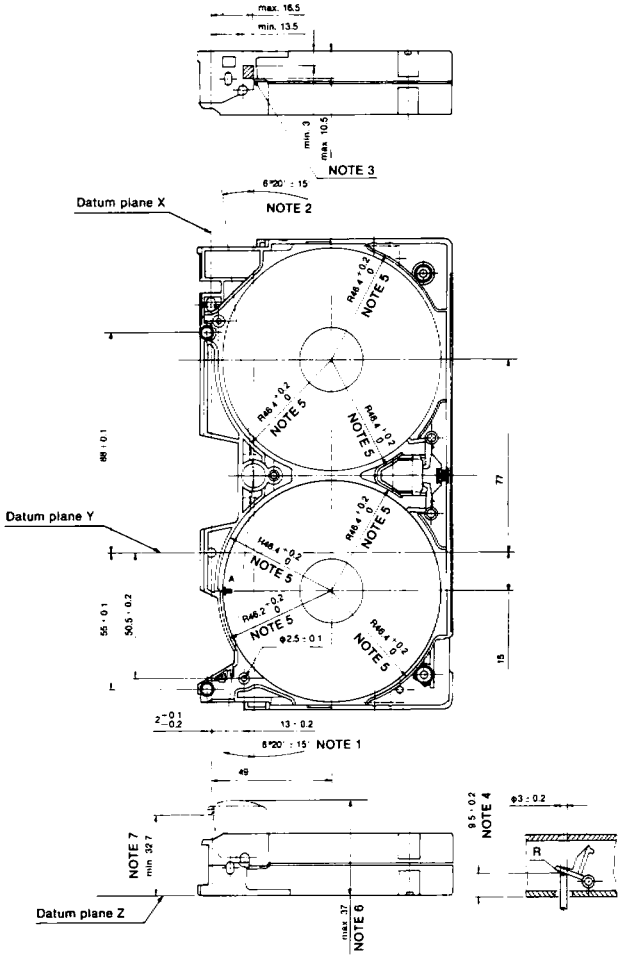
Figure 1 – Top and side views of large cassette



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.

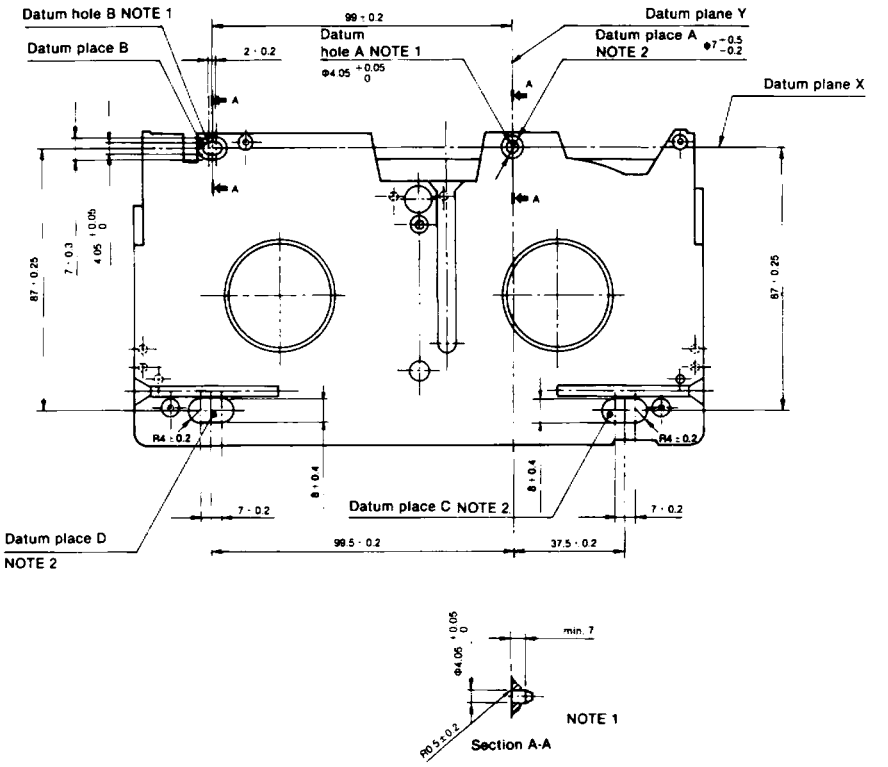
Figure 2 – Bottom view of large cassette



NOTES

1 Supply side sensor optical path angle.
2 Take-up sensor opticla 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 figure 7 for tape threading path.)

Figure 3 – Inner structure of large cassette

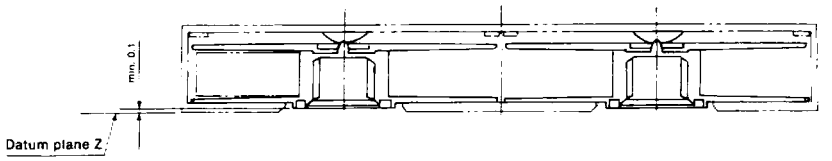


NOTES

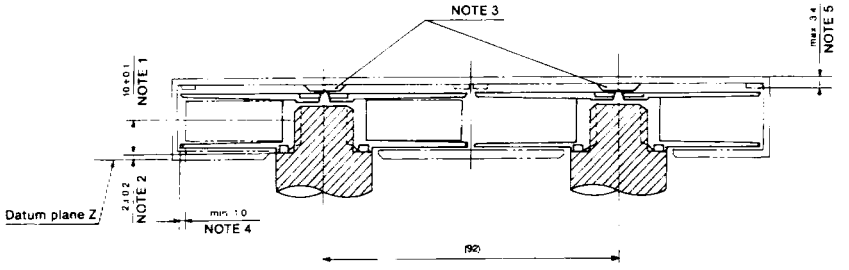
1 The diameter of the datum hole in section A-A shall be 4.05 mm + 0.05 mm – 0.00 mm and 7 mm in depth.
2 The flatness of the four datum places shall be 0.2 mm or less. The datum places are used as the supporting surfaces of the cassette.

Figure 4 – Datum places and support surfaces of large cassette

(a) Condition off the machine



(b) Condition loaded on the machine



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.

