SMPTE Journal, March 1992

PROPOSED SMPTE STANDARD

SMPTE 224M

for Television Digital Component Recording — 19-mm Type D-1 — Tape Record

1 Scope

This standard specifies the dimensions and location of the audio, video, and auxiliary data, analog cue track, time code, and control track records for 19-mm type D-1 television digital component recording, operating on the 525/60 television system encoded according to SMPTE 125M.

2 General specifications

2.1 Dimensions are in the metric system.

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

- Temperature 20°C ± 1°C
- Relative humidity (50 ± 2)%
- Barometric pressure 96 kPa ± 10 kPa
- Tape tension 0.80 N ± 0.05 N

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

- Storage conditioning: Not less than 24 hours
- Environmental: Stabilized to the conditions specified in 2.2
- Tape tension: Wound on a reel at a tension of 0.6 N to 1.5 N

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

2.4.1 All dimensions in table 1 and the figures are to be measured from an equivalent reference edge. The tape reference edge is a line through three points on the edge of the tape separated by 115 mm and constrained to lie in one straight line. This constraint may be a physical deformation or an equivalent mathematical transformation. The program area reference point lies on a perpendicular to the reference edge through the center point of the reference edge. (See annex A and figure 2.) All edge measurements are based on an average length of 10 mm.

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3 Tape speed

The tape speed shall be 286.588 mm/s ± 0.2%.

4 Record location and dimensions

4.1 Record location and dimensions shall be as specified in figures 1 and 3 and table 1.

4.2 In recording, including editing, sector locations on each helical track shall be contained within the tolerance specified in table 1 and figure 1.

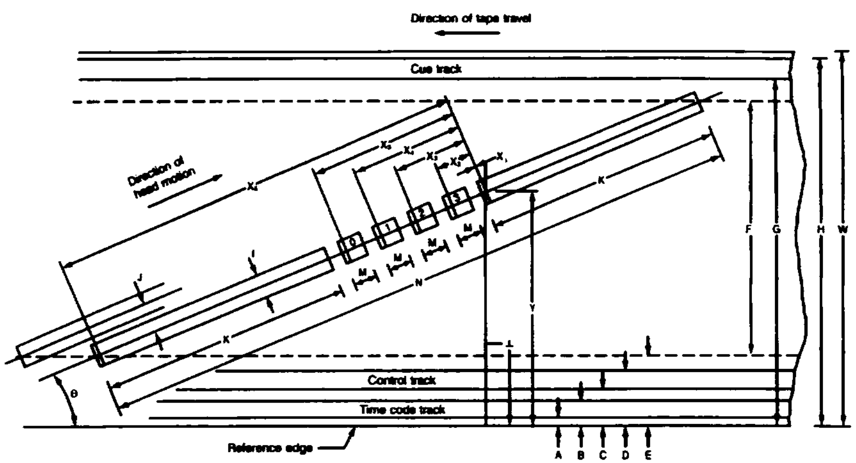
5 Helical track record curvature

5.1 The centerlines of any six consecutive tracks shall be contained within the pattern of the six tolerance zones established in figure 2.

Table 1 – Record location and dimensions for 525/60 standard

		Millimeters	
	Dimensions	Nominal	Tolerance
A	Time code track lower edge	0.2	± 0.1
B	Time code track upper edge	0.7	± 0.1
C	Control track lower edge	1.0	± 0.1
D	Control track upper edge	1.5	± 0.05
E	Program area lower edge	1.8	derived
F	Program area width	16/1.001	derived
G	Audio cue track lower edge	18.1	± 0.15
H	Audio cue track upper edge	18.8	± 0.2
I	Helical track width	0.04	+ 0 − 0.005
J	Program track pitch	0.045	basic
K	Video sector length	77.71	derived
M	Audio sector length	2.55	derived
N	Helical track total length	170/1.001	derived
P	Cue audio/time code (see note 2)	211.9	± 0.5
R	Recording tolerance		± 0.1
T	Control pulse location	0	± 0.1
θ	Track angle	$\sin^{-1}$ (16/170)	basic
W	Tape width	19.01	± 0.015
X_1	Location of start of upper video sector	0	± 0.1
X_2	Location of start of audio sector 3	3.39	± 0.1
X_3	Location of start of audio sector 2	6.79	± 0.1
X_4	Location of start of audio sector 1	10.18	± 0.1
X_5	Location of start of audio sector 0	13.58	± 0.1
X_6	Location of start of lower video sector	92.12	± 0.1
Y	Program area reference	10.49	basic

NOTES
1 Above measurements shall be made under the conditions specified in 2.2.
2 Dimension P is a physical "on tape" dimension, not a transport dimension.



NOTE – X dimensions (X_1–X_6) are determined by the end of preamble location, as defined in SMPTE 227M.

Figure 1 – Location and dimensions of recorded tracks (tape viewed from magnetic coating)

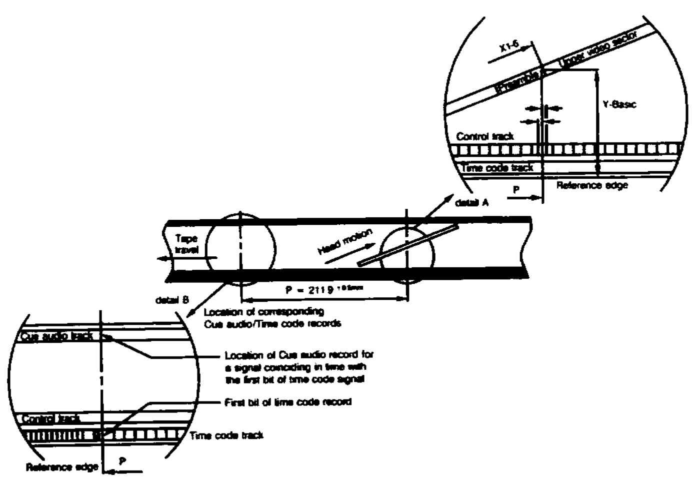
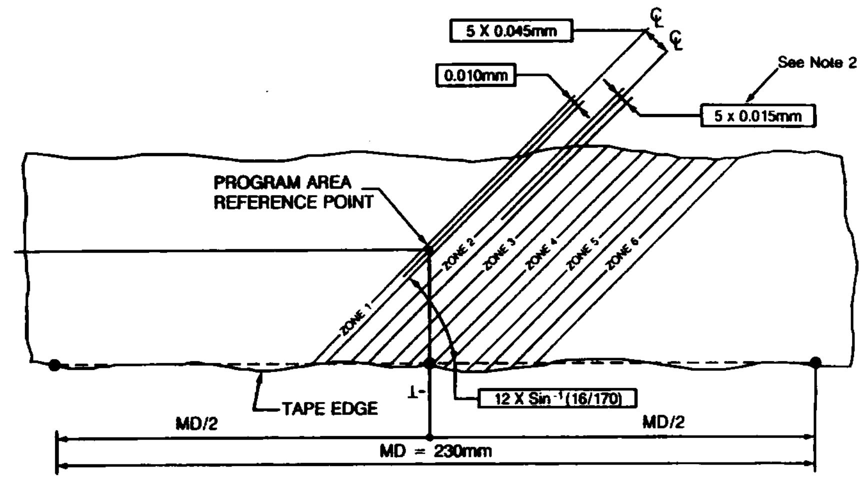


Figure 2 – Location of control track, cue and time code records



NOTES
1 The centerline of any 6 consecutive tracks shall be contained within each zone given.
2 [ ] = Mechanical dimensions repeated 5 times.

Figure 3 – Location and dimensions of tolerance zones of helical track record

5.2 Each zone is defined by two parallel lines which are inclined at an angle of $SIN^{-1}(16/170)$ basic with respect to the tape reference edge.

5.3 The centerlines of all zones shall be spaced 0.045 mm basic apart. The width of the first zone shall be 0.01 mm basic. The width of zones 2 through 6 shall be 0.015 mm basic. These zones are established to contain track angle errors, track straightness errors, and track pitch errors.

6 Relative positions of recorded signals

6.1 Audio, video, auxiliary data, tracking control, time code, and cue track, with information intended to be time coincident, shall be positioned as shown in figures 1 and 3.

6.2 The spatial relationship between the control track record and helical tracks are specified in figures 1 and 3.

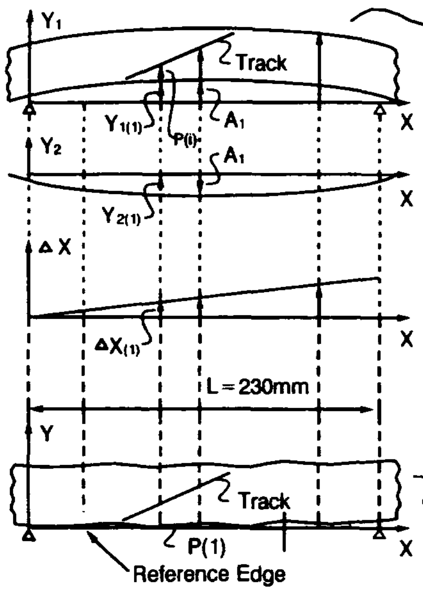
6.3 The program area reference point is defined as a point corresponding to the end of the preamble in the upper video sector. This point is determined by a line parallel to the reference edge of the tape 10.49 mm apart given as Y in the table, intersecting the track centerline as shown in figures 1 and 3. The relationship between sectors and contents of each sector is specified by SMPTE 227M.

7 Gap azimuth

7.1 The azimuth angle of the cue audio, control track, and time code head gaps used to produce longitudinal track records shall be perpendicular to the track record.

7.2 The azimuth angle of the head gaps used for the helical track recording shall be perpendicular to the helical track record within a tolerance of ± 10 minutes.

Annex A (informative)
Tape data



Tape without Tension

Re-Bending-Function

$$Y_2 = \frac{A_1}{2}[2 + A.B.S.(X_2)^3 - 3(X_2)^2]$$

$$X_2 = \frac{2X}{L} - 1$$

Displacement by Tension T

$$\Delta X = \frac{T}{A \cdot E} \cdot X$$

$T = 0.8N$
$A = 19 \cdot 0.016mm^2$
$E = 8000\ N/mm^2$
(Young's Modulus)

Corrected Position of the Tape

$$Y = Y_1 + Y_2$$

$$X_1 = X + \Delta X$$

Figure A.1 – Mathematically processed measured tape data

Annex B (informative)
Bibliography

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

SMPTE 225M, Television Digital Component Recording — 19-mm Type D-1 — Magnetic Tape

SMPTE 226M, Television Digital Component and Composite Recording — 19-mm Type D-1 and D-2 — Tape Cassettes

SMPTE 227M, Television Digital Component Recording — 19-mm Type D-1 — Helical Data and Control Records

SMPTE 228M, Television Digital Component Recording — 19-mm Type D-1 — Time and Control Code and Cue Records

SMPTE EG 10, Tape Transport Geometry Parameters for 19-mm Type D-1 Television Digital Component Recording

SMPTE EG 21, Nomenclature for Television Digital Recording, 19-mm Type D-1 Component and Type D-2 Composite Formats

PROPOSED SMPTE STANDARD

for Television Digital Component Recording — 19-mm Type D-1 — Magnetic Tape

1 Scope

This standard specifies the principal properties of the magnetic tape used for 19-mm type D-1 television digital component recording.

2 Measurement environment

2.1 Dimensions are in the metric system.

2.2 Tests and measurements made on magnetic tape to check the requirements of this standard shall be made under the following atmospheric conditions unless otherwise stated:

- Temperature: 20°C ± 1°C
- Relative humidity: (50 ± 2)%
- Barometric pressure: 90 kPa ± 10 kPa

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

- Storage conditioning: Not less than 24 hours.
- Environmental: Stabilized to the conditions specified in 2.2.
- Tape tension: Wound on a reel at a tension of 0.6 N to 1.5 N.

3 Video tape specifications

3.1 Base

The base material shall be polyester or equivalent.

3.2 Width

The tape width shall be 19.010 mm ± 0.015 mm.

3.2.1 The tape, covered with a glass plate, shall be measured without tension at a minimum of five different positions along the tape using a calibrated microscope or profile projector having an accuracy of at least 2.5 µm. Tape width is defined as the average of the five readings.

3.3 Delta width

Delta width (width fluctuation) shall not exceed 6 µm p-p.

3.3.1 Measurement of delta width shall be over a tape length of 230 mm with a tension of 0.8 N.

3.4 Reference edge straightness

The reference edge straightness maximum deviation is 6 µm p-p.

3.4.1 Edge straightness fluctuation is measured at the edge of a moving tape guided by three guides having contact to the same edge and having a distance of 115 mm from the first to the second guide, and 115 mm from the second to the third guide. Edge measurements are averaged over 10-mm lengths and are made at a point 5 mm from the mid-point between the first and second guide which is 52.5 mm from the first guide.

3.5 Tape thickness

Use of tapes with various thicknesses is permitted within the following values:

- Nominal 16-μm tape shall have a thickness between 13.5 μm and 16 μm.
- Nominal 13-μm tape shall have a thickness between 11 μm and 13 μm.

3.6 Transmissivity

Transmissivity shall be less than 5%, measured over the range of wavelengths 700 nm to 900 nm.

3.7 Offset yield strength

Offset yield strength shall be greater than 15 N.

3.7.1 The force to produce 1% tangential elongation of a 200-mm test sample with a pull rate of 100-mm per minute shall be used to confirm the offset yield strength.

3.7.2 The initial tangential slope is extended and read at 1% elongation.

3.8 Magnetic coating

The magnetic tape used should have a coating of improved metal oxide or equivalent.

3.8.1 The coating coercivity shall be a class 850 oersted (68,000 A/m). For measurement techniques, refer to IEC Publication 735.

3.8.2 The oxide particles shall be longitudinally oriented.

Annex A (informative)
Bibliography

SMPTE 224M, Television Digital Component Recording — 19-mm Type D-1 — Tape Record

SMPTE 226M, Television Digital Component and Composite Recording — 19-mm Type D-1 and D-2 — Tape Cassette

SMPTE 227M, Television Digital Component Recording — 19-mm Type D-1 — Helical Data and Control Records

SMPTE 228M, Television Digital Component Recording — 19-mm Type D-1 — Time and Control Code and Cue Records

SMPTE EG 10, Tape Transport Geometry Parameters for 19-mm Type D-1 Television Digital Component Recording

SMPTE EG 21, Nomenclature for Television Digital Recording, 19-mm Type D-1 Component and Type D-2 Composite Formats

CCIR Recommendation 601, Encoding Parameters of Digital Television for Studios

IEC Publication 735-1982, Measuring Methods for Video Tape Properties

PROPOSED SMPTE STANDARD

for Television Digital Component and Composite Recording — 19-mm Type D-1 and D-2 — Tape Cassettes

1 Scope

This standard specifies dimensions for three sizes of cassettes (S, M, and L) for use with 19-mm type D-1 and D-2 television digital component and composite recorders.

2 Measurements

2.1 Dimensions are in the metric system.

2.2 Tests and measurements on cassette parameters shall be made under the following atmospheric conditions:

- Temperature 20° C ± 1°C
- Relative humidity (50 ± 2)%
- Stabilization time 24 hours

2.3 Dimensions shall be as specified in the figures and tables.

2.4 General tolerances for dimensions, except those for which tolerances are otherwise specified, shall be as follows:

Over	To	mm
0	4	± 0.2
4	16	± 0.3
16	63	± 0.4
63	250	± 0.5
250		± 0.7

3 General specifications

3.1 The three sizes of cassettes shall be defined as:

- S: Small
- M: Medium
- L: Large

3.2 Nominal usable playing time in minutes for a fully loaded cassette shall be as specified in table 1.

3.3 The magnetic coating on the tape shall face out of the cassette as specified in figures 1 to 3.

Table 1 – Nominal usable playing time

Cassette size	Tape thickness 16 µm D-1	13 µm D-1	13 µm D-2
S	11 min	13 min	31 min
M	34 min	41 min	93 min
L	76 min	94 min	207 min

3.4 Transmissivity of the cassette perpendicular to datum plane Z shall be less than 5%, measured over the range of wavelengths 700 nm to 900 nm.

4 Datum planes

4.1 Datum plane Z is determined by datum areas A, B, and C as specified in figures 4 to 6.

4.1.1 Datum C need not correspond to a fastener.

4.2 Datum plane X shall be orthogonal to datum plane Z and shall run through the center of datum hole (a) and datum hole (b) as specified in figures 7 to 9.

4.3 Datum plane Y shall be orthogonal to both datum plane X and datum plane Z and shall run through the center of datum hole (a) as specified in figures 7 to 9.

5 Window and labels

5.1 Window and label areas shall be as specified in figures 10 to 12.

5.2 Labels attached to the cassette shall not extend beyond the external dimensions as shown in figures 10 to 12.

5.2.1 Labels shall not interfere with users' or manufacturers' identification holes.

5.2.2 Labels shall not interfere with the hub drive and support mechanism.

6 Identification holes

6.1 There shall be two sets of identification holes; one for the use of the manufacturer, and the other for the user.

6.1.1 Figures 13 to 15 detail the location of users' and manufacturer's holes. Manufacturer's holes shall be used in combination to indicate tape thickness according to the following logic table:

Hole number:	1	2		
	0	0	=	16 µm tape
	0	1	=	13 µm tape
	1	0	=	Undefined/reserved
	1	1	=	Undefined/reserved

6.1.2 Holes 3 and 4 shall be used to indicate the coercivity of the recording surface.

Hole number:	3	4		(See note.)
	0	0	=	Class 850
	0	1	=	Class 1500
	1	0	=	Undefined/reserved
	1	1	=	Undefined/reserved

NOTE - Presently, only class 850 oersted tape is used in D-1 format recorders. Only class 1500 oersted tape is used in D-2 format recorders.