Figure 5 – Relationship between reels and reel stands for large cassette

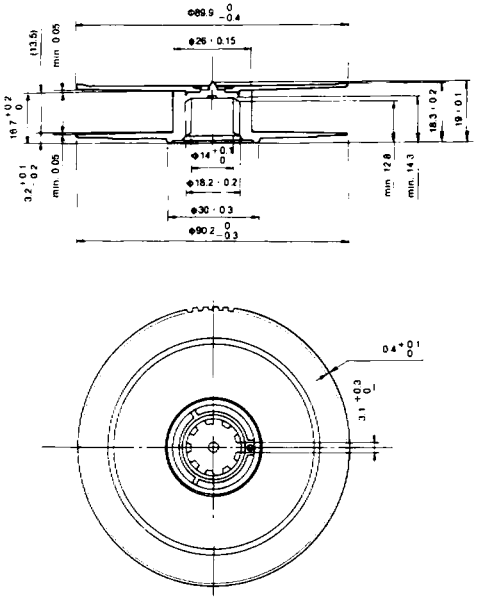


Figure 6 – Reel dimensions of large cassette

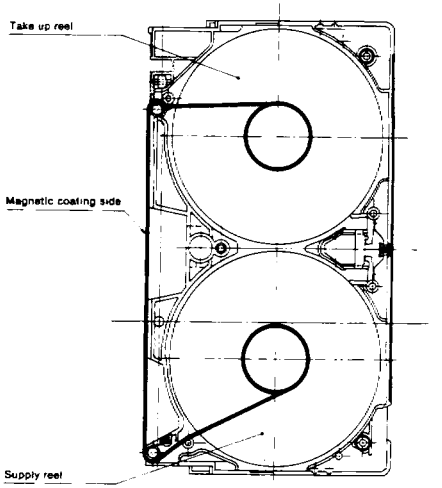
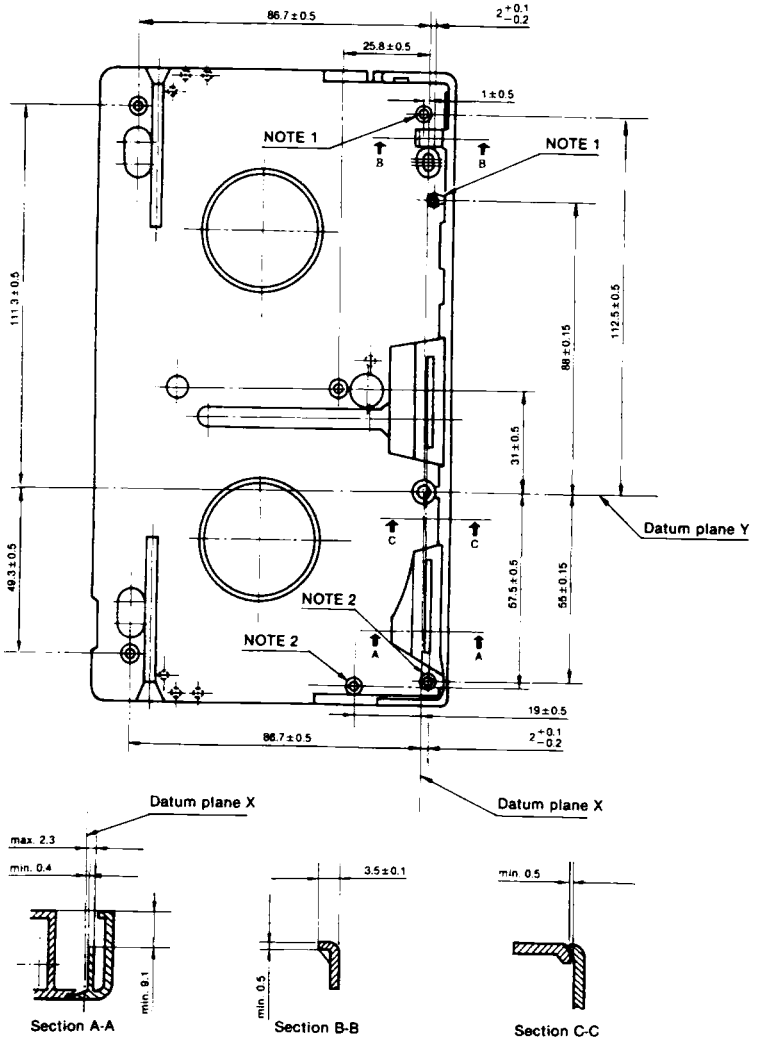
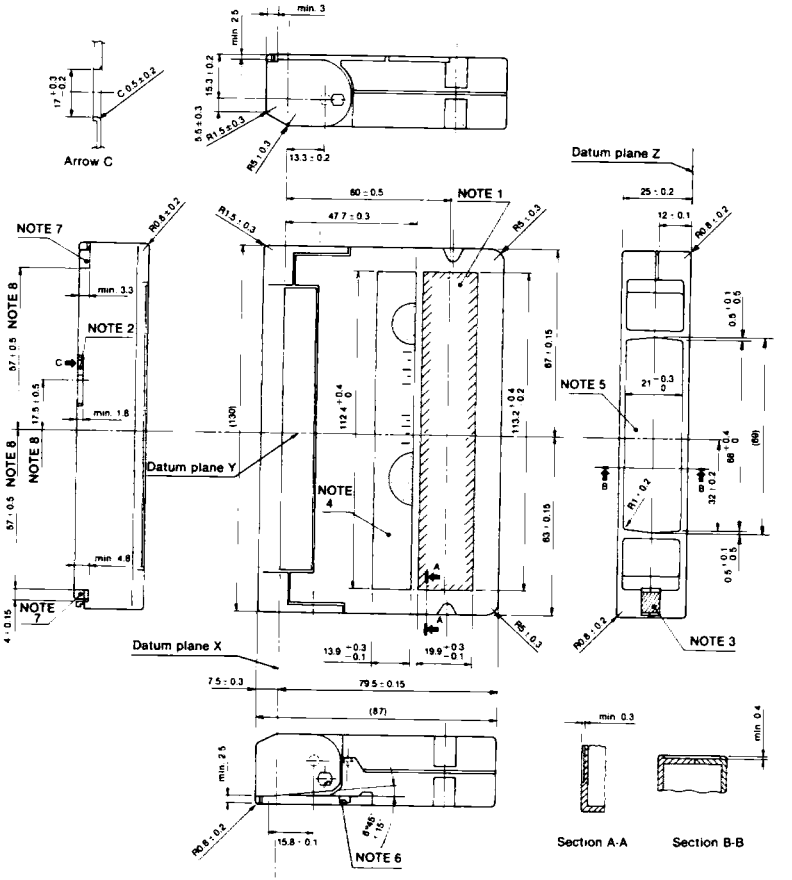


Figure 7 – Tape path in large cassette



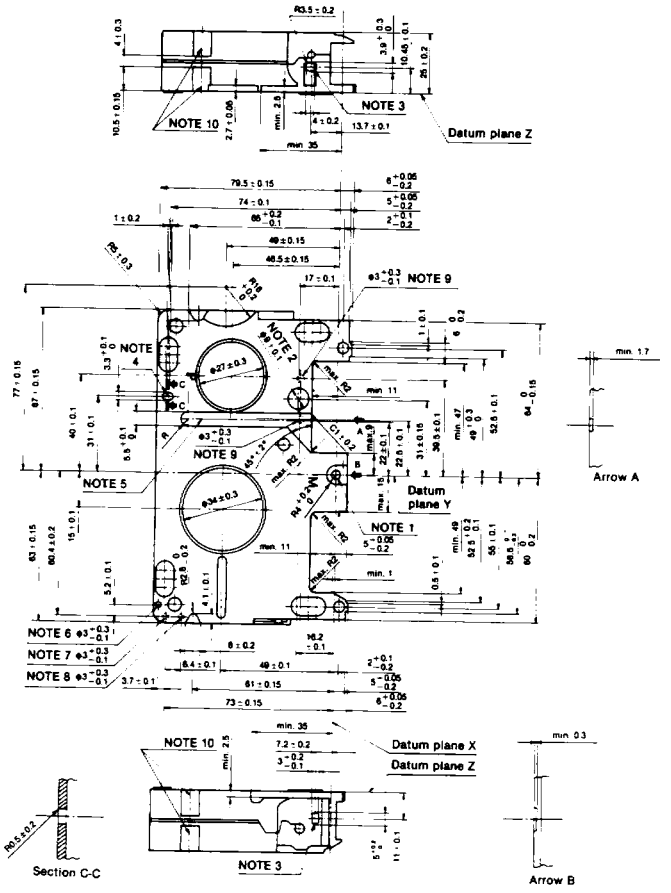
NOTES
1 Either one of two screw positions may be used.
2 Either one of two screw positions may be used.

Figure 8 – Screw positions and lid structure of large cassette



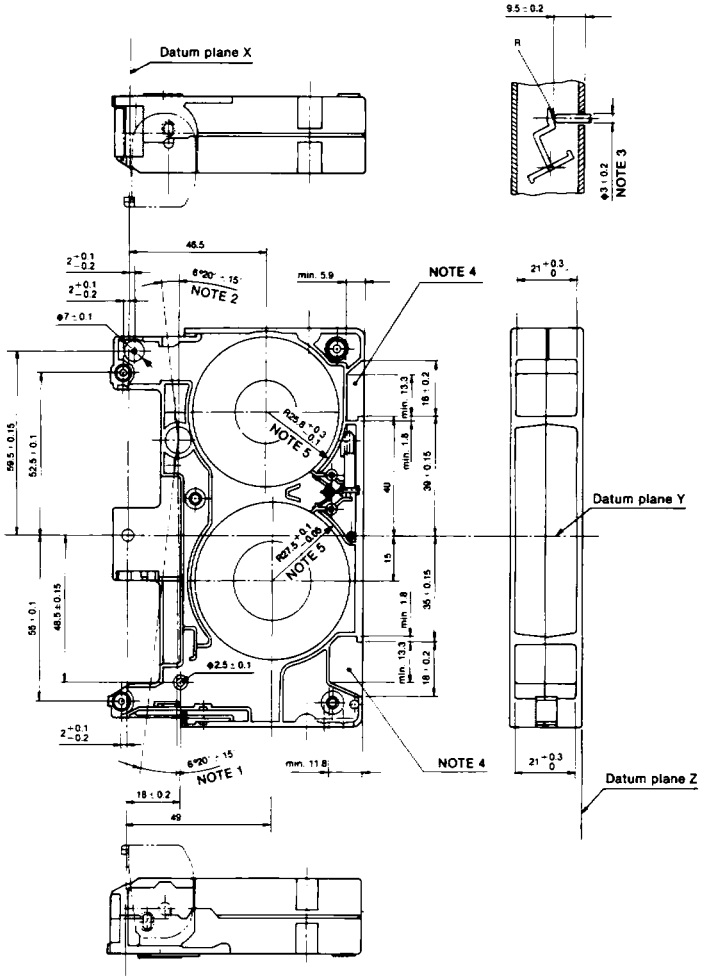
NOTES
1 Top label pasting face. The label shall not protrude beyond the cassette height.
2 Guide groove to prevent misinsertion.
3 Operation of record lock-out hole. When the record lock-out hole is open, recording should be impossible. When the hole is closed, recording should be possible. The record lock-out mechanism shall be coupled with the identification hole shown in figure 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.

Figure 9 – Top and side views of small cassette



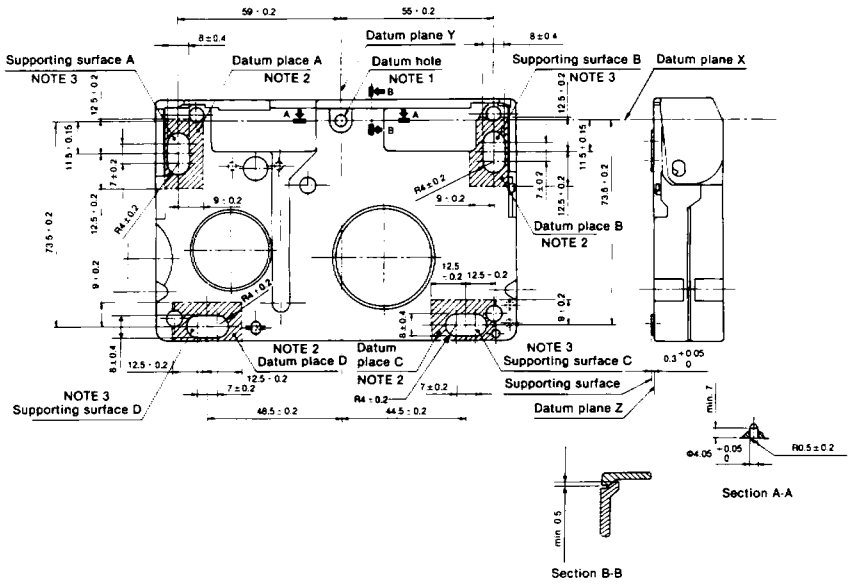
NOTES
1 Datum hole.
2 Hole for sensor lamp.
3 Holes for sensor optical path.
4 Reel brake unlocking hole.
5 Guide groove to prevent misinsertion.
6 Record lock-out identification hole.
7 Tape type identification hole.
8 Tape thickness identification hole.
9 Extra identification holes (two holes).
10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

Figure 10 – Bottom view 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.

Figure 11 – Inner structure of small cassette

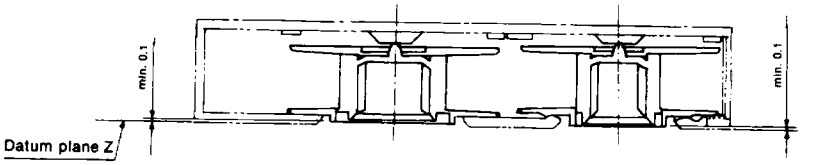


NOTES

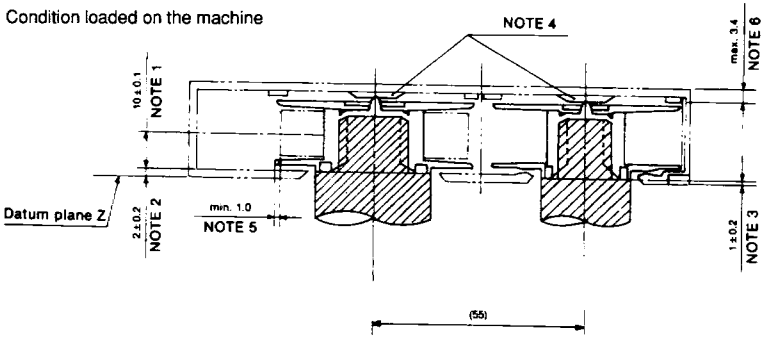
1 The diameter of the datum hole in section A-A shall be 4.05 mm + 0.05 mm – 0.00 mm and 7 mm in depth.
2 The flatness of the four datum places shall be 0.2 mm or less.
3 The flatness of the four supporting surfaces shall be 0.2 mm or less. The supporting surfaces are used as the cassette supporting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

Figure 12 – Datum places and supporting surfaces of small cassette

(a) Condition off the machine



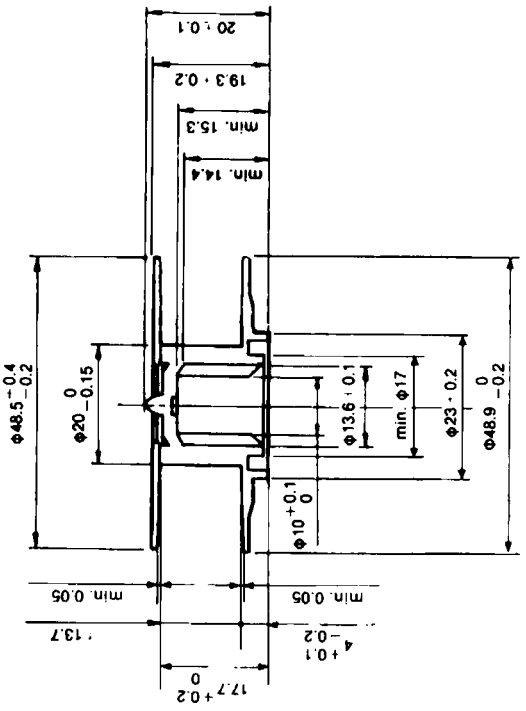
(b) Condition loaded on the machine



NOTES

1 Center line 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.

Figure 13 – Relationship between reels and reel stands of small cassette



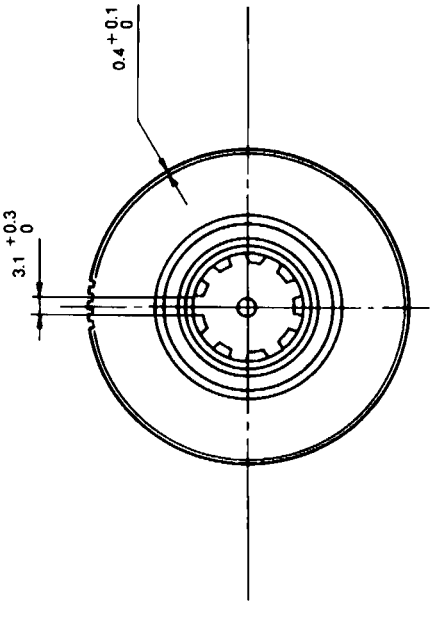


Figure 14 – Supply reel dimensions of small cassette

Figure 15 – Take-up reel dimensions of small cassette

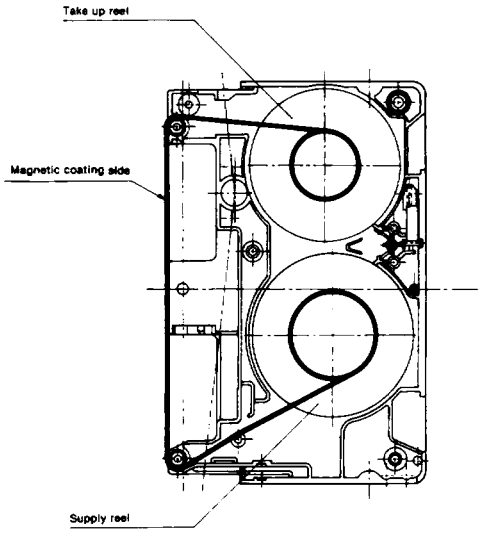
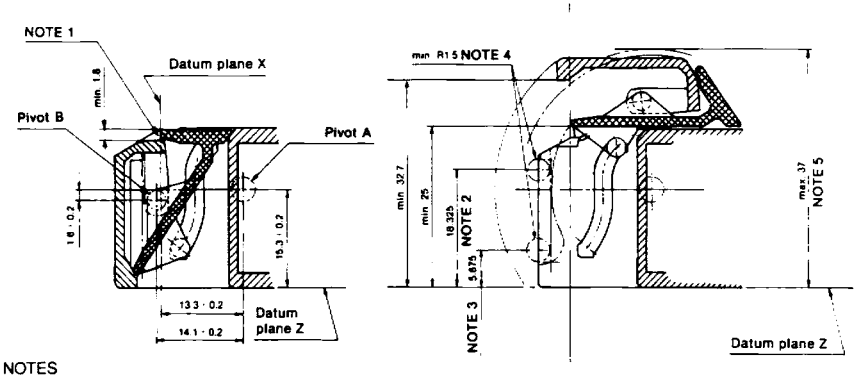
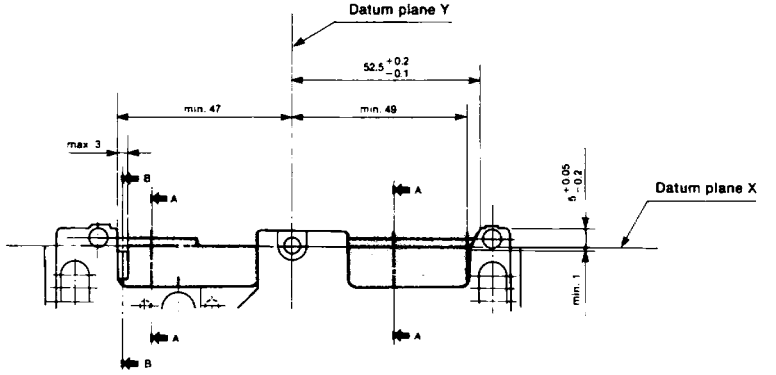


Figure 16 – Tape path in small cassette



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.