6.1.3 A "0" in the above tables indicates that the recorder/player sensor mechanism has detected that the indicator tab has been removed and the hole is open.

6.2 The dimensions and location of the users' holes are specified in figures 13 to 15. Their use shall be defined as follows:

6.2.1 When a "0" state exists, the users' holes shall identify the following conditions:

Hole number 1: Total record lock out (audio/video/cue/time code/control track)
Hole number 2: Reserved and undefined
Hole number 3: Video and control track record lock out
Hole number 4: Reserved and undefined

6.2.2 The user plug mechanism shall withstand an axial force of 0.5 N.

7 Leader/trailer tape

7.1 The cassette shall include leader and trailer tape. When attached to the hub, there shall be a length of 300 mm ± 30 mm between the splice point and the outside of the shell.

7.2 The leader/trailer tape material shall be polyester or equivalent having a transmissivity of at least 60% when measured with a 700 nm to 900 nm light source.

7.3 When attached to the hub, the leader/trailer tape shall not separate when subjected to a force of 22 N or less.

7.4 The width of the leader/trailer tape shall be 19.000 mm ± 0.025 mm.

7.5 The thickness of the leader/trailer tape shall be 20 µm ± 10 µm.

7.6 The splicing tape used to attach the leader tape shall be applied to the nonmagnetic coated side.

8 Reels

8.1 The dimensions of the reels and the relationship between the reels and reel tables are specified in figures 16 and 17.

8.2 The reels shall be locked automatically when the cassette is removed from the recorder/player.

8.3 When an S cassette is inserted into a recorder/player, the reels shall be unlocked automatically as specified in figure 18.

8.3.1 The force needed to release the reel lock of the S cassette shall be 0.5 N ± 0.1 N.

8.4 When an M or L cassette is inserted into a recorder/player, the reel shall be unlocked automatically by opening the lid as specified in figures 19 and 20.

8.5 The reel shall be held in position by a reel spring with a force as shown in table 2, when the height of the reel table support is 2.0 mm ± 0.2 mm from datum plane Z.

9 Lid

9.1 The lid shall be unlocked and opened by the recorder/player when the cassette is inserted.

9.1.1 The lid shall be unlocked by a 0.5 N ± 0.1 N force being exerted upon the release pin, as specified in figures 21 and 22.

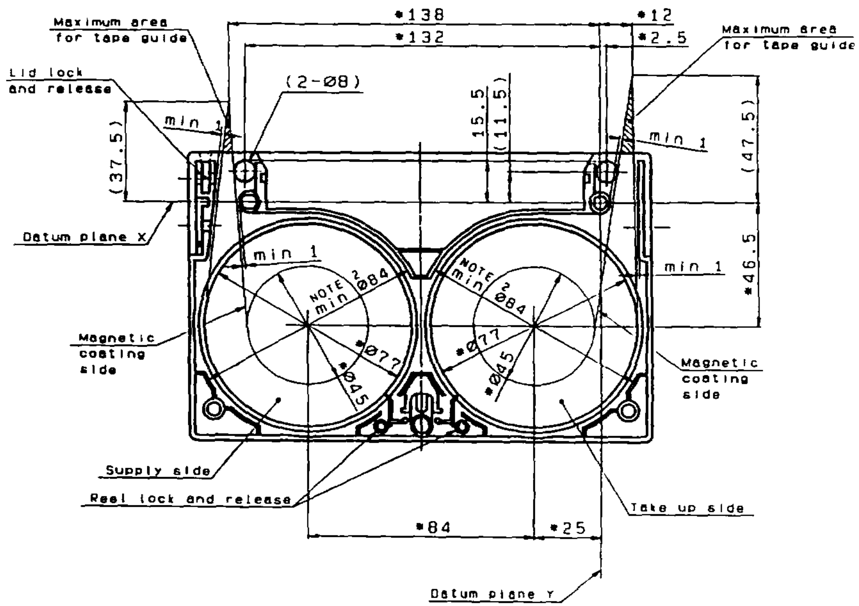
9.1.2 The inner door shall be lifted by the recorder/player to the position shown in figure 23.

9.2 The outer door when open shall not exceed 51 mm with respect to datum plane Z, as specified in figure 23.

9.3 When the cassette is removed from the recorder/player, the lid shall lock automatically.

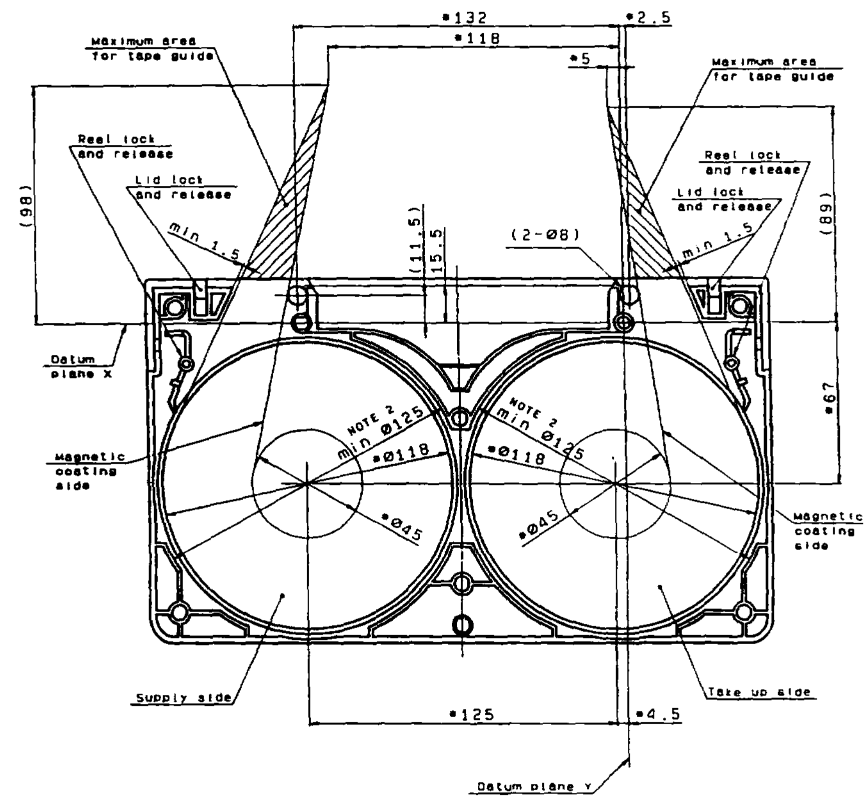
9.4 The maximum force to open the lid shall be 1.5 N at the minimum height defined in figure 23.

9.5 The force required to open the lid shall be applied 90° ± 5° to datum plane Z.



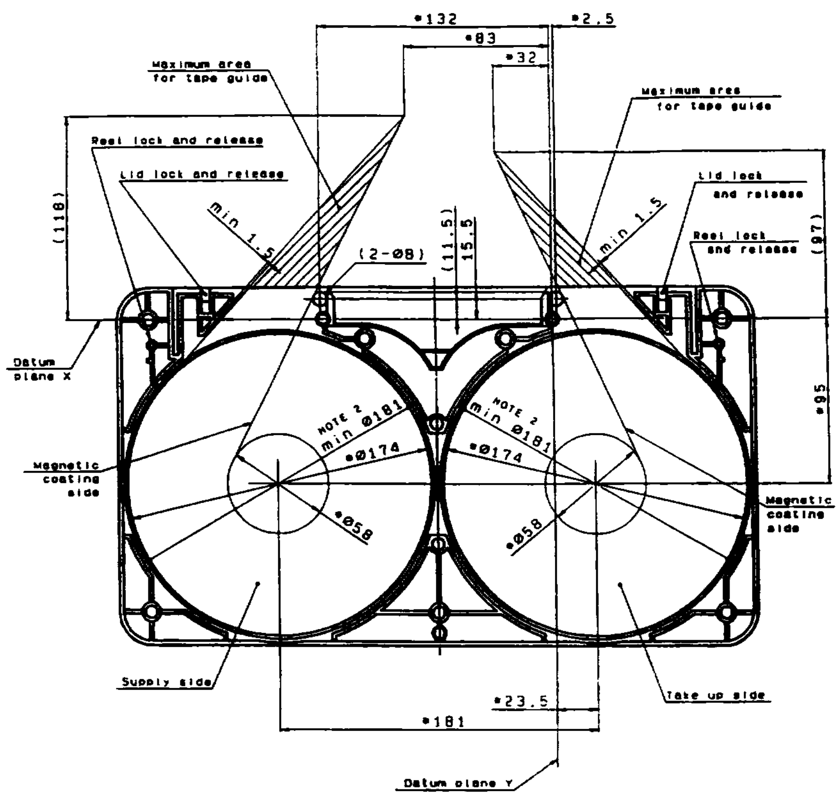
NOTES
1 Dimensions marked with an asterisk are nominal values specifying the tape path.
2 Area for the reel.

Figure 1 – Internal structure and tape path of S cassette – top view (for reference only)



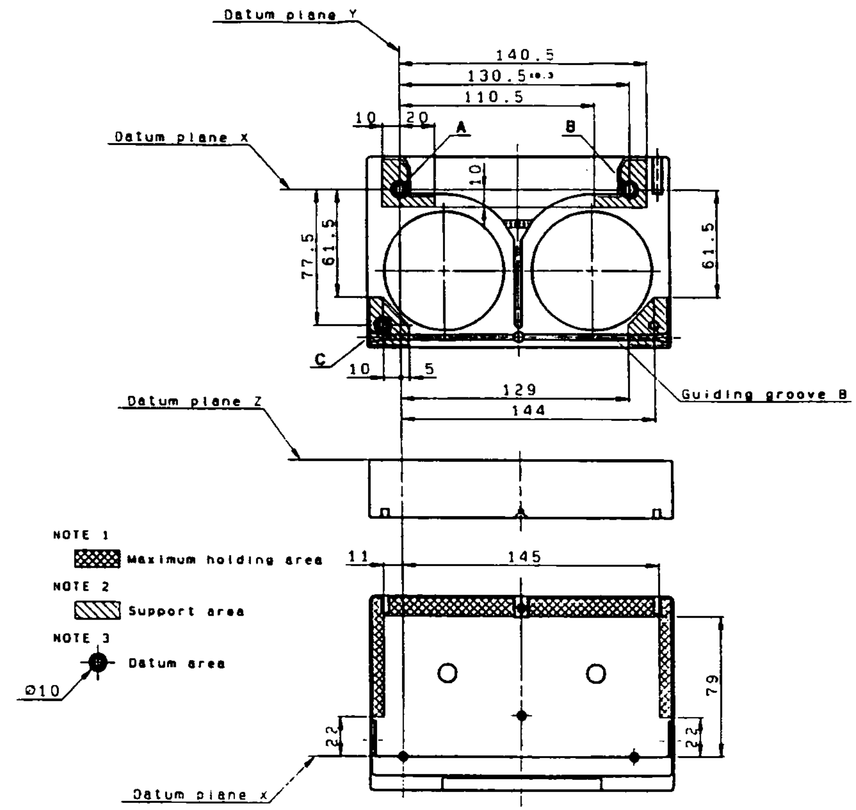
NOTES
1 Dimensions marked with an asterisk are nominal values specifying the tape path.
2 Area for the reel.

Figure 2 – Internal structure and tape path of M cassette – top view (for reference only)



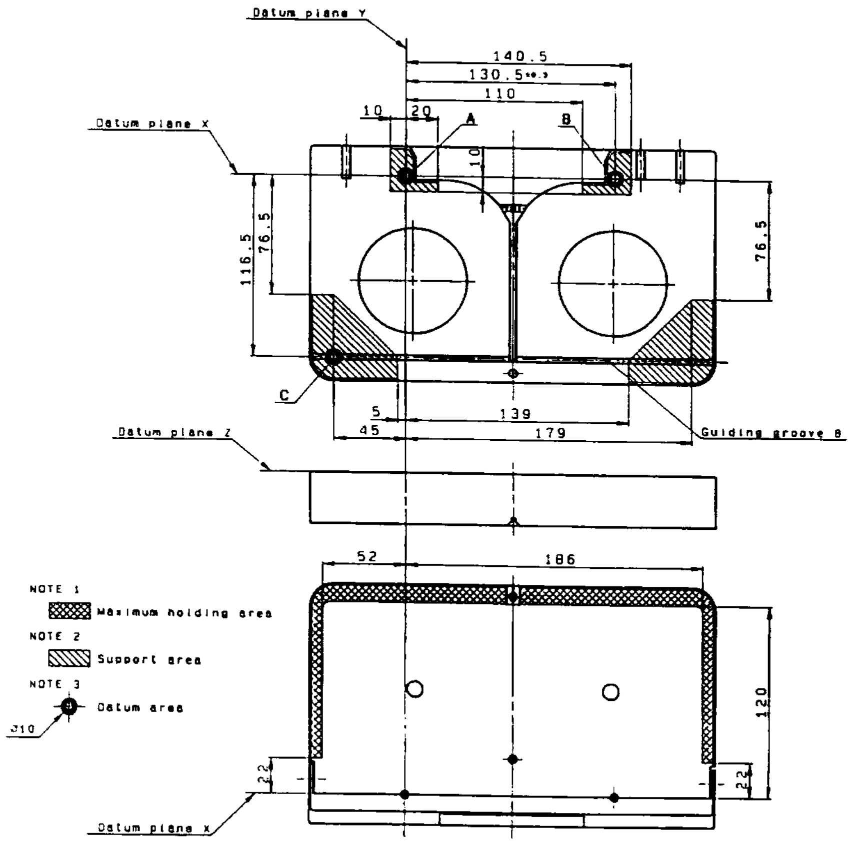
NOTES
1 Dimensions marked with an asterisk are nominal values specifying the tape path.
2 Area for the reel.

Figure 3 – Internal structure and tape path for L cassette – top view (for reference only)



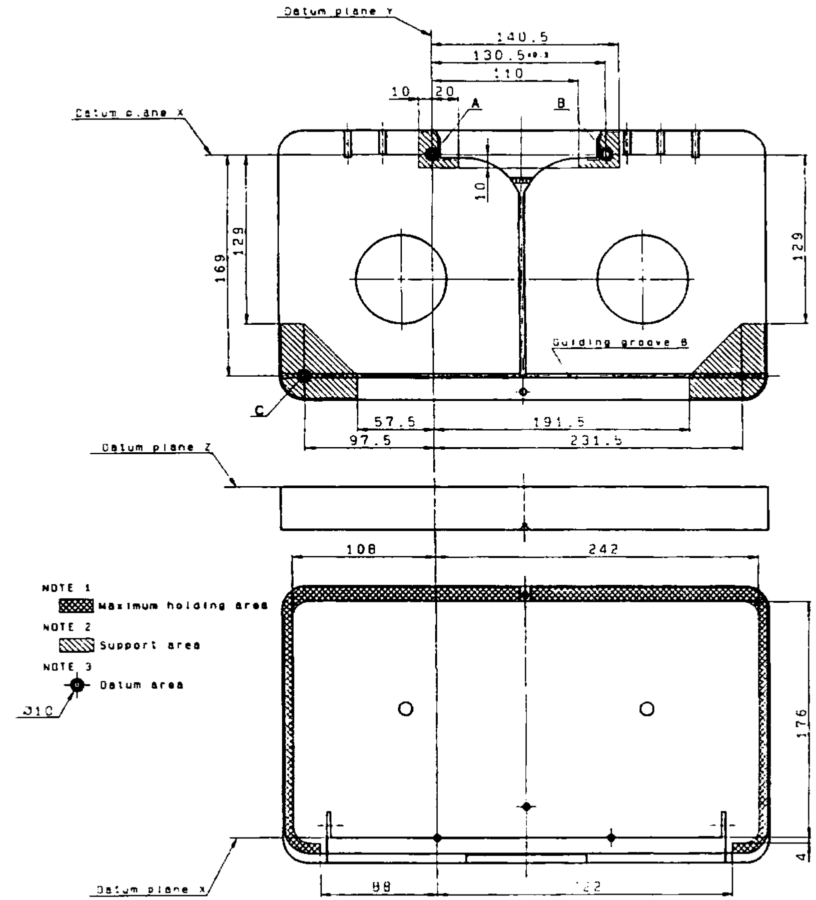
NOTES
1 The cassette shall be secured by the recorder and/or player unit on the dotted area.
2 The periphery within 1.0 mm from the edge of guiding groove B and from the edge of the cassette shall be removed from the support area. The cassette shall be supported by the hatched area.
3 Datum plane Z shall be determined by datum areas A, B, and C.

Figure 4 – Datum area, support area and holding area of S cassette



NOTES
1 The cassette shall be secured by the recorder and/or player unit on the dotted line.
2 The periphery within 1.0 mm from the edge of guiding groove B and from the edge of the cassette shall be removed from the support area. The cassette shall be supported by the recorder and/or player unit on the hatched area.
3 Datum plane Z shall be determined by datum areas A, B, and C.

Figure 5 – Datum area, support area and holding area of M cassette



NOTES
1 The cassette shall be secured by the recorder and/or player unit on the dotted line.
2 The periphery within 1.0 mm from edge of guiding groove B and from the edge of the cassette shall be removed from the support area. The cassette shall be supported by the recorder and/or player unit on the hatched area.
3 Datum plane Z shall be determined by datum areas A, B, and C.

Figure 6 – Datum area, support area and holding area of L cassette

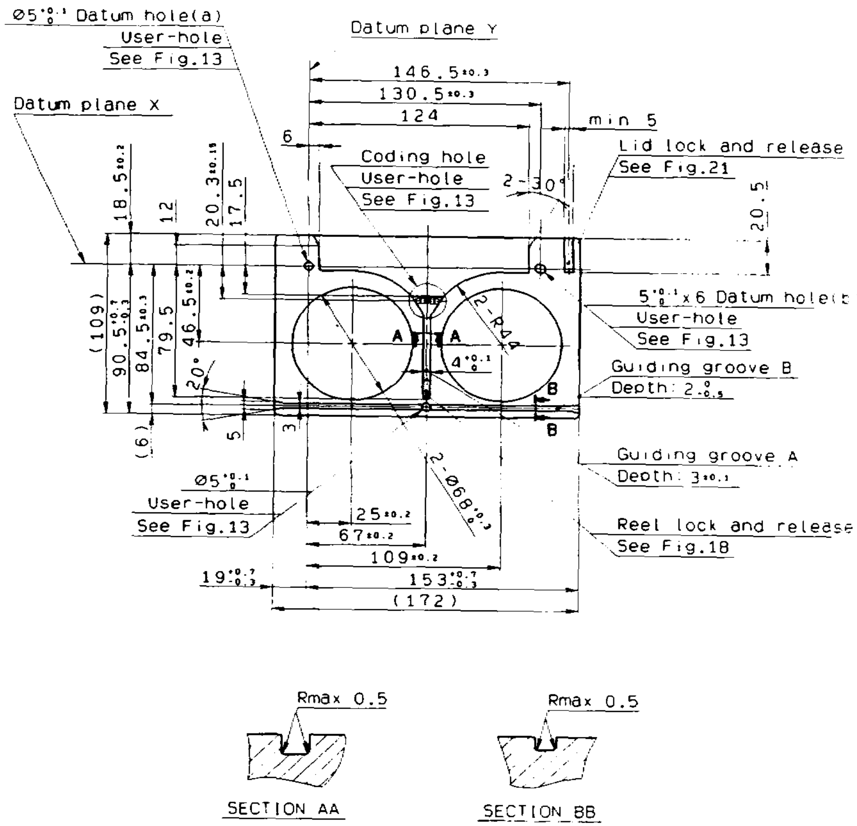


Figure 7 – Bottom view of S cassette

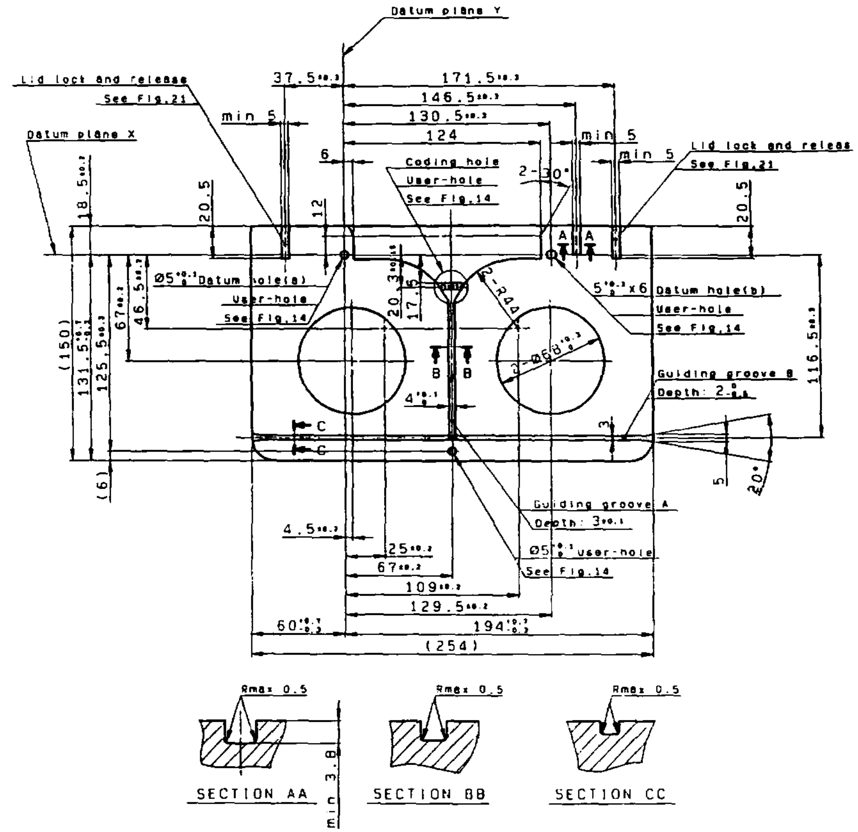


Figure 8 – Bottom view of M cassette

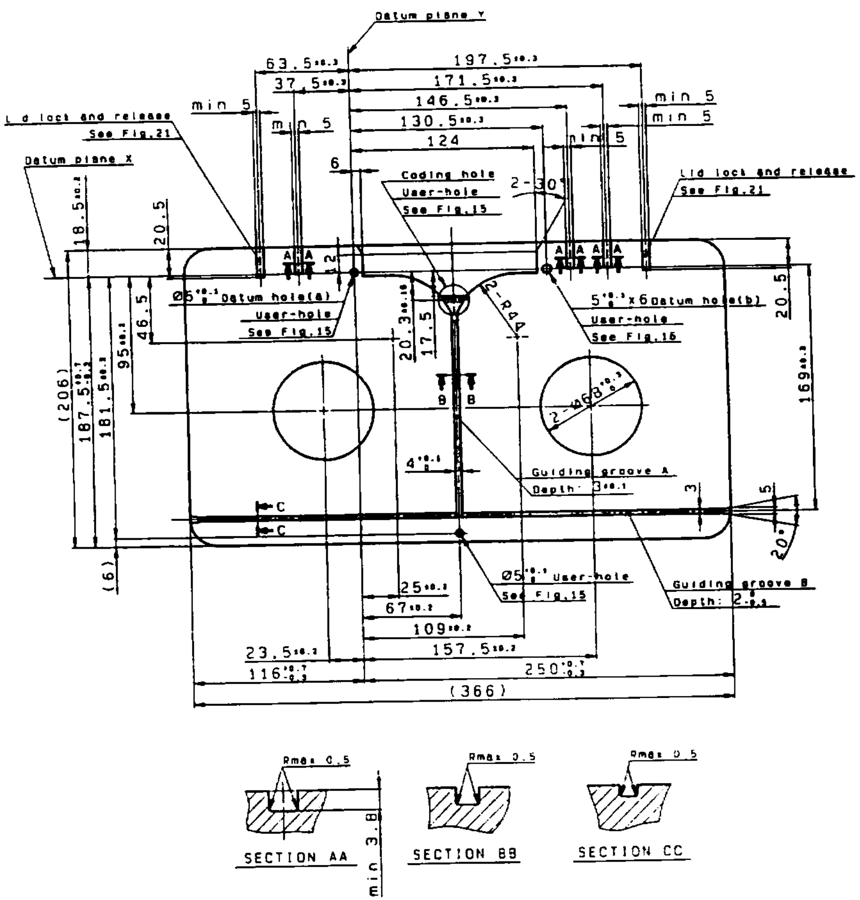
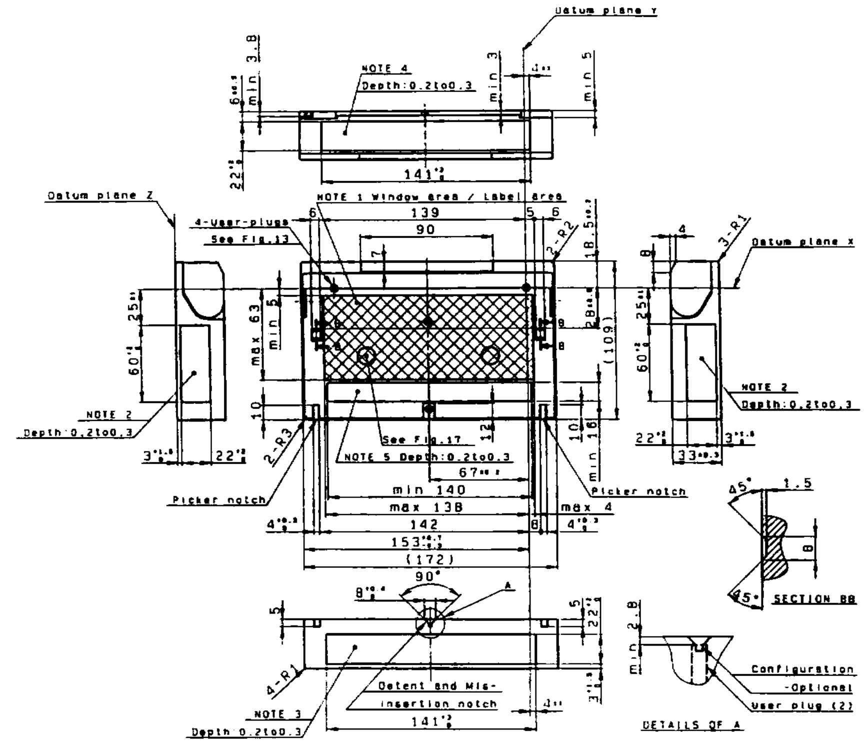


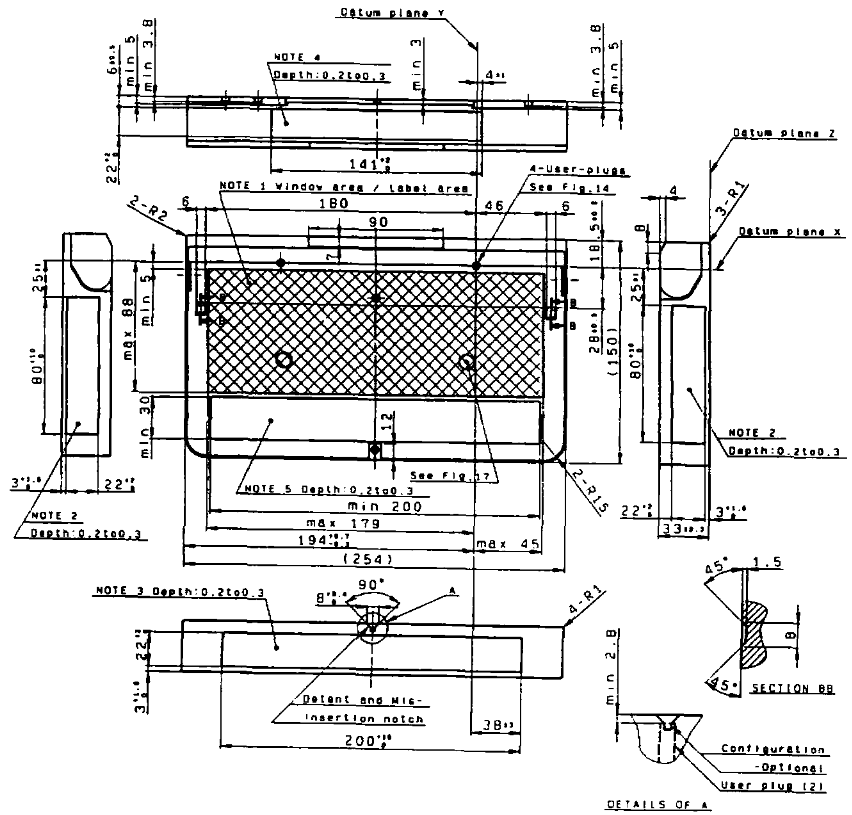
Figure 9 – Bottom view of L cassette



NOTES

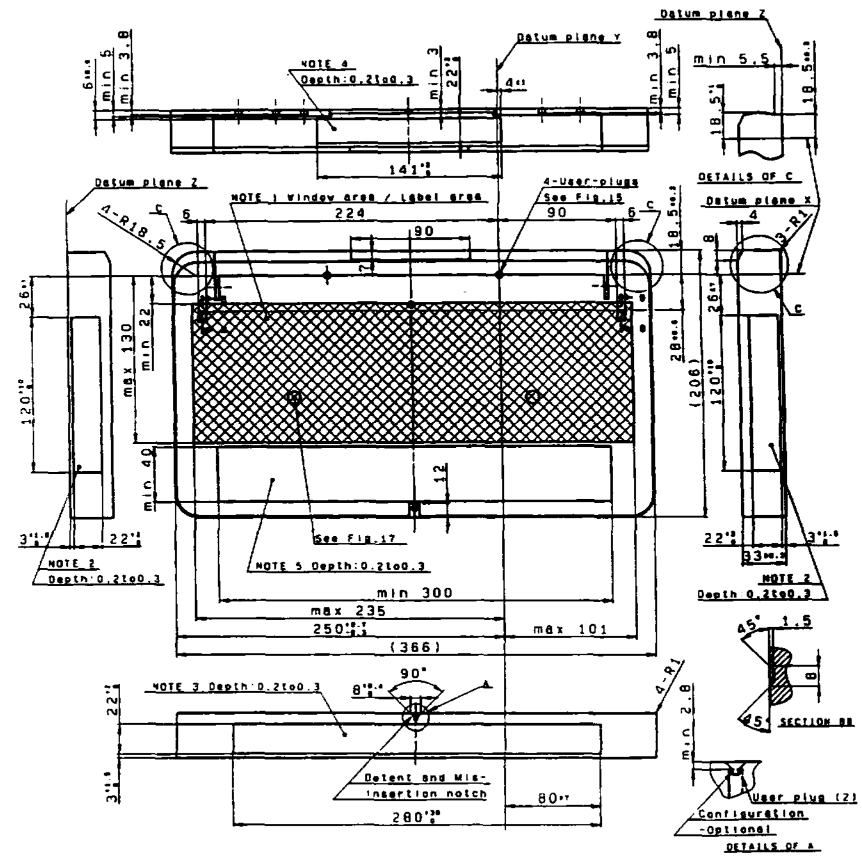
1 The crosshatched area is available for the window/labels.
2 Side label may be attached to this recessed area.
3 Rear label may be attached to this recessed area.
4 Lid label may be attached to this recessed area.
5 Top label may be attached to this recessed area.

Figure 10 – Top and side view of S cassette



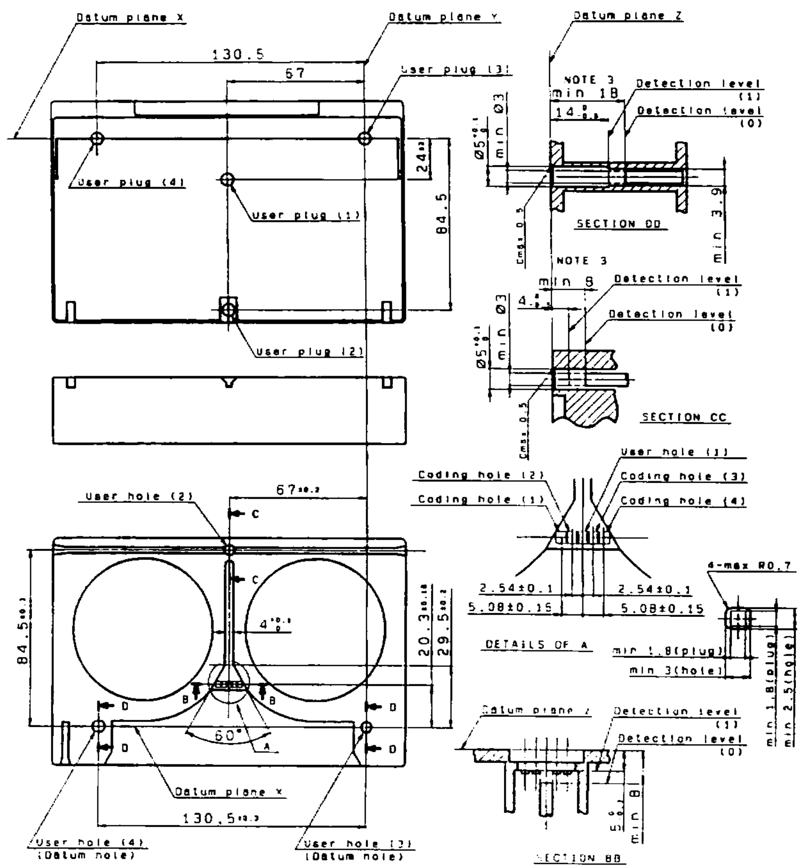
NOTES
1 The crosshatched area is available for the window/labels.
2 Side label may be attached to this recessed area.
3 Rear label may be attached to this recessed area.
4 Lid label may be attached to this recessed area.
5 Top label may be attached to this recessed area.