Figure 17 – Lid structure of small cassette



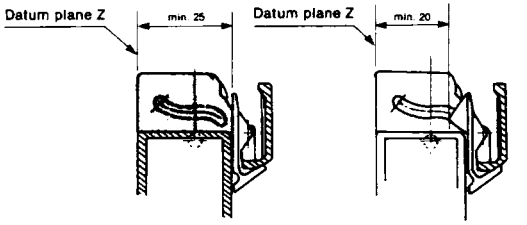
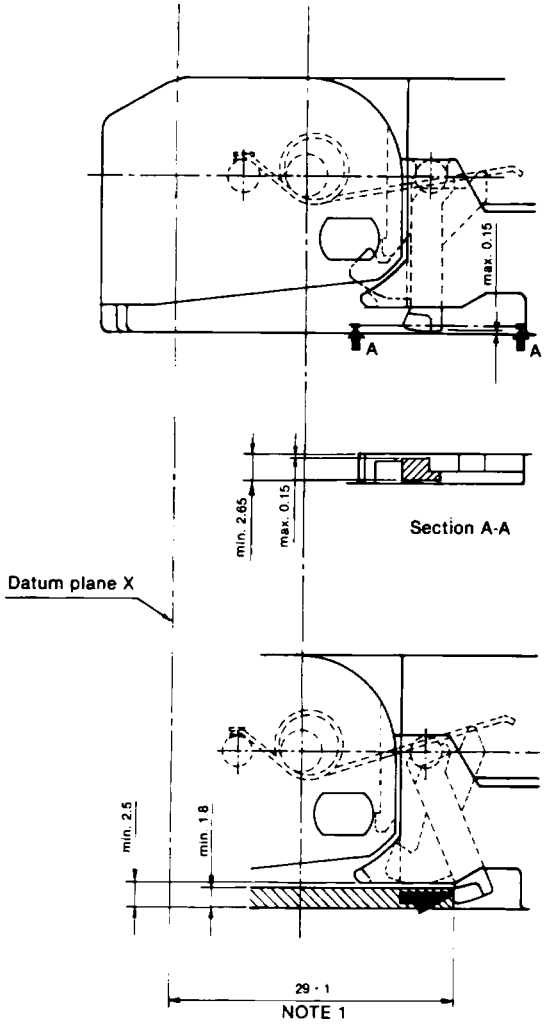
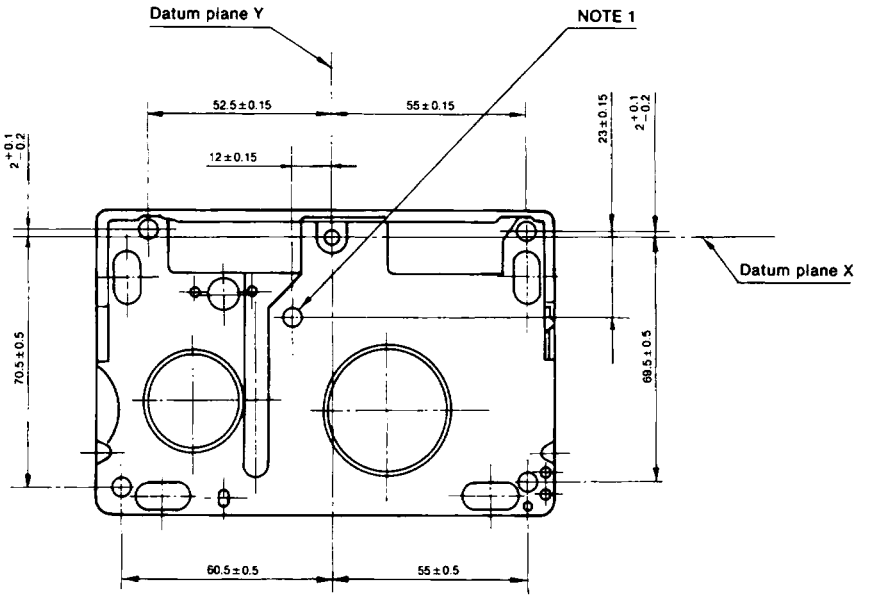


Figure 18 – Minimum clearance for recorder and player loading mechanism



NOTE 1 – Lid unlocking position

Figure 19 – Unlocking structure of lid



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 mm to 5.7 mm, and the depth of the seat to the screw head is 3 mm or more.

Figure 20 – Screw positions of small cassette

SMPTE STANDARD

ANSI/SMPTE 251M-1991

for Television Analog Recording — 1/2-in Type M-2 — Electrical Parameters of Video, Audio, Time and Control Code and Tracking Control

1 Scope

1.1 This standard specifies the recording system for the video, audio, time and control code, and tracking-control signals for 1/2-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 ANSI/SMPTE 250M-1991.

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 ANSI/SMPTE 249M-1991, is a secondary audio recording mode which is specified in ANSI/SMPTE 252M-1991.

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

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. 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 12M-1986, Television — Time and Control Code — Video and Audio Tape for 525-Line/60-Field Systems

ANSI/SMPTE 249M-1991, Television Analog Recording — 1/2-in Type M-2 — Records

ANSI/SMPTE 250M-1991, Television Analog Recording — 1/2-in Type M-2 — Tapes and Cassettes

ANSI/SMPTE 252M-1991, Television Analog Recording — 1/2-in Type M-2 — Pulse Code Modulation Audio

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:

American National Standard

Approved
July 10, 1991

(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

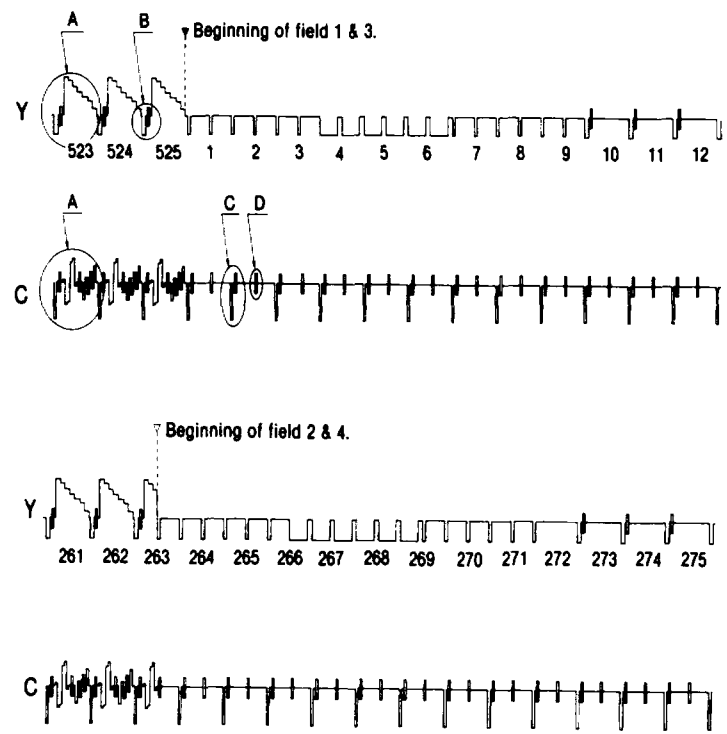
(4) A luminance preemphasis network

(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



NOTE – No burst signals are mixed during the 9H period of Y vertical blanking.