Figure 11 – Top and side view of M cassette



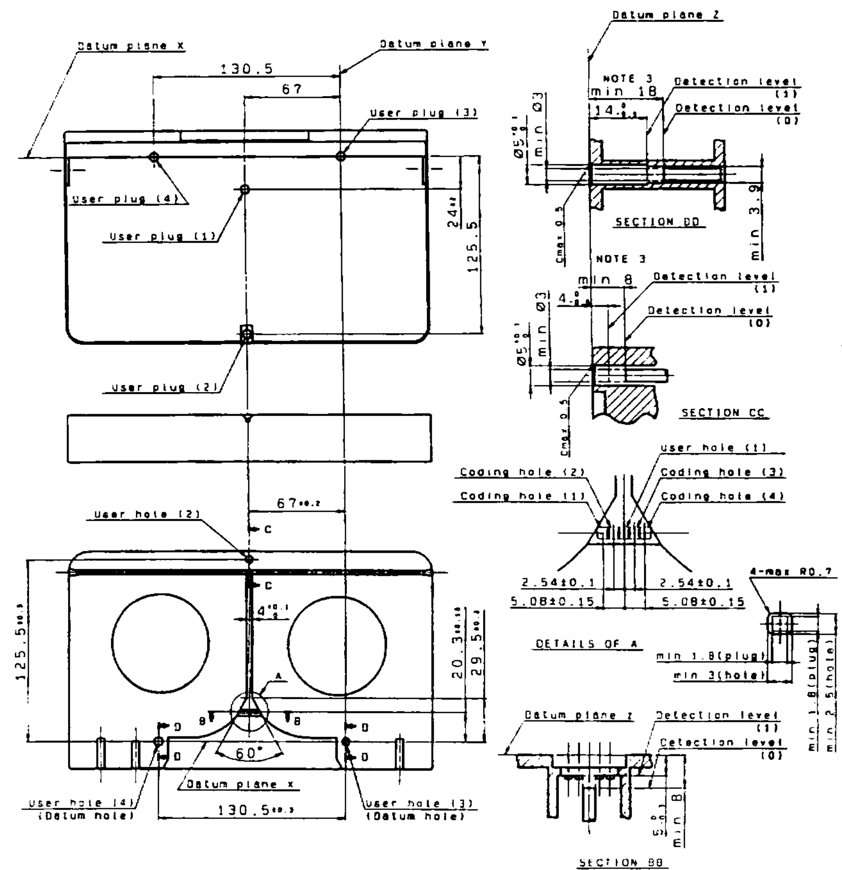
NOTES
1 The crosshatched area is available for window/labels.
2 Side label may be attached to this recessed area.
3 Rear label may be attached to this recessed area.
4 Lid label may be attached to this recessed area.
5 Top label may be attached to this recessed area.

Figure 12 – Top and side view of L cassette



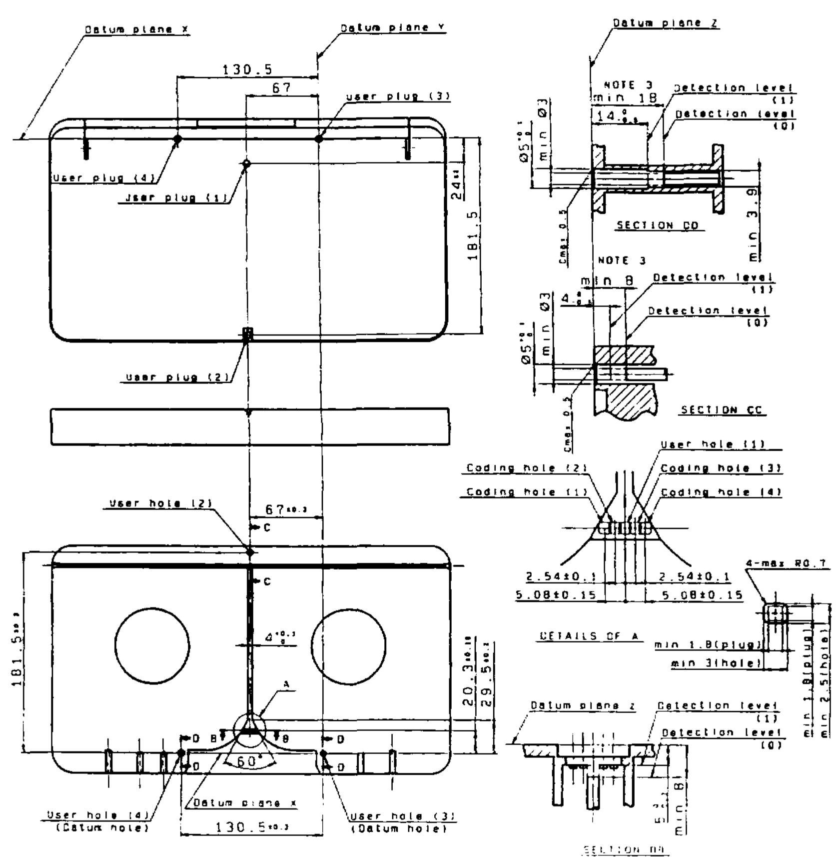
NOTES
1 The cassette shall be provided with four coding holes (1) to (4) and four user holes (1) to (4). When any plug is removed, the opening shall be as shown in detail A. The user plug (1) shall be green.
2 User holes (3) and (4) on the upper shell shall be opened when user plugs are removed.
3 All cassettes shall be provided with holes as defined by sections DD and CC.
4 See annex A.

Figure 13 – S cassette coding holes and user holes



NOTES
1 The cassette shall be provided with four coding holes (1) to (4) and four user holes (1) to (4). When any plug is removed, the opening shall be as shown in detail A. The user plug (1) shall be green.
2 User holes (3) and (4) on the upper shell shall be opened when user plugs are removed.
3 All cassettes shall be provided with holes as defined by sections DD and CC.
4 See annex A.

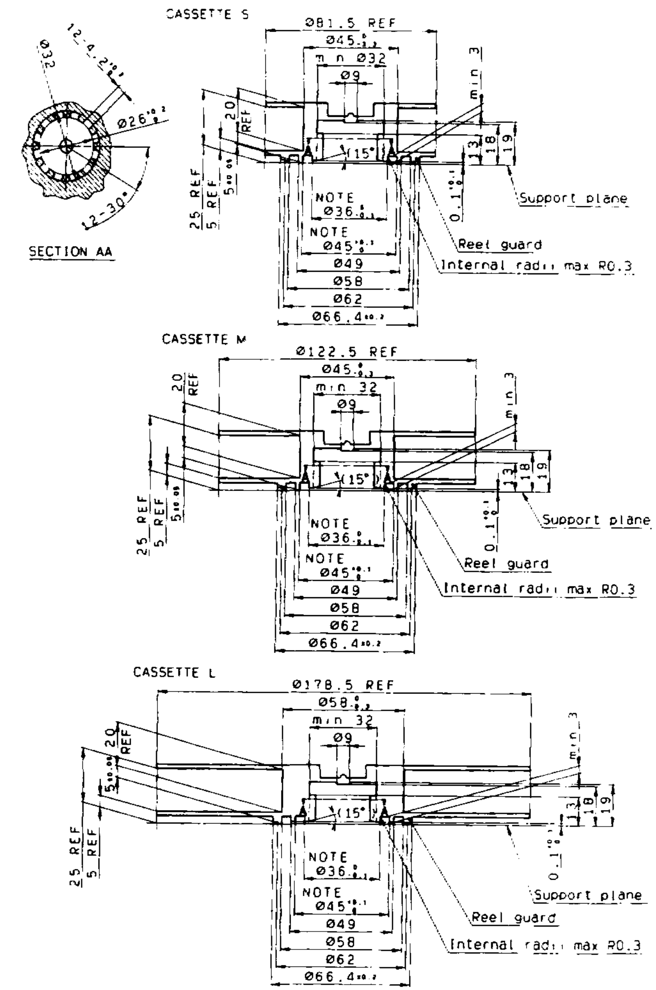
Figure 14 – M cassette coding holes and user holes



NOTES

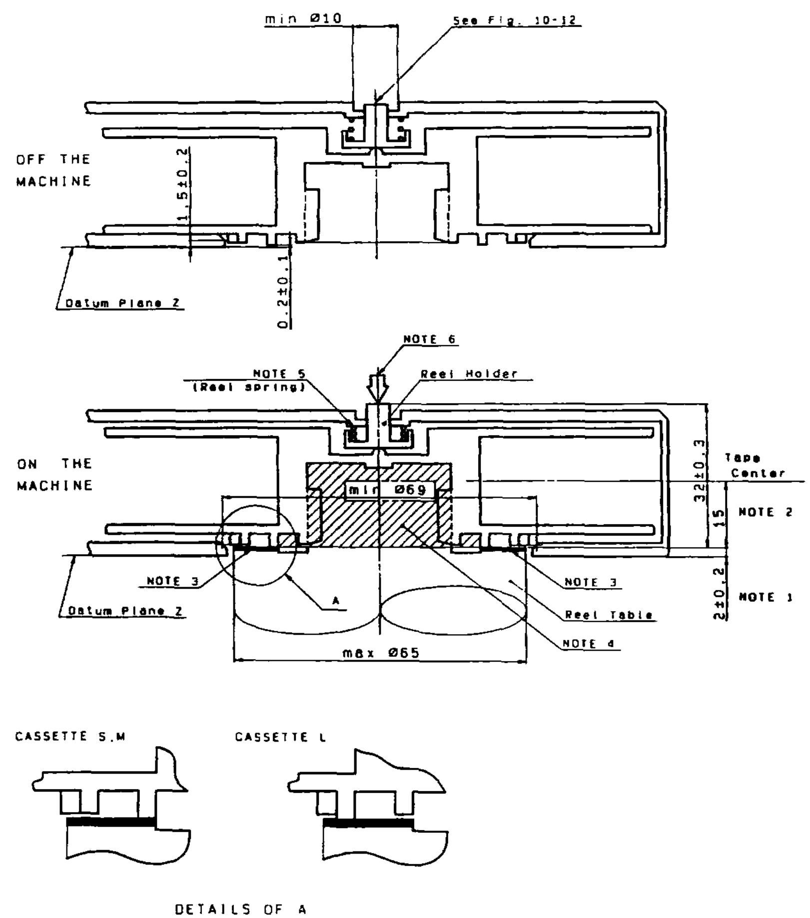
1 The cassette shall be provided with four coding holes (1) to (4) and four user holes (1) to (4). When any plug is removed, the opening shall be as shown in detail A. The user plug (1) shall be green.
2 User holes (3) and (4) on the upper shell shall be opened when user plugs are removed.
3 All cassettes shall be provided with holes as defined by sections DD and CC.
4 See annex A.

Figure 15 – L cassette coding holes and user holes



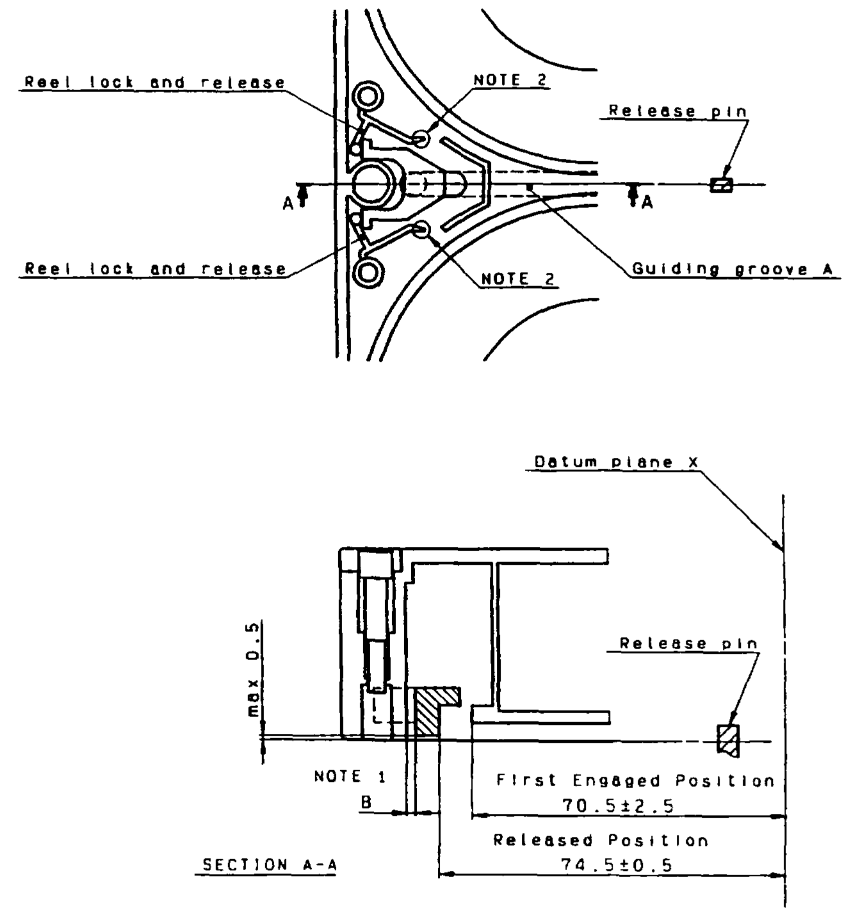
NOTE – The center of the reel and the reel table shall be positioned on either the 36.0 mm + 0 mm – 0.1 mm or the 45.0 mm + 0.1 mm – 0 mm diameter.

Figure 16 – Video cassette reel



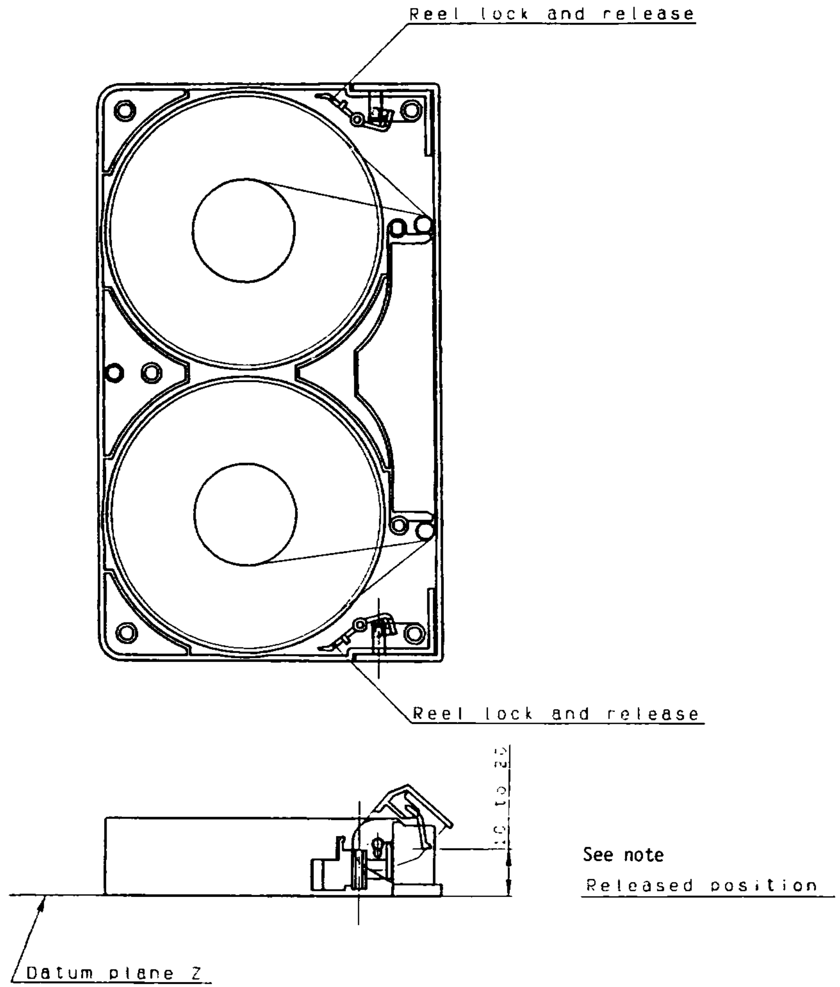
NOTES
1 Distance between the support area of the reel table and datum plane Z.
2 Distance between the support area of the reel table and tape center.
3 Support area of the reel table.
4 Hatched area shows the maximum reel table area.
5 Reel spring pressure shall meet the specifications shown in 8.5.
6 If necessary, more reel spring pressure shall be applied to this portion from the outside.
7 The reel spring structure is at manufacturer's option.

Figure 17 – Relationship between reel and reel table



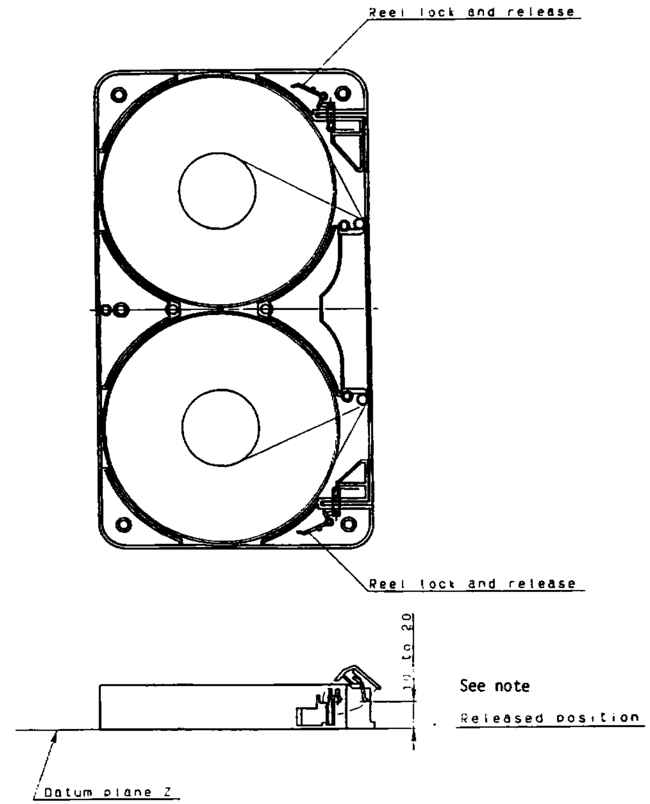
NOTES
1 Clearance B shall be 0.5 mm at a mimimun when the release pin is located 75 mm away from datum plane X.
2 The end of the reel lock shall be outside the reel area 84 mm min in diameter, when the release pin is located 74 mm away from datum plane X.

Figure 18 – S cassette reel lock and release



NOTE – The reel lock shall release when the lid is opened 15 mm ± 5 mm above datum plane Z.

Figure 19 – M cassette reel lock and release

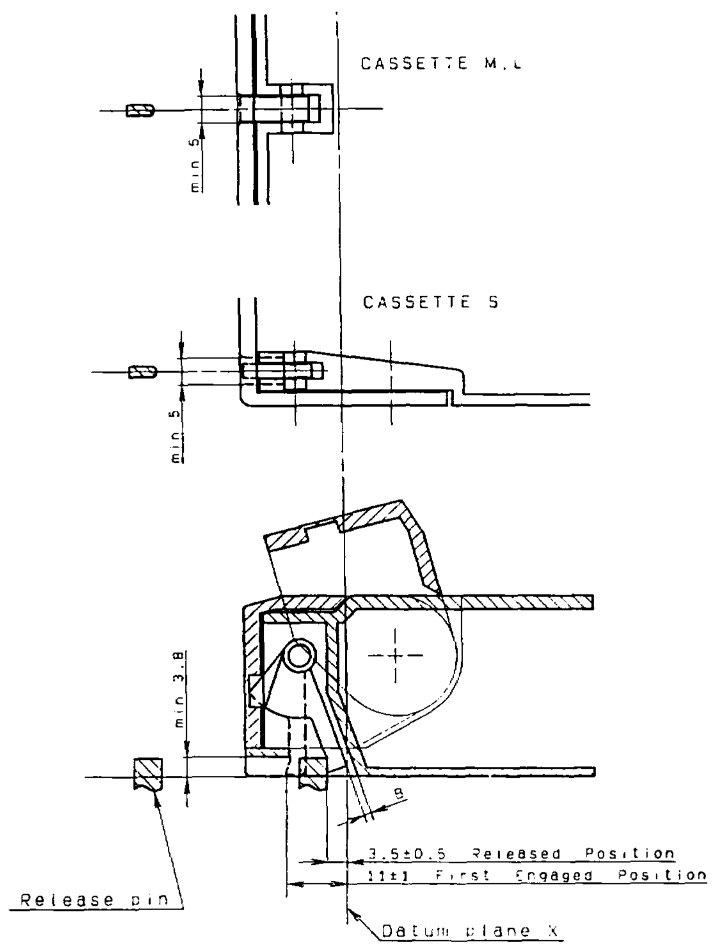


NOTE – The reel lock shall release when the lid is opened 15 mm ± 5 mm above datum plane Z.

Figure 20 – L cassette reel lock and release

Table 2 – Reel spring force

Cassette size	Force
S	3 – 4 N
M	9 – 11 N
L	9 – 11 N



NOTES
1 Clearance B shall be 0.5 mm at a minimum when the release pin is located 3 mm away from datum plane X.
2 The lid lock shall be released when the release pin is located 4 mm away from datum plane X.

Figure 21 – Lid lock and release

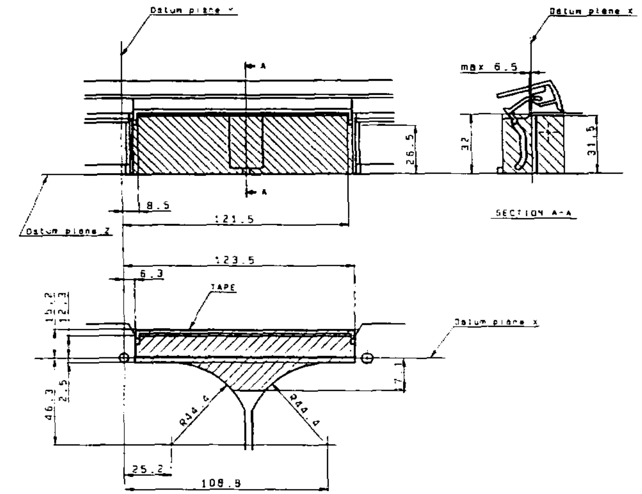
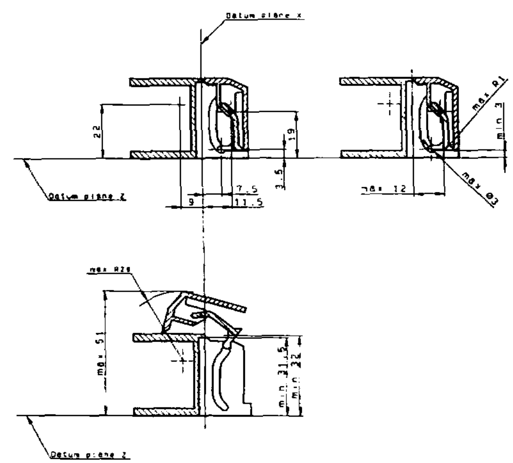


Figure 22 – Minimum space for VTR loading mechanism



NOTES
1 Lid shall open to a height of at least 32 mm.
2 Mechanical implementation is for reference only.

Figure 23 – Lid structure

Annex A (informative)
Cassette tabs

Cassettes manufactured prior to the approval of this standard may have manufacturer's tabs with different dimensions. Specifically, the manufacturer's tabs may have less than the dimension and tolerance now specified.

Annex B (informative)
Bibliography

SMPTE 224M, Television Digital Component Recording — 19-mm Type D-1 — Tape Record

SMPTE 225M, Television Digital Component Recording — 19-mm Type D-1 — Magnetic Tape

SMPTE 227M, Television Digital Component Recording — 19-mm Type D-1 — Helical Data and Control Records

SMPTE 228M, Television Digital Component Recording — 19-mm Type D-1 — Time and Control Code and Cue Records

SMPTE 245M, Television Digital Recording — 19-mm Type D-2 Composite Format — Tape Record

SMPTE 246M, Television Digital Recording — 19-mm Type D-2 Composite Format — Magnetic Tape

SMPTE 247M, Television Digital Recording — 19-mm Type D-2 Composite Format — Helical Data and Control Records

SMPTE 248M, Television Digital Recording — 19-mm Type D-2 Composite Format — Cue Record and Time and Control Code Record

SMPTE RP 156-1990, Bar Code Labeling for Type D-1 Component and Type D-2 Composite Cassette Identification

SMPTE EG 10, Tape Transport Geometry Parameters for 19-mm Type D-1 Television Digital Component Recording

SMPTE EG 20, Tape Transport and Geometry Parameters for 19-mm Type D-2 Composite Format for Television Digital Recording

SMPTE EG 21, Nomenclature for Television Digital Recording, 19-mm Type D-1 Component and Type D-2 Composite Formats

SMPTE EG 22, Description and Index of Documents for 19-mm Type D-2 Composite Television Digital Recording

PROPOSED SMPTE STANDARD

for Television Digital Component Recording — 19-mm Type D-1 — Helical Data and Control Records

1 Scope

This standard specifies the content, format, and recording method of the data blocks forming the helical records on the tape containing video, audio, and associated data in 19-mm type D-1 television digital component recording. In addition, clause 6 of this document specifies the content, format, and recording method of the longitudinal record containing tracking information for the scanning head associated with the helical records. Track dimensions and locations are specified in SMPTE 224M.

The standard applies to recorders operating in the 525-line television system with a frame frequency of 29.97 Hz nominal and in accord with CCIR Recommendation 601. One video channel and four independent audio channels are recorded. Audio channels operate in accord with ANSI S4.40-1985 at a 48-kHz sampling frequency.

Figure 1 shows a block diagram of the processes involved in the recorder.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. 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 editions of the standards indicated below.

ANSI S4.40-1985, Digital Audio Engineering — Serial Transmission Format for Linearly Represented Digital Audio Data

SMPTE 224M, Television Digital Component Recording — 19-mm Type D-1 — Tape Record

CCIR Recommendation 601, Encoding Parameters of Digital Television for Studios

3 Helical record content, format, synchronization, and recording method

3.1 Introduction

The helical track defined mechanically in SMPTE 224M is recorded with the digital data from the video channel and the four audio channels. Data is arranged in six sectors per track as shown in figure 2. Two sectors are employed for video data and four sectors each containing data from one of the four audio channels. Details of sector assignment are shown in clauses 4 and 5 of this document. Each sector is divided into the following elements:

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

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

- Postamble containing channel sync pattern and an identification pattern.

Details of the elements are shown in figure 3. The space between sectors may be unrecorded or filled with the clock run-up sequence $(CC)_H$. This space is used to accommodate sector timing errors and to allow editing.

A portion of the guard-space at the beginning of the track may contain run-up sequence data pattern $(CC)_H$ of a length up to 100 bytes.

3.2 Labelling convention for audio and video data

3.2.1 Least significant bit is written on left and is the first recorded to tape.

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

3.2.3 Byte values are expressed in hexidecimal notation unless otherwise noted.

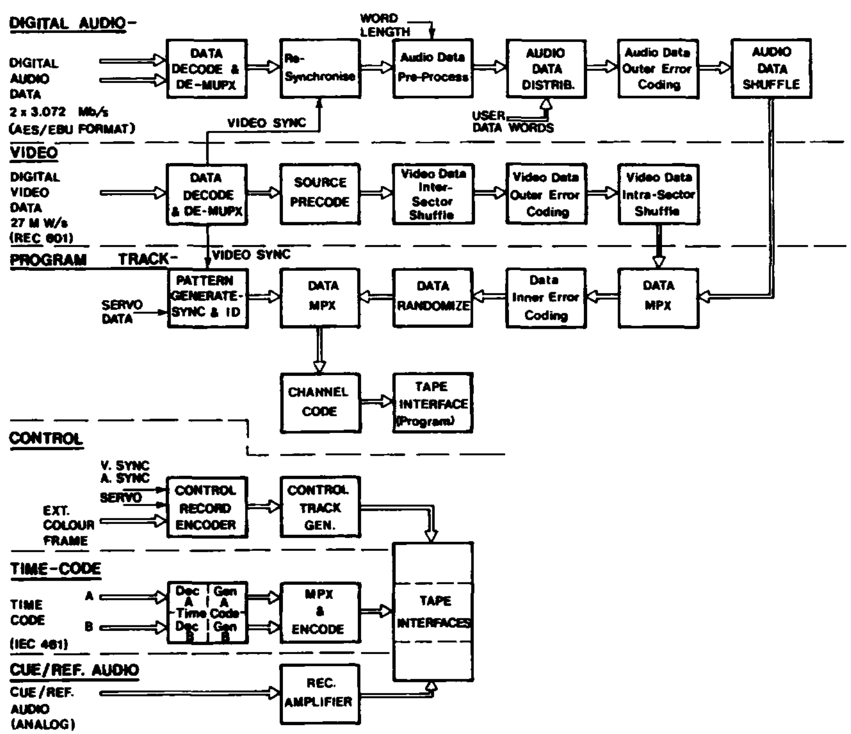


Figure 1 - Digital recorder-record path processing

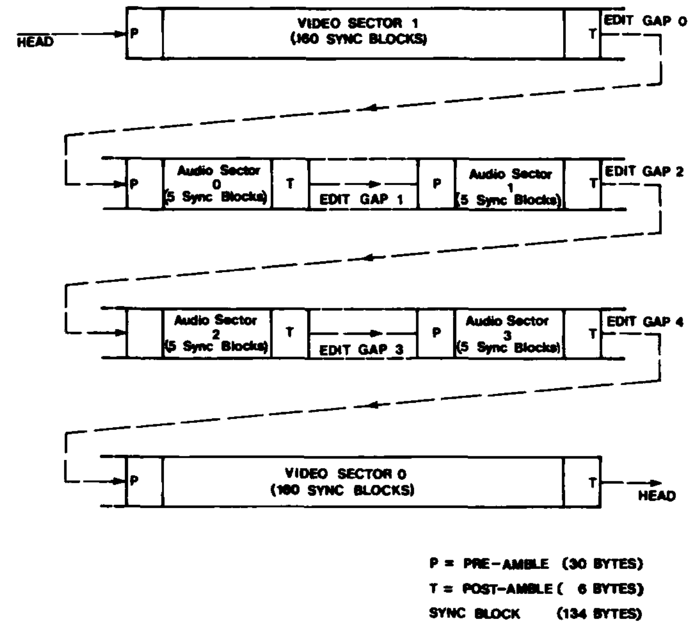


Figure 2 – Sector arrangement on helical track

Table 1 – Helical track sector length

Sector Name	Length mm	Size	
		S. blocks	Bytes
V1	77.71	160	21476
A0	2.55	5	706
A1	2.55	5	706
A2	2.55	5	706
A3	2.55	5	706
V0	77.71	160	21476
Edit gap 0–4	5 x 0.84	—	5 x 232
Total	169.83*	—	46936

* 169.83 is derived from specified value $\frac{170.0\ \text{mm}}{1.001}$

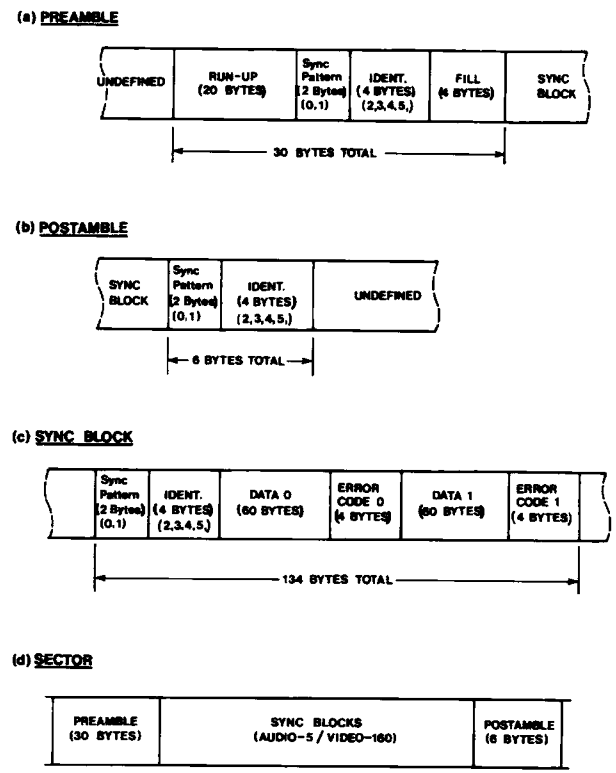


Figure 3 – Sector components

3.3 Sector details

3.3.1 Sync block

Details of the sync block are shown in figure 3(c). All sync blocks consist of 134 bytes consisting of sync pattern (2 bytes) and identification pattern (4 bytes including error coding) followed by 128 data bytes.

3.3.2 Sync pattern

(a) Length: 16 bits (2 bytes)

(b) Pattern: 30 F5 (in hexadecimal notation)

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

(c) Protection: None

(d) Randomization: None

3.3.3 Identification pattern

(a) Length: 32 bits (4 bytes)

(b) Arrangement:

Byte 2 — sync block ID — see figure 4
Byte 3 — sync block ID — see figure 4
Byte 4 — segment ID — see figures 4 and 9
Byte 5 — sector ID — see figures 4 and 9

(c) Protection: 4 to 8 mapping as in table 2

(d) Randomization: None

The values of the sync block ID are shown in figure 4.

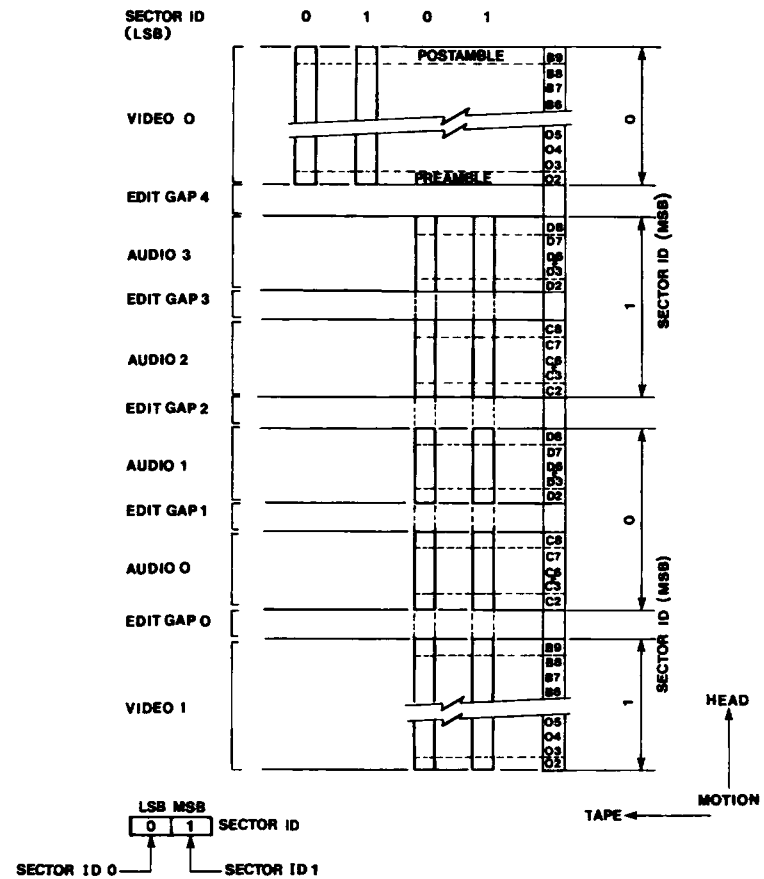


Figure 4 – Values of sync block identification and sector identification codes

Table 2 – 4- to 8-bit mapping

Input	Output	Input	Output
0	1B	8	96
1	2E	9	A3
2	35	A	B8
3	47	B	CA
4	5C	C	D1
5	69	D	E4
6	72	E	Illegal
7	8D	F	

NOTE – Values expressed in hexadecimal.

3.3.3.1 Identification pattern — Byte 2

Mapped from word 0 (4 bits) where word 0 is the right-hand character identified in figure 4. See table 2 and figure 5.

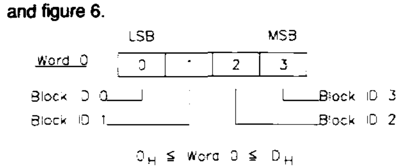


Figure 5 – Identification pattern – Byte 2

3.3.3.2 Identification pattern — Byte 3

Mapped from word 1 (4 bits) where word 1 is the left-hand character identified in figure 4. See table 2 and figure 6.