Figure 1 — Waveform of burst mixed luminance and burst and sync added chrominance signals

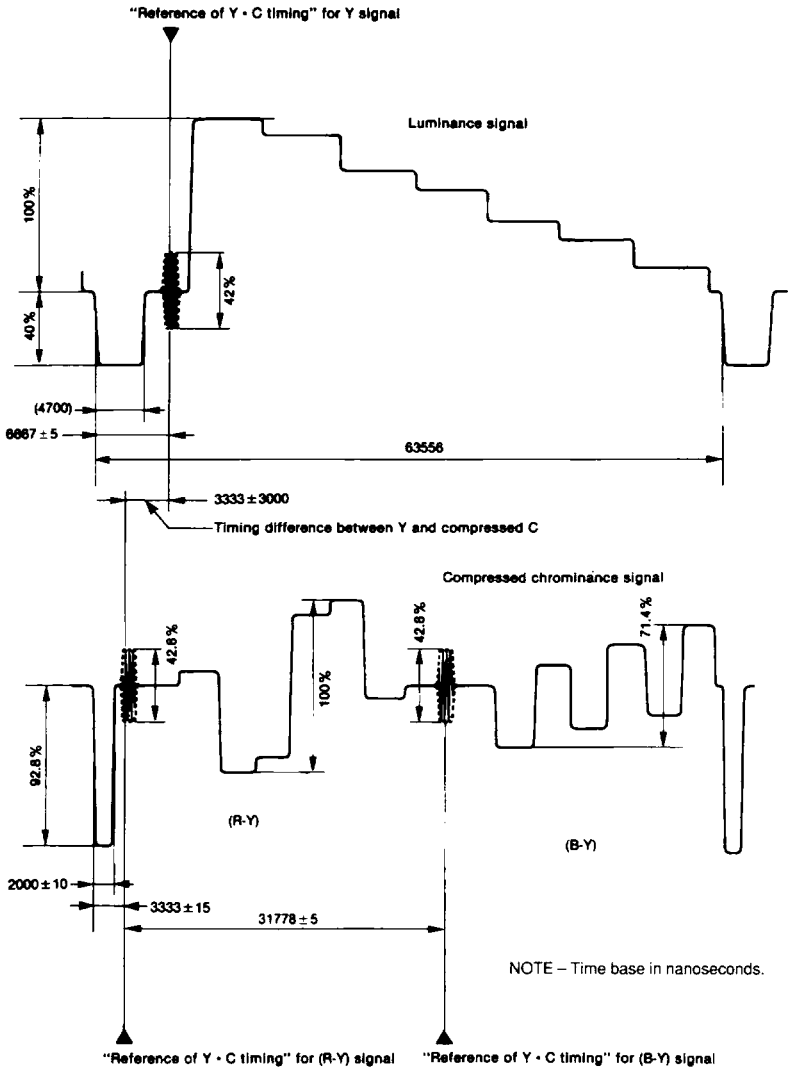


Figure 2 – Luminance signal and compressed chrominance signals for 100/7.5/77/7.5 color bars (Details of figure 1A)

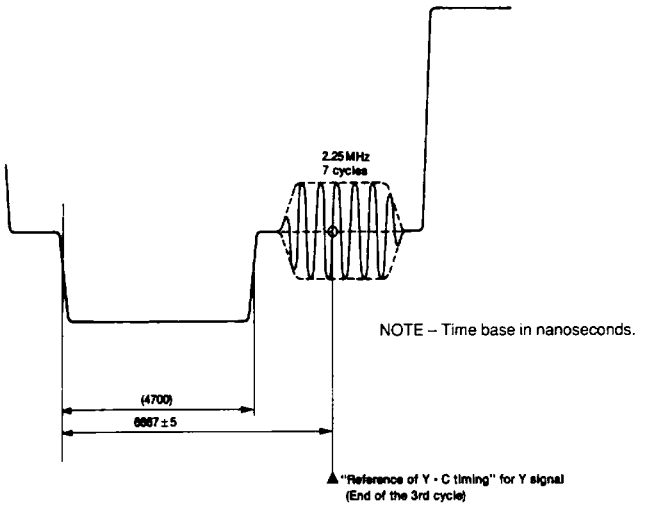


Figure 3 – Details of figure 1B

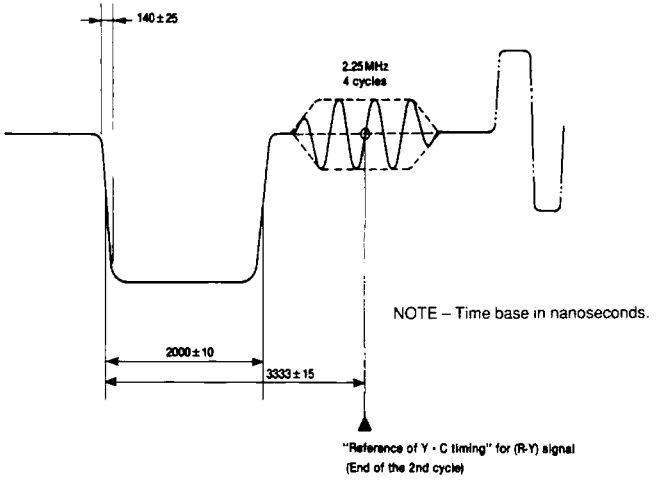
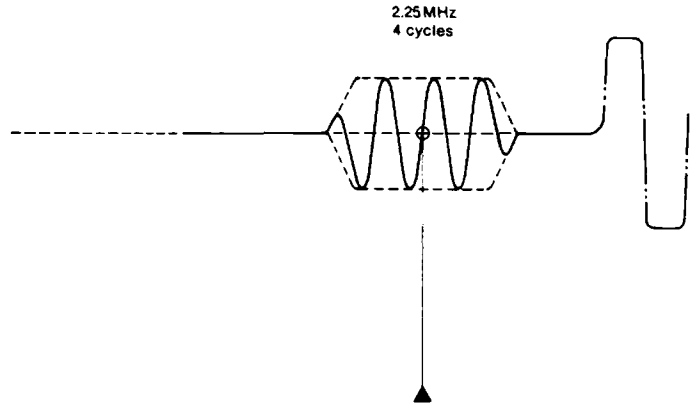
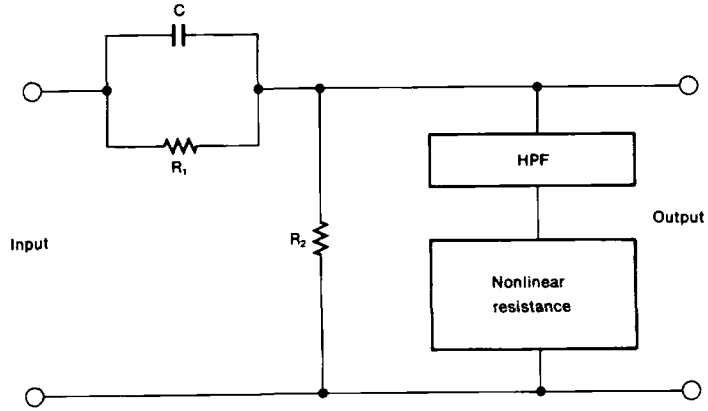


Figure 4 – Details of figure 1C



NOTE – Time base in nanoseconds.

Figure 5 – Details of figure 1D



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

Figure 6 – Luminance nonlinear preemphasis circuit

3.1.2 Burst signal addition

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

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 figure 6.
2 Values are in decibels.

3.1.4 Luminance preemphasis

The network and circuit parameters shall be as shown in figure 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.

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 MHz to 10 MHz contained within limit lines as shown in figure 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

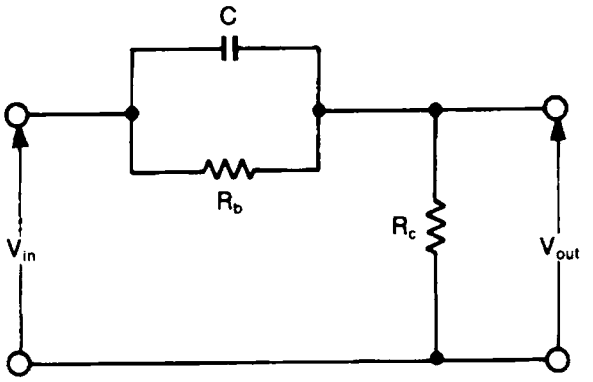
(2) Means to individually adjust the R-Y and B-Y levels in the ratio specified

(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



$T_Y = CR_b = 1.34\ \mu s$

$X_Y = R_b / R_c = 2.5$

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

NOTE — Input source impedance = 0; output load impedance = ∞.

Figure 7 – Luminance preemphasis network

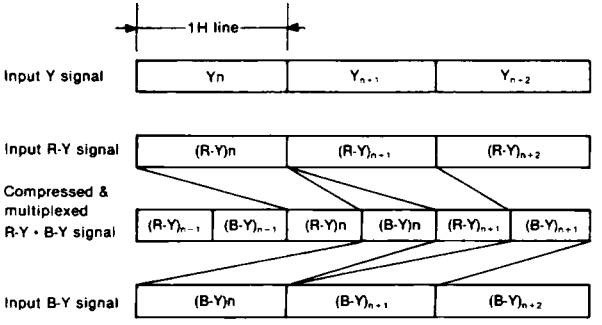


Figure 8 – Time-base compression and multiplexing

(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 figures 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 figure 8. The compressed and multiplexed R-Y and B-Y signals shall be delayed by one horizontal line with respect to the luminance signal.