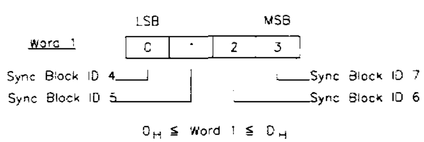


Figure 6 – Identification pattern – Byte 3

3.3.3.3 Identification pattern — Byte 4

Mapped from word 2 (4 bits) by table 2. See figure 7.

3.3.3.4 Identification pattern — Byte 5

Mapped from word 3 (4 bits) by table 2. See figure 8.

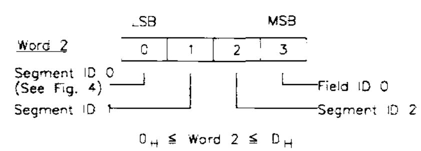


Figure 7 – Identification pattern – Byte 4

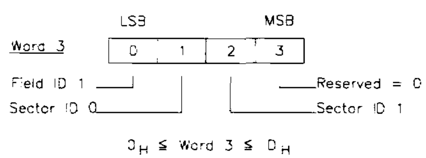
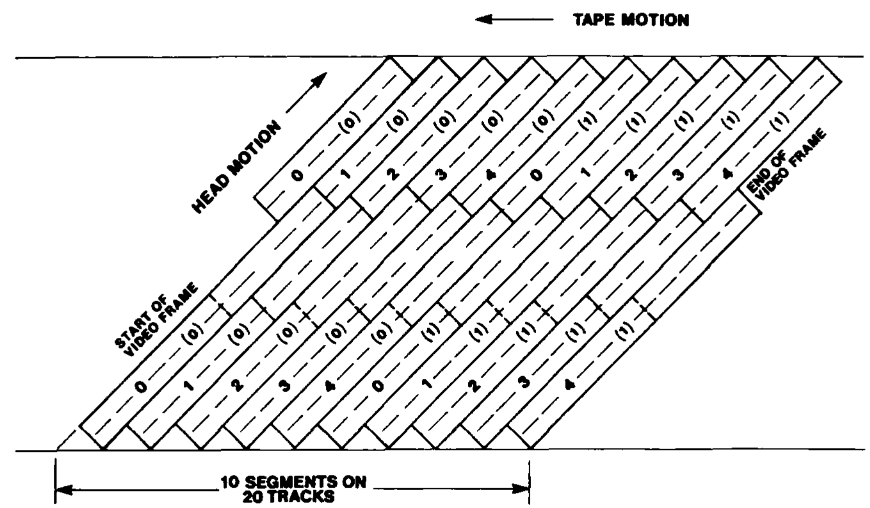


Figure 8 – Identification pattern – Byte 5

NOTES to figures 5, 6, 7, and 8 –
1 Sync block ID is an 8-bit word formed from two 4-bit words, each lying in the range 0 – D_H, uniquely identifying each sync block within one sector. Figure 4 specifies these values.
2 Field ID lies in the range 0 – 3 with the origin aligned with the field sequence identification pulse doublet mark (see clause 6). The values of field ID are shown in figure 9. These values must be continuous, even after editing operations.
3 Segment ID lies in the range 0–4 as shown in figure 9.



NOTES
1 Segment numbers lie in the range 0–4 (unbracketed).
2 Field numbers lie in the range 0–3 (bracketed).
3 Fields 0–1 shown; Fields 2–3 are similar.

Figure 9 – Segment and field numbers

3.3.4 Data field – Sync block

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

(a) Length: 2 inner code blocks, each of 60 data bytes plus 4 inner error-code check bytes. (Outer error-code check bytes are considered as data.)

(b) Arrangement: See figure 3(c).

(c) Protection (inner code):

Type: Reed-Solomon

Galois field: GF(256)

Field generator polynomial: $x^8 + x^4 + x^3 + x^2 + x^0$ (x^i are place keeping variables in GF(2), the binary field).

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

Code generator polynomial (in GF(256)): $G(x) = (x + \alpha^0)(x + \alpha^1)(x + \alpha^2)(x + \alpha^3)$, where α^1 is given by 02_H in GF(256).

Check characters: K_3, K_2, K_1, K_0 in $K_3x^3 + K_2x^2 + K_1x^1 + K_0x^0$ obtained as the remainder after dividing $x^4 \times D(x)$ by $G(x)$ where $D(x) = B_{59}x^{59} + B_{58}x^{58} + ... + B_1x^1 + B_0x^0$.

Equation of full code: $B_{59}x^{63} + B_{58}x^{62} + ... + B_0x^4 + K_3x^3 + ... + K_0x^0$.

An example of three possible patterns is shown in table 3, where pattern 1 is the impulse function where the values in the check locations represent the expansion of the code generator polynomial.

Table 3 – Sync block data field patterns

	Data symbols D(x)							Check symbols					
Symbol position	0	1	2	3	4	5	6	58	59	60	61	62	63
Pattern 1	00	00	00	00	00	00	00	00	01	0F	36	78	40
Pattern 2	00	01	02	03	04	05	06	3A	3B	85	24	A9	08
Pattern 3	CC	CC	CC	CC	CC	CC	CC	CC	CC	B6	D4	B6	D4
Symbol identify	B_{59}	B_{58}	B_{57}	B_{56}	B_{55}	B_{54}	B_{53}	B_1	B_0	K_3	K_2	K_1	K_0

(d) Interleaving: Not used.

(e) Randomization: All data and error correction check characters are randomized before being recorded. (Sync, identification, and fill patterns are not randomized). The randomizing is equivalent to performing the EXOR operation between the serial data stream, and the serial stream generated by the polynomial function $x^8 + x^4 + x^3 + x^2 + x^0$ (in GF(2)). The first term is the most significant and the first to enter the division computation.

In order that successive sync blocks are randomized with different sequences, the polynomial generator noted above is pre-set to 80_H (see note) to read for byte 0 of the sync block locations having ID values as follows:

03, 08, 0D, 14, 19, 20, 25, 2A, 31, 36, 3B, 42, 47, 4C, 53, 58, 5D, 64, 69, 70, 75, 7A, 81, 86, 8B, 92, 97, 9C, A3, A8, AD, B4, C3, D3.

NOTE – This will generate a byte sequence beginning 80, 38, D2, 81, 49, etc. Although the sync and identification patterns are not randomized, the polynomial generator continues to cycle during this period.

3.3.5 Sector preamble

All sectors commence with the preamble sequence.

(a) Length: 30 bytes

(b) Arrangement: See figure 3(a)

Run-up: 20 bytes minimum of CC_H (for clock reference)
Sync pattern: 2 bytes (see 3.3.2)
Identification pattern: 4 bytes (see 3.3.3)
Fill: 4 bytes of CC_H

(c) Protection: None (ID data directly recorded)

(d) Randomization: None

(e) Interleaving: None

3.3.6 Sector postamble

All sectors terminate with the postamble sequence.

(a) Length: 6 bytes

(b) Arrangement: See figure 3(b)

Sync pattern: 2 bytes (see 3.3.2)
Identification pattern: 4 bytes (see 3.3.3)

(c) Protection: None

(d) Randomization: None

(e) Interleaving: None

3.4 Edit gaps

The space, of 232-byte (0.84 mm) nominal length, between sectors may be left unwritten. The area may be unwritten or filled with $(CC)_H$.

3.5 Channel code

The NRZ data stream shall be recorded directly without further coding.

3.6 Magnetization

During the time interval of a recorded data 1, the polarity of data flux shall be such that the north pole of the magnetic domain shall point in the direction of head motion. Similarly, during the time interval of a recorded data 0, the polarity of data flux shall be such as to cause the south pole of the magnetic domain to point in the direction of head motion. Magnetization shall bring the tape to saturation.

4 Video processing

4.1 Recorded data

Information receive during the digital horizontal blanking interval is not recorded on tape. The appropriate blanking data are recreated for output during playback.

4.1.1 Recorded lines

The last 250 lines from each television field are recorded. These comprise lines 14 through 263 inclusive from field 1 and lines 276 through 525 inclusive from field 2. Lines 21 to 263 inclusive and 283 to 525 inclusive contain video data.

4.1.2 Digital active line

720 luminance bytes and 360 bytes for each of the two color difference components, for a total of 1440 bytes, are recorded. These are taken from bytes 0 through 1439 following the 4-byte start of active video (SAV) timing reference signals.

4.1.3 Source precoding

The input video data stream is precoded by a one-for-one mapping of each source data byte as defined in table 4. The inverse mapping for the regeneration of the original video source data bytes is defined in table 5. Data in lines 14-20 and 276-282 inclusive are not precoded.

4.2 Pixel labelling

There are 250 recorded lines per field, with 720 pixels per line. They can be considered as an array of 250 rows by 720 columns, in which each pixel is identified by a pair of integers (i, j), where i identifies the row and is numbered 0 to 249 from top to bottom, and j identifies the column and is numbered 0 to 719 from left to right. Columns with even j are associated with a luminance value Y_{ij} and two cosited color difference values, CB_{ij} and CR_{ij}, where CB and CR designate scaled B-Y and R-Y components, respectively. The 4:2:2 video data sequence for line i is written as follows:

$CB_{i,0}\ Y_{i,0}\ CR_{i,0}\ Y_{i,1} \ldots$
$CB_{i,k}\ Y_{i,k}\ CR_{i,k}\ Y_{i,k+1} \ldots$
$CB_{i,718}\ Y_{i,718}\ CR_{i,718}\ Y_{i,719}$
$0 \le i \le 249$
$0 \le j \le 719$
and $k = 2(\text{int}(j/2))$

Table 4 – Source video mapping

Input: MS word (4 bits) \ LS word (4 bits)	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	00	80	40	20	10	08	04	02	01	C0	A0	90	88	84	82	81
1	60	50	48	44	42	41	30	28	24	22	21	18	14	12	11	0C
2	0A	09	06	05	03	E0	D0	C8	C4	C2	C1	B0	A8	A4	A2	A1
3	98	94	92	91	8C	8A	89	86	85	83	70	68	64	62	61	58
4	54	52	51	4C	4A	49	46	45	43	38	34	32	31	2C	2A	29
5	26	25	23	1C	1A	19	16	15	13	0E	0D	0B	07	F0	E8	E4
6	E2	E1	D8	D4	D2	D1	CC	CA	C9	C6	C5	C3	B8	B4	B2	B1
7	AC	AA	A9	A6	A5	A3	9C	9A	99	96	95	93	8E	8D	8B	87
8	78	74	72	71	6C	6A	69	66	65	63	5C	5A	59	56	55	53
9	4E	4D	4B	47	3C	3A	39	36	35	33	2E	2D	2B	27	1E	1D
A	1B	17	0F	F8	F4	F2	F1	EC	EA	E9	E6	E5	E3	DC	DA	D9
B	D6	D5	D3	CE	CD	CB	C7	BC	BA	B9	B6	B5	B3	AE	AD	AB
C	A7	9E	9D	9B	97	8F	7C	7A	79	76	75	73	6E	6D	6B	67
D	5E	5D	5B	57	4F	3E	3D	3B	37	2F	1F	FC	FA	F9	F6	F5
E	F3	EE	ED	EB	E7	DE	DD	DB	D7	CF	BE	BD	BB	B7	AF	9F
F	7E	7D	7B	77	6F	5F	3F	FE	FD	FB	F7	EF	DF	BF	7F	FF

Table 5 – Inverse video mapping

MS word (4 bits) \ LS word (4 bits)	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0	00	08	07	24	06	23	22	5C	05	21	20	5B	1F	5A	59	A2
1	04	1E	1D	58	1C	57	56	A1	1B	55	54	A0	53	9F	9E	DA
2	03	1A	19	52	18	51	50	9D	17	4F	4E	9C	4D	9B	9A	D9
3	16	4C	4B	99	4A	98	97	D8	49	96	95	D7	94	D6	D5	F6
4	02	15	14	48	13	47	46	93	12	45	44	92	43	91	90	D4
5	11	42	41	8F	40	8E	8D	D3	3F	8C	8B	D2	8A	D1	D0	F5
6	10	3E	3D	89	3C	88	87	CF	3B	86	85	CE	84	CD	CC	F4
7	3A	83	82	CB	81	CA	C9	F3	80	C8	C7	F2	C6	F1	F0	FE
8	01	0F	0E	39	0D	38	37	7F	0C	36	35	7E	34	7D	7C	C5
9	0B	33	32	7B	31	7A	79	C4	30	78	77	C3	76	C2	C1	EF
A	0A	2F	2E	75	2D	74	73	C0	2C	72	71	BF	70	BE	BD	EE
B	2B	6F	6E	BC	6D	BB	BA	ED	6C	B9	B8	EC	B7	EB	EA	FD
C	09	2A	29	6B	28	6A	69	B6	27	68	67	B5	66	B4	B3	E9
D	26	65	64	B2	63	B1	B0	EB	62	AF	AE	E7	AD	E6	E5	FC
E	25	61	60	AC	5F	AB	AA	E4	5E	A9	A8	E3	A7	E2	E1	FB
F	5D	A6	A5	E0	A4	DF	DE	FA	A3	DD	DC	F9	DB	F8	F7	FF

4.3 Intersector distribution

Consider the pixels in a field to be numbered according to 4.2.

Let m designate the number of a given line within a segment then

m = i mod 50

Let r designate the sector number within a segment, $0 \le r \le 3$.

The pixels within each segment are evenly distributed between the four corresponding sectors as shown in figure 9 and by the following equations:

(i) for the luminance (Y) component,
$r_y = 2((f+g+j)\bmod 2) + \mathrm{int}(((j+2(m \bmod 2))\bmod 4)/2)$

(ii) and for the color difference components (CB and CR), $r_c = 2((f+g+\mathrm{int}(j/2))\bmod 2) + \mathrm{int}(((\mathrm{int}(j/2)+2(m \bmod 2))\bmod 4)/2)$

when g designates the segment in which a given line i falls: g = int(i/50)

f = least significant part of the field ID for the 525 system only.

(The function int(x) yields the integer part of (x).)

This results in 180 luminance pixels and 90 pairs of color difference pixels per line in each sector of a segment.

The distribution of pixels in each sector is further described in table 6.

4.4 Intrasector shuffling

The intrasector shuffling sequence during the record process shall be described in terms of two successive shuffling processes:

– An intraline shuffle which shuffles video and ancillary words within a single line prior to outer error coding;

– A sector array shuffle which shuffles data and error correction code words within the sector, prior to being written to tape.

The sector array dimensions are 32 rows by 600 columns. Each column corresponds to one outer code block and contains 30 video data bytes plus two outer correction check bytes. The sector array is further divided into 10 contiguous subarrays, each having dimensions of 32 rows by 60 columns. The 60 data bytes within a single subarray row correspond to one inner code block on tape.

4.4.1 Intraline shuffle

Let the horizontal pixel index, j, be normalized to the range (0 –179) following the intersector distribution described in 4.3.

For luminance component,
$j_y' = \mathrm{int}(j_y/4)$

For the color difference components (CB and CR),
$j_c' = 2\,\mathrm{int}(j_c/8)$

where j′ indicates a normalized index.

Then the sector data sequence for a given line contains 360 bytes as shown in table 7.

Table 6 – Intersector shuffling for odd and even lines

For (f + g) mod2 = 0										
Even line numbers (m. mod2 = 0)	j=	0 1	2 3	4 5	6 7	8 9	10 11	12 13	14 15	16. . .
	r_y=	0 2	1 3	0 2	1 3	0 2	1 3	0 2	1 3	0
	r_c=	0	2	1	3	0	2	1	3	0
Odd line numbers (m. mod2 = 1)	j=	0 1	2 3	4 5	6 7	8 9	10 11	12 13	14 15	16. . .
	r_y=	1 3	0 2	1 3	0 2	1 3	0 2	1 3	0 2	1
	r_c=	1	3	0	2	1	3	0	2	1
For (f + g) mod2 = 1										
Even line numbers (m. mod2 = 0)	j=	0 1	2 3	4 5	6 7	8 9	10 11	12 13	14 15	16
	r_y=	2 0	3 1	2 0	3 1	2 0	3 1	2 0	3 1	2
	r_c=	2	0	3	1	2	0	3	1	2
Odd line numbers (m. mod2 = 1)	j=	0 1	2 3	4 5	6 7	8 9	10 11	12 13	14 15	16. . .
	r_y=	3 1	2 0	3 1	2 0	3 1	2 0	3 1	2 0	3
	r_c=	3	1	2	0	3	1	2	0	3

Table 7 – Sector data sequence

k:	0	1	2	3	4	5	6	7	356	357	358	359
byte:	CB_0	Y_0	CR_0	Y_1	CB_2	Y_2	CR_2	Y_3	CB_{178}	Y_{178}	CR_{178}	Y_{179}

The 360 luminance and chrominance bytes are distributed among 12 outer code blocks as shown in table 8. Each column represents an outer code block. The last two bytes, KV1 and KV0, are outer correction check bytes added by the outer coder. The byte number refers to the byte position within an outer code block.

Let k be the position of a video data byte within a line of the sector data sequence, following the intersector distribution as described above, $0 \le k \le 359$. Let Oblk be the outer block column index of table 7, $0 \le Oblk \le 11$. Let Obyt be the outer block byte number of table 7, $0 \le Obyt \le 31$.

Then the intraline shuffle described by the following formulas is applied:

$$Oblk = 4int(k/120) + (k \bmod 4)$$

$$Obyt = int((k \bmod 120)/4) \quad (\text{For } 0 \le Obyt \le 29)$$

The result is shown in table 8.

The inverse mapping is given by the formula
$$k = 120int(Oblk/4) + (Oblk \bmod 4) + (4 \times Obyt)$$

4.4.2 Sector array shuffling

The sector array may be divided into 150 4-column groups, ranging from 0 to 149. The 4 columns within a column group contain (CB, Y, CR, Y) pixel data bytes, respectively. Along a given row within a column group, CB and CR are cosited with respect to the source data, and cosited (or nearly so) with the first Y pixel data byte, while the second Y pixel byte is horizontally offset from the first with respect to the source data.

A column map, which is a permutation of the integers 0 to 149, is used to define the sequence in which column groups are stored in the sector array. A row map, which is a permutation of the integers 0 to 31, is used to define the sequence of rows in which data for a given column is stored in the sector array. The starting point of the row map is different for each column group, and, in addition, the starting point of the row map sequence for the fourth column of each column group is further offset by a constant from the starting point of the row map sequence for the first 3 columns of the column group.

The sector array shuffling is defined by algorithm 1. Tables 9 (a-j) show the result of this algorithm and figure 10 shows a conceptual block diagram of the method. The algorithm may be considered to operate as follows:

The column counter is cleared at the beginning of each 50-line segment, and incremented every outer block or 12 times per TV line. The least significant 2 bits of the column counter select a column within a 4-column group. The most significant 8 bits are used to address a PROM containing the column map function. The row start PROM is used to select an initial starting point for the row map sequence for each column group, except for the fourth column of the column group, which has a different initial starting point for the row map sequence. The row counter is loaded with the row start preset data at the beginning of each outer block and increments mod 32 every data byte. The row map PROM is used to select the actual row address where the byte is stored in the sector array.

Tables 9 (a-j) explicitly list the relation between every byte in the sector array and its location in the input data stream. The array values represent normalized pixel indices, j_Y' or j_C', as defined in 4.4.1.

Algorithm 2 shows the de-shuffling scheme.

4.4.2.1 Algorithm 1, intrasector shuffling (reference only)

Let m designate the line number within a segment, $0 \le m \le 49$.

Let Oblk designate the outer block number within a line, as defined in 4.4.1, $0 \le Oblk \le 11$.

Let Obyt designate the outer block byte index, as defined in 4.4.1, $0 \le Obyt \le 31$.

Define the outer block number counting from beginning of the segment, lcnt,
$$lcnt = Oblk + 12m, \quad 0 \le lcnt \le 599$$

Define the unpermuted 4-column group number, lgrp,
$$lgrp = int(lcnt/4), \quad 0 \le lgrp \le 149$$

Define the permuted 4-column group number, Jgrp,
$$Jgrp = (41 \times lgrp) \bmod 150$$

Table 8 – Intraline word shuffle

Outer block number within line (Oblk)

Byte# (Obyt)	0	1	2	3	4	5	6	7	8	9	10	11
0	CB0	Y0	CR0	Y1	CB60	Y60	CR60	Y61	CB120	Y120	CR120	Y121
1	CB2	Y2	CR2	Y3	CB62	Y62	CR62	Y63	CB122	Y122	CR122	Y123
2	CB4	Y4	CR4	Y5	CB64	Y64	CR64	Y65	CB124	Y124	CR124	Y125
3	CB6	Y6	CR6	Y7	CB66	Y66	CR66	Y67	CB126	Y126	CR126	Y127
4	CB8	Y8	CR8	Y9	CB68	Y68	CR68	Y69	CB128	Y128	CR128	Y129
5	CB10	Y10	CR10	Y11	CB70	Y70	CR70	Y71	CB130	Y130	CR130	Y131
6	CB12	Y12	CR12	Y13	CB72	Y72	CR72	Y73	CB132	Y132	CR132	Y133
7	CB14	Y14	CR14	Y15	CB74	Y74	CR74	Y75	CB134	Y134	CR134	Y135
8	CB16	Y16	CR16	Y17	CB76	Y76	CR76	Y77	CB136	Y136	CR136	Y137
9	CB18	Y18	CR18	Y19	CB78	Y78	CR78	Y79	CB138	Y138	CR138	Y139
10	CB20	Y20	CR20	Y21	CB80	Y80	CR80	Y81	CB140	Y140	CR140	Y141
11	CB22	Y22	CR22	Y23	CB82	Y82	CR82	Y83	CB142	Y142	CR142	Y143
12	CB24	Y24	CR24	Y25	CB84	Y84	CR84	Y85	CB144	Y144	CR144	Y145
13	CB26	Y26	CR26	Y27	CB86	Y86	CR86	Y87	CB146	Y146	CR146	Y147
14	CB28	Y28	CR28	Y29	CB88	Y88	CR88	Y89	CB148	Y148	CR148	Y149
15	CB30	Y30	CR30	Y31	CB90	Y90	CR90	Y91	CB150	Y150	CR150	Y151
16	CB32	Y32	CR32	Y33	CB92	Y92	CR92	Y93	CB152	Y152	CR152	Y153
17	CB34	Y34	CR34	Y35	CB94	Y94	CR94	Y95	CB154	Y154	CR154	Y155
18	CB36	Y36	CR36	Y37	CB96	Y96	CR96	Y97	CB156	Y156	CR156	Y157
19	CB38	Y38	CR38	Y39	CB98	Y98	CR98	Y99	CB158	Y158	CR158	Y159
20	CB40	Y40	CR40	Y41	CB100	Y100	CR100	Y101	CB160	Y160	CR160	Y161
21	CB42	Y42	CR42	Y43	CB102	Y102	CR102	Y103	CB162	Y162	CR162	Y163
22	CB44	Y44	CR44	Y45	CB104	Y104	CR104	Y105	CB164	Y164	CR164	Y165
23	CB46	Y46	CR46	Y47	CB106	Y106	CR106	Y107	CB166	Y166	CR166	Y167
24	CB48	Y48	CR48	Y49	CB108	Y108	CR108	Y109	CB168	Y168	CR168	Y169
25	CB50	Y50	CR50	Y51	CB110	Y110	CR110	Y111	CB170	Y170	CR170	Y171
26	CB52	Y52	CR52	Y53	CB112	Y112	CR112	Y113	CB172	Y172	CR172	Y173
27	CB54	Y54	CR54	Y55	CB114	Y114	CR114	Y115	CB174	Y174	CR174	Y175
28	CB56	Y56	CR56	Y57	CB116	Y116	CR116	Y117	CB176	Y176	CR176	Y177
29	CB58	Y58	CR58	Y59	CB118	Y118	CR118	Y119	CB178	Y178	CR178	Y179
30	KV1	KV1	KV1	KV1	KV1	KV1	KV1	KV1	KV1	KV1	KV1	KV1
31	KV0	KV0	KV0	KV0	KV0	KV0	KV0	KV0	KV0	KV0	KV0	KV0

Table 9(a) – Intrasector shuffle memory map for sub-array 0

Jgrp:	0		1		2		3		4		5		6		7		8		9		10		11		12		13		14	
Igrp:	0		11		22		33		44		55		66		77		88		99		110		121		132		143		4	
Line:	0		3		7		11		14		18		22		25		29		33		36		40		44		47		1	
Col:	0	3	4	7	8	11	12	15	16	19	20	23	24	27	28	31	32	35	36	39	40	43	44	47	48	51	52	55	56	59
Data:	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y
Rstrt:	0	5	10	15	20	25	30	3	8	13	18	23	28	1	6	11	16	21	26	31	4	9	14	19	24	29	2	7	24	29
Row																														
0	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	76	67
1	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	KV0	113
2	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	104	95
3	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	86	77
4	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	68	KV0
5	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	114	105
6	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	96	87
7	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	78	69
8	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	60	115
9	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	106	97
10	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	88	79
11	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	70	61
12	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	116	107
13	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	98	89
14	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	80	71
15	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	62	117
16	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	108	99
17	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	90	81
18	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	72	63
19	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	118	109
20	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	100	91
21	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	82	73
22	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	64	119
23	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	110	101
24	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	92	83
25	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	74	65
26	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	KV1	111
27	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	102	93
28	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	84	75
29	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	66	KV1
30	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	112	103
31	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	94	85

NOTES

1 Columns 1 and 2 have the same distribution as column 0, columns 5 and 6 the same as 4, etc.

2 Numerical table entries represent horizontal position of byte within TV line. KV0 and KV1 are outer ECC check bytes.

Define the sector array column index, Col,
Col = 4 × Jgrp + (Icnt mod 4), 0 ≤ Col ≤ 599

Define u = 0 for (Icnt mod 4) = 0,1,2; u = 1 for (Icnt mod 4) = 3

Define the row count starting value, Rstart,
Rstart = (30 × Igrp + 5 u) mod 32

Define the row count value, Rcnt,
Rcnt = (Obyt + Rstart) mod 32

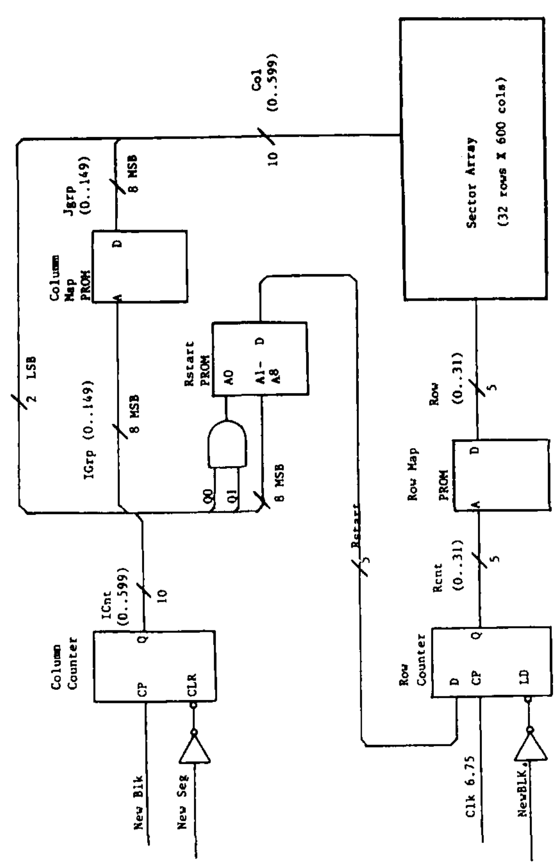


Figure 10 – Intrasector shuffle conceptual implementation (Reference only)

Table 9(c) – Intrasector shuffle memory map for sub-array 2

Jgrp:	30		31		32		33		34		35		36		37		38		39		40		41		42		43		44	
Igrp:	30		41		52		63		74		85		96		107		118		129		140		1		12		23		34	
Line:	10		13		17		21		24		28		32		35		39		43		46		0		4		7		11	
Col:	120	123	124	127	128	131	132	135	136	139	140	143	144	147	148	151	152	155	156	159	160	163	164	167	168	171	172	175	176	179
Data:	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y
Rstrt:	4	9	14	19	24	29	2	7	12	17	22	27	0	5	10	15	20	25	30	3	8	13	30	3	8	13	18	23	28	1
Row																														
0	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	64	119	48	39	148	139	68	KV0
1	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	110	101	30	21	130	121	114	105
2	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	92	83	12	3	176	167	96	87
3	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	74	65	58	49	158	149	78	69
4	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	KV1	111	40	31	140	131	60	115
5	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	102	93	22	13	122	177	106	97
6	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	84	75	4	59	168	159	88	79
7	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	66	KV1	50	41	150	141	70	61
8	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	112	103	32	23	132	123	116	107
9	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	94	85	14	5	178	169	98	89
10	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	76	67	KV1	51	160	151	80	71
11	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	KV0	113	42	33	142	133	62	117
12	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	104	95	24	15	124	179	108	99
13	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	86	77	6	KV1	170	161	90	81
14	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	68	KV0	52	43	152	143	72	63
15	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	114	105	34	25	134	125	118	109
16	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	96	87	16	7	KV1	171	100	91
17	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	78	69	KV0	53	162	153	82	73
18	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	60	115	44	35	144	135	64	119
19	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	106	97	26	17	126	KV1	110	101
20	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	88	79	8	KV0	172	163	92	83
21	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	70	61	54	45	154	145	74	65
22	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	116	107	36	27	136	127	KV1	111
23	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	98	89	18	9	KV0	173	102	93
24	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	80	71	0	55	164	155	84	75
25	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	62	117	46	37	146	137	66	KV1
26	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	108	99	28	19	128	KV0	112	103
27	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	90	81	10	1	174	165	94	85
28	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	72	63	56	47	156	147	76	67
29	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	118	109	38	29	138	129	KV0	113
30	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	100	91	20	11	120	175	104	95
31	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	82	73	2	57	166	157	86	77

NOTES

1 Columns 121 and 122 have the same distribution as column 120, columns 125 and 126 the same as 124, etc.

2 Numerical table entries represent horizontal position of byte within TV line. KV0 and KV1 are outer ECC check bytes.

Table 9(b) – Intrasector shuffle memory map for sub-array 1

Jgrp:	15		16		17		18		19		20		21		22		23		24		25		26		27		28		29	
Igrp:	15		26		37		48		59		70		81		92		103		114		125		136		147		8		19	
Line:	5		8		12		16		19		23		27		30		34		38		41		45		49		2		6	
Col:	60	63	64	67	68	71	72	75	76	79	80	83	84	87	88	91	92	95	96	99	100	103	104	107	108	111	112	115	116	119
Data:	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y
Rstrt:	2	7	12	17	22	27	0	5	10	15	20	25	30	3	8	13	18	23	28	1	6	11	16	21	26	31	16	21	26	31
Row																														
0	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	152	143	72	63
1	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65	58	49	134	125	118	109
2	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	KV1	171	100	91
3	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	162	153	82	73
4	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	144	135	64	119
5	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	126	KV1	110	101
6	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	172	163	92	83
7	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	154	145	74	65
8	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	136	127	KV1	111
9	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	KV0	173	102	93
10	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	164	155	84	75
11	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	146	137	66	KV1
12	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	128	KV0	112	103
13	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	174	165	94	85
14	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	156	147	76	67
15	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	138	129	KV0	113
16	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	120	175	104	95
17	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	166	157	86	77
18	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	148	139	68	KV0
19	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	130	121	114	105
20	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	176	167	96	87
21	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	98	89	18	9	158	149	78	69
22	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	140	131	60	115
23	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	122	177	106	97
24	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	108	99	28	19	168	159	88	79
25	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	150	141	70	61
26	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	132	123	116	107
27	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	118	109	38	29	178	169	98	89
28	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	160	151	80	71
29	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	142	133	62	117
30	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119	48	39	124	179	108	99
31	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	170	161	90	81

NOTES

1 Columns 61 and 62 have the same distribution as column 60, columns 65 and 66 the same as 64, etc.

2 Numerical table entries represent horizontal position of byte within TV line. KV0 and KV1 are outer ECC check bytes.

Table 9(e) – Intrasector shuffle memory map for sub-array 4

Jgrp:	60		61		62		63		64		65		66		67		68		69		70		71		72		73		74	
Igrp:	60		71		82		93		104		115		126		137		148		9		20		31		42		53		64	
Line:	20		23		27		31		34		38		42		45		49		3		6		10		14		17		21	
Col:	240	243	244	247	248	251	252	255	256	259	260	263	264	267	268	271	272	275	276	279	280	283	284	287	288	291	292	295	296	299
Data:	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y
Rstrt:	8	13	18	23	28	1	6	11	16	21	26	31	4	9	14	19	24	29	14	19	24	29	2	7	12	17	22	27	0	5
Row																														
0	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67	36	27	136	127	KV1	111	40	31	140	131	60	115
1	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113	18	9	KV0	173	102	93	22	13	122	177	106	97
2	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95	0	55	164	155	84	75	4	59	168	159	88	79
3	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77	46	37	146	137	66	KV1	50	41	150	141	70	61
4	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0	28	19	128	KV0	112	103	32	23	132	123	116	107
5	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105	10	1	174	165	94	85	14	5	178	169	98	89
6	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87	56	47	156	147	76	67	KV1	51	160	151	80	71
7	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	78	69	38	29	138	129	KV0	113	42	33	142	133	62	117
8	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115	20	11	120	175	104	95	24	15	124	179	108	99
9	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97	2	57	166	157	86	77	6	KV1	170	161	90	81
10	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	88	79	48	39	148	139	68	KV0	52	43	152	143	72	63
11	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61	30	21	130	121	114	105	34	25	134	125	118	109
12	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107	12	3	176	167	96	87	16	7	KV1	171	100	91
13	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	98	89	58	49	158	149	78	69	KV0	53	162	153	82	73
14	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71	40	31	140	131	60	115	44	35	144	135	64	119
15	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117	22	13	122	177	106	97	26	17	126	KV1	110	101
16	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	108	99	4	59	168	159	88	79	8	KV0	172	163	92	83
17	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81	50	41	150	141	70	61	54	45	154	145	74	65
18	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63	32	23	132	123	116	107	36	27	136	127	KV1	111
19	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	118	109	14	5	178	169	98	89	18	9	KV0	173	102	93
20	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91	KV1	51	160	151	80	71	0	55	164	155	84	75
21	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73	42	33	142	133	62	117	46	37	146	137	66	KV1
22	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119	24	15	124	179	108	99	28	19	128	KV0	112	103
23	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101	6	KV1	170	161	90	81	10	1	174	165	94	85
24	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83	52	43	152	143	72	63	56	47	156	147	76	67
25	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65	34	25	134	125	118	109	38	29	138	129	KV0	113
26	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111	16	7	KV1	171	100	91	20	11	120	175	104	95
27	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93	KV0	53	162	153	82	73	2	57	166	157	86	77
28	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75	44	35	144	135	64	119	48	39	148	139	68	KV0
29	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1	26	17	126	KV1	110	101	30	21	130	121	114	105
30	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103	8	KV0	172	163	92	83	12	3	176	167	96	87
31	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85	54	45	154	145	74	65	58	49	158	149	78	69