3.2.4 Chrominance nonlinear preemphasis

A block diagram of a nonlinear preemphasis circuit is shown in figure 9. The typical frequency characteristics of this nonlinear preemphasis circuit output signal are as shown in table 2.

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.

3.2.5 Chrominance preemphasis

The network and circuit parameters shall be as shown in figure 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:

Positive excursion limit + 147.7% (nominal)
+ 157.7% (maximum)

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

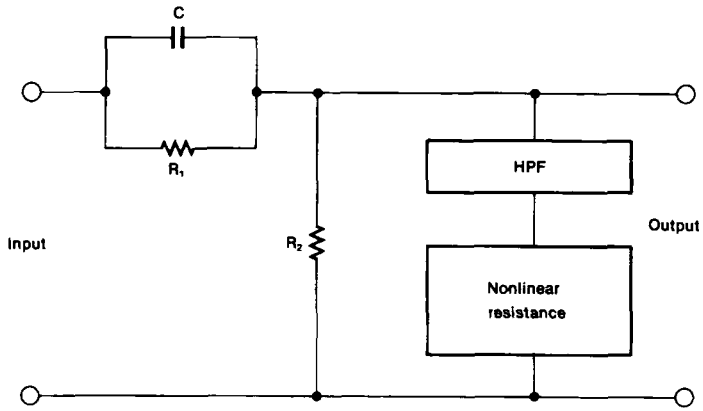
	100/7.5/77/7.5 color bar signal	
	R–Y	B–Y
Peak of positive excursion	6.20	6.00
Peak of negative excursion	4.80	5.00
Blanking	5.50	5.50
Sync-tip	4.20	—
Maximum p-p deviation	1.40	1.00
Deviation p-p tolerance	±0.02	±0.015
Blanking carrier tolerance	±0.05	±0.05

NOTE — Frequency in megahertz.

3.2.8 C track record head current

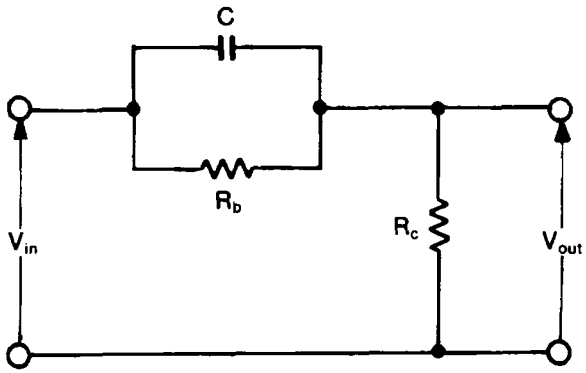
3.2.8.1 The amplitude of the record current for the C track shall be such that the maximum level of remanent flux on the tape is produced when recording the chrominance blanking level.

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 MHz to 10 MHz contained within limit lines as shown in figure 11.



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

Figure 9 – Chrominance nonlinear preemphasis circuit



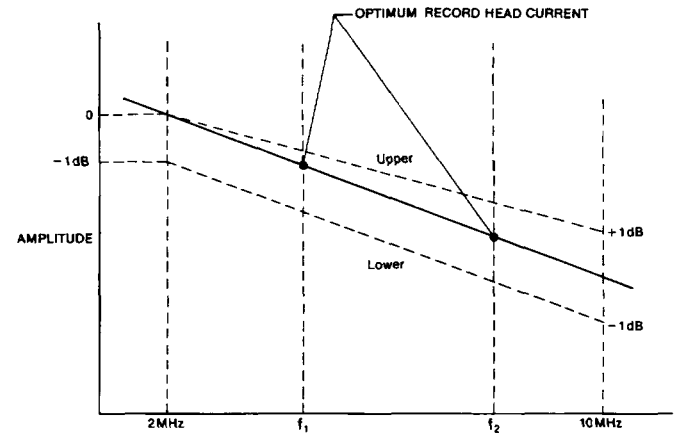
$T_c = CR_b = 0.60\ \mu s$

$X_c = R_b / R_c = 2.5$

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

NOTE – Input source impedance = 0; output load impedance = ∞.

Figure 10 – Chrominance preemphasis network



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

Figure 11 — Record equalization

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 figure 12.

3.3.2 Tolerance of compressed Y-C timing

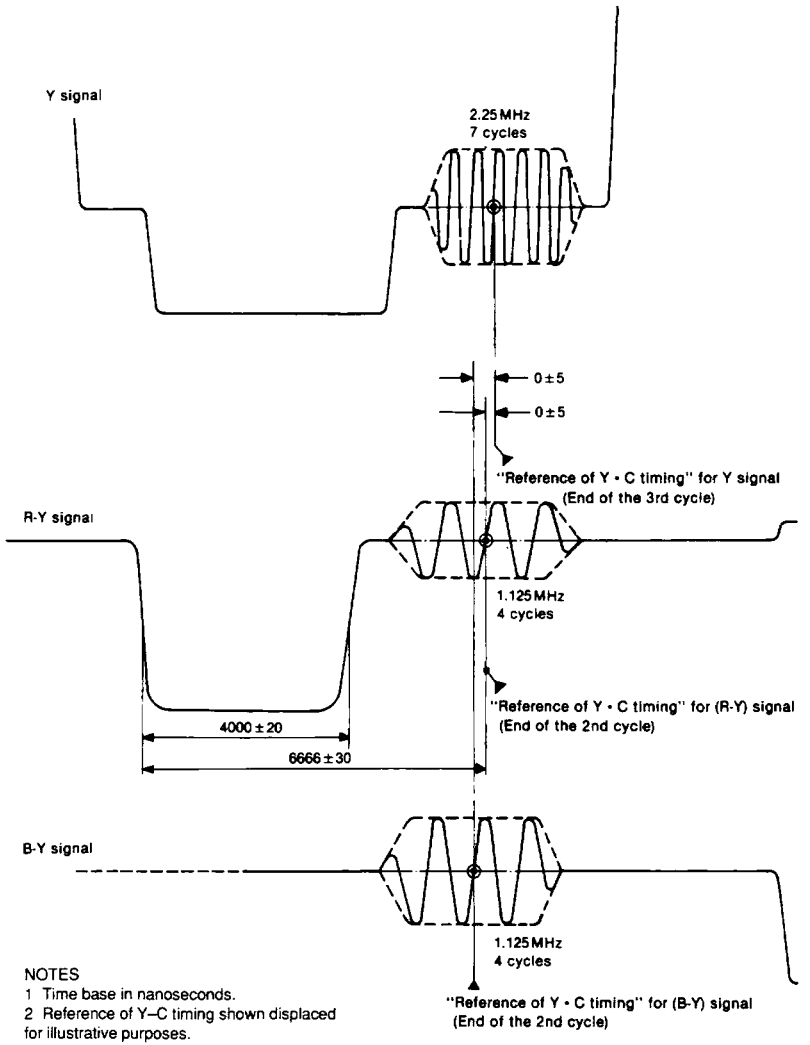
The timing difference between the luminance and the compressed chrominance signals shall be the value as shown in figure 2.

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



NOTES
1 Time base in nanoseconds.
2 Reference of Y–C timing shown displaced for illustrative purposes.

Figure 12 – Reference of Y-C timing

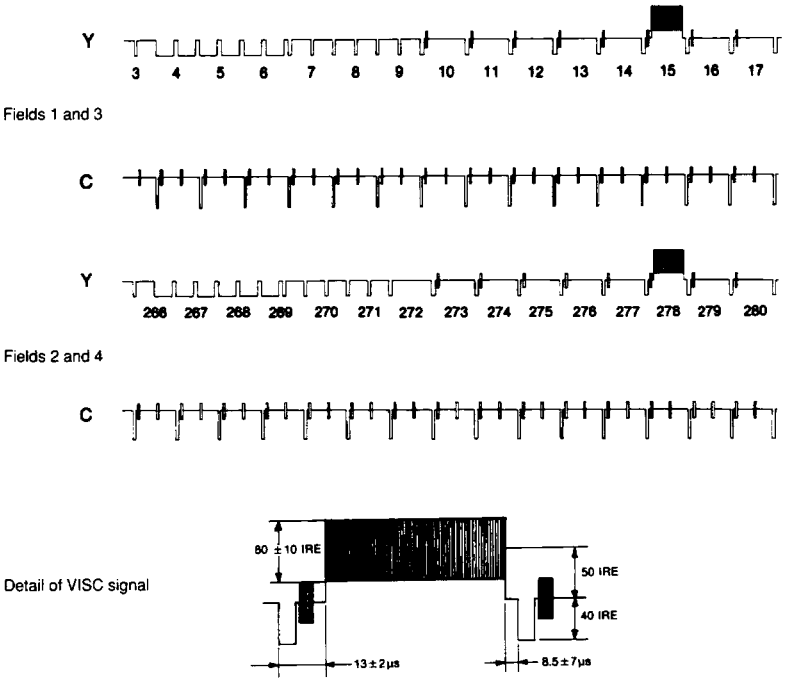


Figure 13 – Waveforms of VISC signal

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 standard volume indicator or its equivalent.

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 a 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:

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

where $L\phi$ (f) is the relative tape flux level;
f is the frequency at which the response is calculated;
F_l is the low-frequency transition frequency, 50 Hz; and
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.

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 the tape movement.

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.

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 of 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.

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 should be as shown in figure 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 figure 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 figure 16.

5.5 Frequency modulation

5.5.1 Carrier frequency

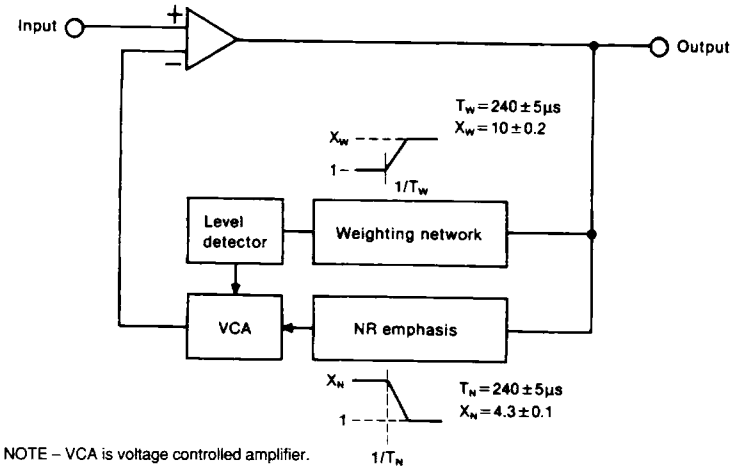
The left channel (CH3) signal frequency shall be 400 kHz ± 5 kHz. The right channel (CH4) signal frequency shall be 700 kHz ± 5 kHz.

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.

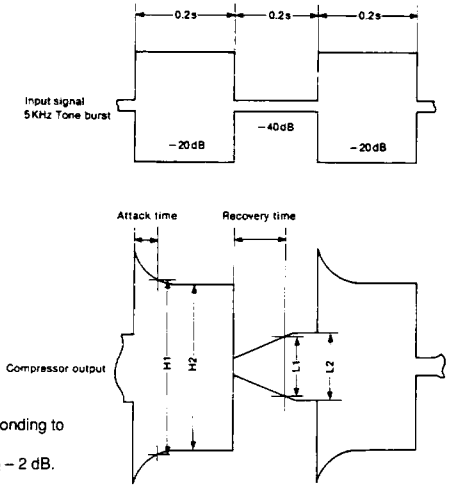
5.6 Recording head current

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 kHz to 800 kHz.



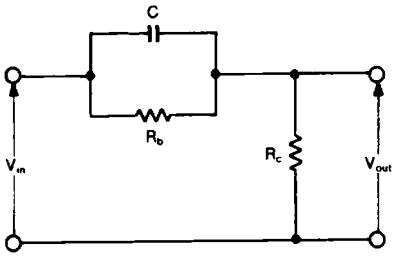
NOTE – VCA is voltage controlled amplifier.

Figure 14 – Noise-reduction circuit for AFM signals



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

Figure 15 – Transient response of compressor for AFM noise reduction



$T_D = CR_b = 56.0\ \mu s$

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

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

NOTE - Input source impedance = 0; output load impedance = ∞.

Figure 16 – Audio preemphasis network

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.

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 figure 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 figure 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 figure 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 figure 17.

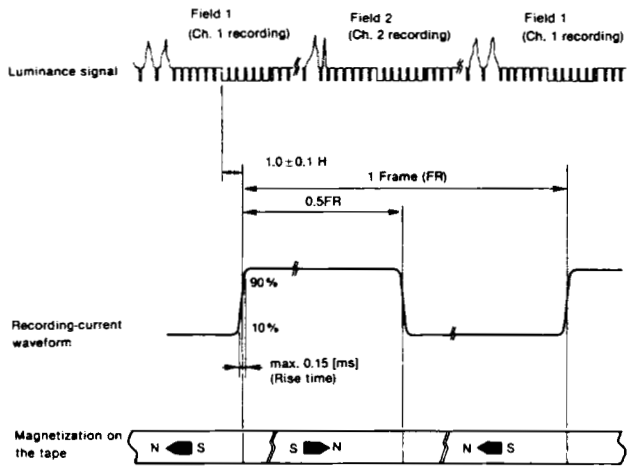


Figure 17 – Control track signal waveforms and timing for component signal

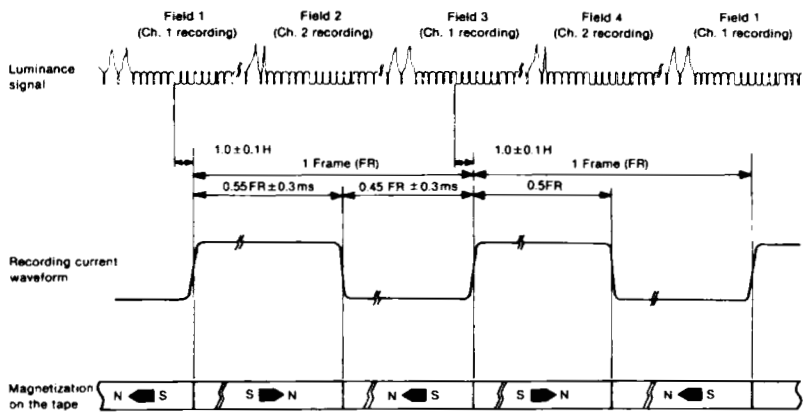


Figure 18 – Waveforms and timing of control track signal with color framing information

Annex A (informative)
Bibliography

CCIR Report 624-3 (MOD F), Characteristics of Television Systems

SMPTE STANDARD

for Television Analog Recording — 1/2-in Type M-2 — Pulse Code Modulation Audio

1 Scope

This standard specifies the pulse code modulation (PCM) audio mode of encoding and recording system utilizing a 1/2-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 ANSI/SMPTE 250M-1991.

2 Normative references

The following documents contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. 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 249M-1991, Television Analog Recording — 1/2-in Type M-2 — Records

ANSI/SMPTE 250M-1991, Television Analog Recording — 1/2-in Type M-2 — Tapes and Cassettes

SMPTE RP 155–1990, Audio Levels and Indicators for Digital Audio Records on Digital Television Tape Recorders

3 Recording location

The PCM audio signal is recorded on tape regions PD, PE, and PF, located on the video track as shown in ANSI/SMPTE 249M-1991. Since the recording area for longitudinal audio CH-1 is allocated for the PCM recording, longitudinal audio recording can be accomplished only on one channel (CH-2).

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 figure 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.

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 155–1990.

Track allocation: CH-5 shall be recorded by the luminance head. CH-6 shall be recorded by the chrominance head.

Stereo mode: CH-5 is the left channel. CH-6 is the right channel.

4.1.2 Audio data coding

Sampling frequency:	48 kHz (synchronous with video signal)
Sampling order:	CH-5, CH-6 simultaneous
Quantization:	16-bit linear
Coding:	Twos complement binary code

American National Standard

Approved
July 10, 1991

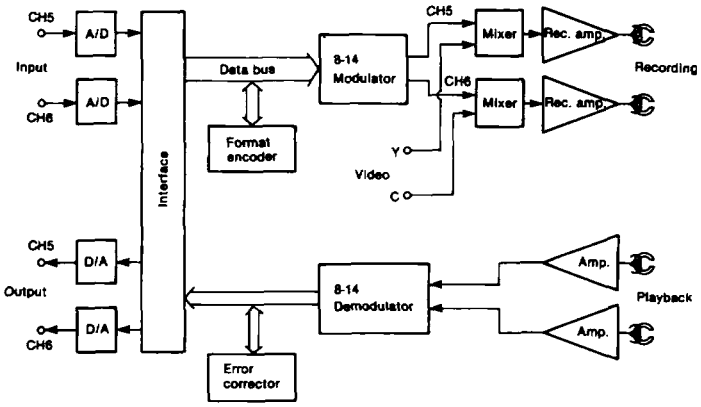


Figure 1 — Block diagram of PCM audio recording system

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 audio fields 0, 1, 2, and 3, but the data in audio field 4 shall be replaced by ID6 and ID7.

4.1.5 ID data specification

The ID data region is available for the user, and its contents are shown in figure 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 figure 3 where the recording order for each data sample is MSB first.

4.2.1 PCM signal construction

The PCM signal construction is shown in figure 4.

Preamble area:

Length: one horizontal line (63.5 µsec).

Content: a single frequency signal frequency signal of 5.0625 MHz (basic)

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

Table 1 – Source data arrangements for fields 0, 1, 2 and 3

Block Number	#0	#1	#2	#3	#4	#31	#32	#33	#34	#35	#63	#64	#65	#66
Data Symbol	D0U	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
	D0L	D 2L	D 4L	D 6L	D 8L	D 62L	D 64L	D66L	D 1L	D 3L	D 59L	D 61L	D 63L	D 65L
	D 67U	D 69U	D 71U	D 73U	D 75U	D129U	D131U	D133U	D 68U	D 70U	D126U	D128U	D130U	D132U
	D737U	D739U	D741U	D743U	D745U	D799U	ID 0	ID 4	D738U	D740U	D796U	D798U	D800U	ID 2
	D737L	D739L	D741L	D743L	D745L	D799L	ID 1	ID 5	D738L	D740L	D796L	D798L	D800L	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
Data Symbol	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	D129U	D131U	D133U	D 68U	D 70U	D126U	D128U	D130U	D132U
	D737U	D739U	D741U	D743U	D745U	D799U	ID 0	ID 4	D738U	D740U	D796U	D798U	ID 6	ID 2
	D737L	D739L	D741L	D743L	D745L	D799L	ID 1	ID 5	D738L	D740L	D796L	D798L	ID 7	ID 3

NOTE – U stands for the upper 8 bits, and L for the lower 8 bits.

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.

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 figure 3.

ECC2, ECC1: Specified in 4.2.2.

Transmission data rate: 11.57 Mbps per channel.

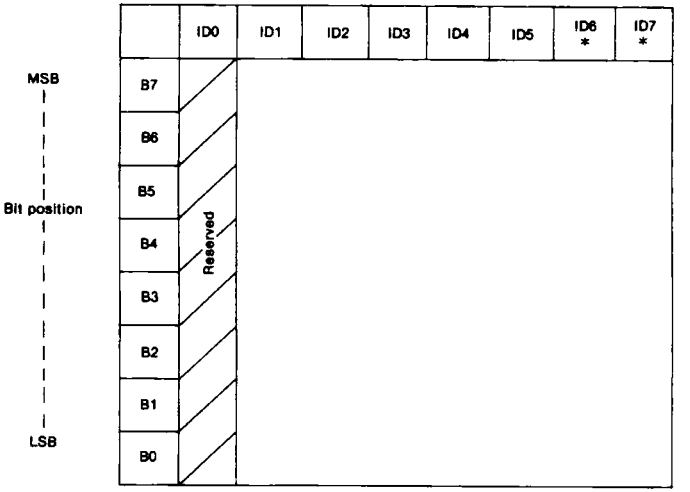
4.2.2 Error correction codes

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 figure 5.



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					

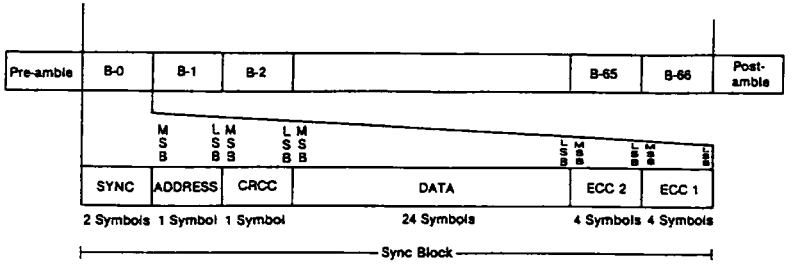
NOTE – Not available in fields 0, 1, 2, 3

Figure 2 – ID data content and reserved region for field address

Block Address →

	SYNC	SYNC	SYNC	SYNC		SYNC	SYNC		SYNC	SYNC
	ADDRESS	ADR0	ADR1	ADR2		ADR33	ADR34		ADR65	ADR66
	CRCC	CRCC	CRCC	CRCC		CRCC	CRCC		CRCC	CRCC
Recording Direction ↓	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 69U		D 130U	D 132U
		D 737U	D 739U	D 741U		ID 4	D 739U		*	ID 2
		D 737L	D 739L	D 741L		ID 5	D 739L		**	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

Figure 3 – PCM signal format



NOTE – 1 symbol = 8 bits.

Figure 4 – PCM signal construction

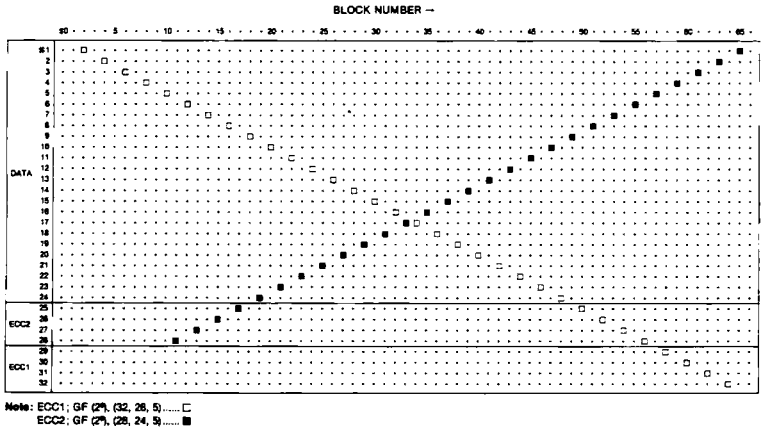


Figure 5 – Error correction format

4.2.3 Channel coding

The channel code shall conform to the 8-14 modulation method. (See figure 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.

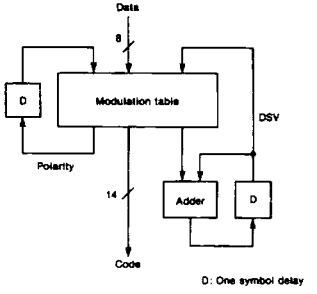


Figure 6 – Block diagram for 8-14 modulation

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 figure 7.

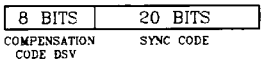


Figure 7 – Sync pattern

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

	Polarity	
DSV	Positive	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 figure 8 due to the Y/C head offset as shown in table 2 of ANSI/SMPTE 249M-1991.

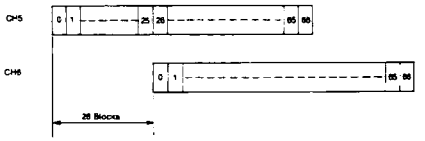
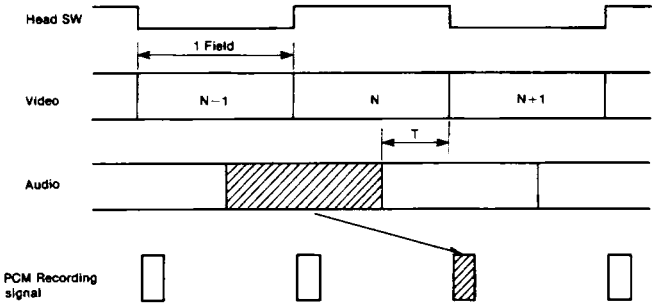


Figure 8 – Physical offset between two audio channels

4.2.6 Recording video and audio timing

The recording timing between video and audio signals shall be as shown in figure 9.



NOTE – T = 3.0 ± 0.2 ms.

Figure 9 – Recording video and audio timing

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	01001001010100	0	01001001010010	0
0E	01001010100100	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	01001001000100	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	00000101001000	−6
6C	10000010001010	2	00010100001010	−6
6D	10001000100010	2	00101000100100	−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	01010000100100	−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	00010001001000	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	10101001010000	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	00001010000100	−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	00100100010100	−2
CD	01001010001010	4	00100101001000	−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	00001000100010	0	00001000100010	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

Annex A (informative)
Bibliography

ANSI/SMPTE 251M-1991, Television Analog Recording — 1/2-in Type M-2 — Electrical Parameters of Video, Audio, Time and Control Code and Tracking Control

SMPTE RP 158-1991, Basic System and Transport Geometry Parameters for 1/2-in Type M-2 Format