NOTES

1 Columns 241 and 242 have the same distribution as column 240, columns 245 and 246 the same as 244, etc.

2 Numerical table entries represent horizontal position of byte within TV line. KV0 and KV1 are outer ECC check bytes.

Table 9(d) – Intrasector shuffle memory map for sub-array 3

Jgrp:	45		46		47		48		49		50		51		52		53		54		55		56		57		58		59	
Igrp:	45		56		67		78		89		100		111		122		133		144		5		16		27		38		49	
Line:	15		18		22		26		29		33		37		40		44		48		1		5		9		12		16	
Col:	180	183	184	187	188	191	192	195	196	199	200	203	204	207	208	211	212	215	216	219	220	223	224	227	228	231	232	235	236	239
Data:	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y
Rstrt:	6	11	16	21	26	31	4	9	14	19	24	29	2	7	12	17	22	27	0	5	22	27	0	5	10	15	20	25	30	3
Row																														
0	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	140	131	60	115	44	35	144	135	64	119
1	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	122	177	106	97	26	17	126	KV1	110	101
2	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	108	99	28	19	168	159	88	79	8	KV0	172	163	92	83
3	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	150	141	70	61	54	45	154	145	74	65
4	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	132	123	116	107	36	27	136	127	KV1	111
5	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	118	109	38	29	178	169	98	89	18	9	KV0	173	102	93
6	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	160	151	80	71	0	55	164	155	84	75
7	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	142	133	62	117	46	37	146	137	66	KV1
8	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119	48	39	124	179	108	99	28	19	128	KV0	112	103
9	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	170	161	90	81	10	1	174	165	94	85
10	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	152	143	72	63	56	47	156	147	76	67
11	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65	58	49	134	125	118	109	38	29	138	129	KV0	113
12	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	KV1	171	100	91	20	11	120	175	104	95
13	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	162	153	82	73	2	57	166	157	86	77
14	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	144	135	64	119	48	39	148	139	68	KV0
15	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	126	KV1	110	101	30	21	130	121	114	105
16	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	172	163	92	83	12	3	176	167	96	87
17	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	154	145	74	65	58	49	158	149	78	69
18	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	136	127	KV1	111	40	31	140	131	60	115
19	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	KV0	173	102	93	22	13	122	177	106	97
20	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	164	155	84	75	4	59	168	159	88	79
21	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	146	137	66	KV1	50	41	150	141	70	61
22	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	128	KV0	112	103	32	23	132	123	116	107
23	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	174	165	94	85	14	5	178	169	98	89
24	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	156	147	76	67	KV1	51	160	151	80	71
25	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	138	129	KV0	113	42	33	142	133	62	117
26	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	120	175	104	95	24	15	124	179	108	99
27	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	166	157	86	77	6	KV1	170	161	90	81
28	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	148	139	68	KV0	52	43	152	143	72	63
29	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	130	121	114	105	34	25	134	125	118	109
30	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	176	167	96	87	16	7	KV1	171	100	91
31	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	98	89	18	9	158	149	78	69	KV0	53	162	153	82	73

NOTES

1 Columns 181 and 182 have the same distribution as column 180, columns 185 and 186 the same as 184, etc.

2 Numerical table entries represent horizontal position of byte within TV line. KV0 and KV1 are outer ECC check bytes.

Table 9(g) – Intrasector shuffle memory map for sub-array 6

Jgrp:	90		91		92		93		94		95		96		97		98		99		100		101		102		103		104	
Igrp:	90		101		112		123		134		145		6		17		28		39		50		61		72		83		94	
Line:	30		33		37		41		44		48		2		5		9		13		16		20		24		27		31	
Col:	360	363	364	367	368	371	372	375	376	379	380	383	384	387	388	391	392	395	396	399	400	403	404	407	408	411	412	415	416	419
Data:	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y
Rstrt:	12	17	22	27	0	5	10	15	20	25	30	3	20	25	30	3	8	13	18	23	28	1	6	11	16	21	26	31	4	9
Row																														
0	40	31	140	131	60	115	44	35	144	135	64	119	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107
1	22	13	122	177	106	97	26	17	126	KV1	110	101	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	98	89
2	4	59	168	159	88	79	8	KV0	172	163	92	83	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71
3	50	41	150	141	70	61	54	45	154	145	74	65	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117
4	32	23	132	123	116	107	36	27	136	127	KV1	111	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	108	99
5	14	5	178	169	98	89	18	9	KV0	173	102	93	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81
6	KV1	51	160	151	80	71	0	55	164	155	84	75	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63
7	42	33	142	133	62	117	46	37	146	137	66	KV1	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	118	109
8	24	15	124	179	108	99	28	19	128	KV0	112	103	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91
9	6	KV1	170	161	90	81	10	1	174	165	94	85	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73
10	52	43	152	143	72	63	56	47	156	147	76	67	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119
11	34	25	134	125	118	109	38	29	138	129	KV0	113	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101
12	16	7	KV1	171	100	91	20	11	120	175	104	95	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83
13	KV0	53	162	153	82	73	2	57	166	157	86	77	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65
14	44	35	144	135	64	119	48	39	148	139	68	KV0	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111
15	26	17	126	KV1	110	101	30	21	130	121	114	105	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93
16	8	KV0	172	163	92	83	12	3	176	167	96	87	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75
17	54	45	154	145	74	65	58	49	158	149	78	69	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1
18	36	27	136	127	KV1	111	40	31	140	131	60	115	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103
19	18	9	KV0	173	102	93	22	13	122	177	106	97	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85
20	0	55	164	155	84	75	4	59	168	159	88	79	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67
21	46	37	146	137	66	KV1	50	41	150	141	70	61	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113
22	28	19	128	KV0	112	103	32	23	132	123	116	107	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95
23	10	1	174	165	94	85	14	5	178	169	98	89	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77
24	56	47	156	147	76	67	KV1	51	160	151	80	71	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0
25	38	29	138	129	KV0	113	42	33	142	133	62	117	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105
26	20	11	120	175	104	95	24	15	124	179	108	99	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87
27	2	57	166	157	86	77	6	KV1	170	161	90	81	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	78	69
28	48	39	148	139	68	KV0	52	43	152	143	72	63	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115
29	30	21	130	121	114	105	34	25	134	125	118	109	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97
30	12	3	176	167	96	87	16	7	KV1	171	100	91	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	88	79
31	58	49	158	149	78	69	KV0	53	162	153	82	73	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61

NOTES

1 Columns 361 and 362 have the same distribution as column 360, columns 365 and 366 the same as 364, etc.

2 Numerical table entries represent horizontal position of byte within TV line. KV0 and KV1 are outer ECC check bytes.

Table 9(f) – Intrasector shuffle memory map for sub-array 5

Jgrp:	75		76		77		78		79		80		81		82		83		84		85		86		87		88		89	
Igrp:	75		86		97		108		119		130		141		2		13		24		35		46		57		68		79	
Line:	25		28		32		36		39		43		47		0		4		8		11		15		19		22		26	
Col:	300	303	304	307	308	311	312	315	316	319	320	323	324	327	328	331	332	335	336	339	340	343	344	347	348	351	352	355	356	359
Data:	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y
Rstrt:	10	15	20	25	30	3	8	13	18	23	28	1	6	11	28	1	6	11	16	21	26	31	4	9	14	19	24	29	2	7
Row																														
0	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111
1	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93
2	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75
3	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1
4	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103
5	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85
6	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67
7	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	130	121	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113
8	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95
9	10	1	174	165	94	85	14	5	178	169	98	89	18	9	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77
10	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	140	131	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0
11	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105
12	20	11	120	175	104	95	24	15	124	179	108	99	28	19	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87
13	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	150	141	70	61	54	45	154	145	74	65	58	49	158	149	78	69
14	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115
15	30	21	130	121	114	105	34	25	134	125	118	109	38	29	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97
16	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	160	151	80	71	0	55	164	155	84	75	4	59	168	159	88	79
17	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61
18	40	31	140	131	60	115	44	35	144	135	64	119	48	39	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107
19	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	170	161	90	81	10	1	174	165	94	85	14	5	178	169	98	89
20	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71
21	50	41	150	141	70	61	54	45	154	145	74	65	58	49	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117
22	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	108	99
23	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81
24	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63
25	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	118	109
26	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91
27	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73
28	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119
29	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101
30	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83
31	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65

NOTES

1 Columns 301 and 302 have the same distribution as column 300, columns 305 and 206 the same as 304, etc.

2 Numerical table entries represent horizontal position of byte within TV line. KV0 and KV1 are outer ECC check bytes.

Table 9(i) – Intrasector shuffle memory map for sub-array 8

Jgrp:	120		121		122		123		124		125		126		127		128		129		130		131		132		133		134	
Igrp:	120		131		142		3		14		25		36		47		58		69		80		91		102		113		124	
Line:	40		43		47		1		4		8		12		15		19		23		26		30		34		37		41	
Col:	480	483	484	487	488	491	492	495	496	499	500	503	504	507	508	511	512	515	516	519	520	523	524	527	528	531	532	535	536	539
Data:	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y
Rstrt:	16	21	26	31	4	9	26	31	4	9	14	19	24	29	2	7	12	17	22	27	0	5	10	15	20	25	30	3	8	13
Row																														
0	32	23	132	123	116	107	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	108	99
1	14	5	178	169	98	89	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81
2	KV1	51	160	151	80	71	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63
3	42	33	142	133	62	117	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	118	109
4	24	15	124	179	108	99	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91
5	6	KV1	170	161	90	81	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73
6	52	43	152	143	72	63	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119
7	34	25	134	125	118	109	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101
8	16	7	KV1	171	100	91	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83
9	KV0	53	162	153	82	73	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65
10	44	35	144	135	64	119	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111
11	26	17	126	KV1	110	101	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93
12	8	KV0	172	163	92	83	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75
13	54	45	154	145	74	65	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1
14	36	27	136	127	KV1	111	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103
15	18	9	KV0	173	102	93	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85
16	0	55	164	155	84	75	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67
17	46	37	146	137	66	KV1	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113
18	28	19	128	KV0	112	103	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95
19	10	1	174	165	94	85	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77
20	56	47	156	147	76	67	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0
21	38	29	138	129	KV0	113	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105
22	20	11	120	175	104	95	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87
23	2	57	166	157	86	77	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	78	69
24	48	39	148	139	68	KV0	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115
25	30	21	130	121	114	105	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97
26	12	3	176	167	96	87	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	88	79
27	58	49	158	149	78	69	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61
28	40	31	140	131	60	115	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107
29	22	13	122	177	106	97	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	98	89
30	4	59	168	159	88	79	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71
31	50	41	150	141	70	61	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117

NOTES

1 Columns 481 and 482 have the same distribution as column 480, columns 485 and 486 the same as 484, etc.

2 Numerical table entries represent horizontal position of byte within TV line. KV0 and KV1 are outer ECC check bytes.

Table 9(h) – Intrasector shuffle memory map for sub-array 7

Jgrp:	105		106		107		108		109		110		111		112		113		114		115		116		117		118		119	
Igrp:	105		116		127		138		149		10		21		32		43		54		65		76		87		98		109	
Line:	35		38		42		46		49		3		7		10		14		18		21		25		29		32		36	
Col:	420	423	424	427	428	431	432	435	436	439	440	443	444	447	448	451	452	455	456	459	460	463	464	467	468	471	472	475	476	479
Data:	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y
Rstrt:	14	19	24	29	2	7	12	17	22	27	12	17	22	27	0	5	10	15	20	25	30	3	8	13	18	23	28	1	6	11
Row																														
0	36	27	136	127	KV1	111	40	31	140	131	100	91	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103
1	18	9	KV0	173	102	93	22	13	122	177	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85
2	0	55	164	155	84	75	4	59	168	159	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67
3	46	37	146	137	66	KV1	50	41	150	141	110	101	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113
4	28	19	128	KV0	112	103	32	23	132	123	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95
5	10	1	174	165	94	85	14	5	178	169	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77
6	56	47	156	147	76	67	KV1	51	160	151	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0
7	38	29	138	129	KV0	113	42	33	142	133	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105
8	20	11	120	175	104	95	24	15	124	179	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87
9	2	57	166	157	86	77	6	KV1	170	161	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	78	69
10	48	39	148	139	68	KV0	52	43	152	143	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115
11	30	21	130	121	114	105	34	25	134	125	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97
12	12	3	176	167	96	87	16	7	KV1	171	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	88	79
13	58	49	158	149	78	69	KV0	53	162	153	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61
14	40	31	140	131	60	115	44	35	144	135	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107
15	22	13	122	177	106	97	26	17	126	KV1	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	98	89
16	4	59	168	159	88	79	8	KV0	172	163	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71
17	50	41	150	141	70	61	54	45	154	145	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117
18	32	23	132	123	116	107	36	27	136	127	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	108	99
19	14	5	178	169	98	89	18	9	KV0	173	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81
20	KV1	51	160	151	80	71	0	55	164	155	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63
21	42	33	142	133	62	117	46	37	146	137	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	118	109
22	24	15	124	179	108	99	28	19	128	KV0	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91
23	6	KV1	170	161	90	81	10	1	174	165	70	61	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73
24	52	43	152	143	72	63	56	47	156	147	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119
25	34	25	134	125	118	109	38	29	138	129	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101
26	16	7	KV1	171	100	91	20	11	120	175	80	71	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83
27	KV0	53	162	153	82	73	2	57	166	157	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65
28	44	35	144	135	64	119	48	39	148	139	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111
29	26	17	126	KV1	110	101	30	21	130	121	90	81	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93
30	8	KV0	172	163	92	83	12	3	176	167	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75
31	54	45	154	145	74	65	58	49	158	149	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1

NOTES

1 Columns 421 and 422 have the same distribution as column 420, columns 425 and 426 the same as 424, etc.

2 Numerical table entries represent horizontal position of byte within TV line. KV0 and KV1 are outer ECC check bytes.

Table 9(j) – Intrasector shuffle memory map for sub-array 9

Jgrp:	135		136		137		138		139		140		141		142		143		144		145		146		147		148		149	
Igrp:	135		146		7		18		29		40		51		62		73		84		95		106		117		128		139	
Line:	45		48		2		6		9		13		17		20		24		28		31		35		39		42		46	
Col:	540	543	544	547	548	551	552	555	556	559	560	563	564	567	568	571	572	575	576	579	580	583	584	587	588	591	592	595	596	599
Data:	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y	CbYCr	Y
Rstrt:	18	23	28	1	18	23	28	1	6	11	16	21	26	31	4	9	14	19	24	29	2	7	12	17	22	27	0	5	10	15
Row																														
0	28	19	128	KV0	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95
1	10	1	174	165	70	61	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77
2	56	47	156	147	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0
3	38	29	138	129	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105
4	20	11	120	175	80	71	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87
5	2	57	166	157	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	78	69
6	48	39	148	139	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115
7	30	21	130	121	90	81	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97
8	12	3	176	167	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	88	79
9	58	49	158	149	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61
10	40	31	140	131	100	91	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107
11	22	13	122	177	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	98	89
12	4	59	168	159	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71
13	50	41	150	141	110	101	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117
14	32	23	132	123	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	108	99
15	14	5	178	169	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81
16	KV1	51	160	151	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63
17	42	33	142	133	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	118	109
18	24	15	124	179	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83	12	3	176	167	96	87	16	7	KV1	171	100	91
19	6	KV1	170	161	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65	58	49	158	149	78	69	KV0	53	162	153	82	73
20	52	43	152	143	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111	40	31	140	131	60	115	44	35	144	135	64	119
21	34	25	134	125	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93	22	13	122	177	106	97	26	17	126	KV1	110	101
22	16	7	KV1	171	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75	4	59	168	159	88	79	8	KV0	172	163	92	83
23	KV0	53	162	153	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1	50	41	150	141	70	61	54	45	154	145	74	65
24	44	35	144	135	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103	32	23	132	123	116	107	36	27	136	127	KV1	111
25	26	17	126	KV1	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85	14	5	178	169	98	89	18	9	KV0	173	102	93
26	8	KV0	172	163	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67	KV1	51	160	151	80	71	0	55	164	155	84	75
27	54	45	154	145	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113	42	33	142	133	62	117	46	37	146	137	66	KV1
28	36	27	136	127	96	87	16	7	KV1	171	100	91	20	11	120	175	104	95	24	15	124	179	108	99	28	19	128	KV0	112	103
29	18	9	KV0	173	78	69	KV0	53	162	153	82	73	2	57	166	157	86	77	6	KV1	170	161	90	81	10	1	174	165	94	85
30	0	55	164	155	60	115	44	35	144	135	64	119	48	39	148	139	68	KV0	52	43	152	143	72	63	56	47	156	147	76	67
31	46	37	146	137	106	97	26	17	126	KV1	110	101	30	21	130	121	114	105	34	25	134	125	118	109	38	29	138	129	KV0	113

NOTES

1 Columns 541 and 542 have the same distribution as column 540, columns 545 and 546 the same as 544, etc.

2 Numerical table entries represent horizontal position of byte within TV line. KV0 and KV1 are outer ECC check bytes.

Define the sector array row address, Row,
Row = (7 × Rcnt) mod 32

Col and Row define the sector array location where a data byte (either video data or outer correction check) is located.

For field 0, sectors 0 and 2, data are read from the sector array in a "raster scan" sequence and written to tape. (That is, the data in row 0, columns 0 through 599 are read, then row 1, columns 0 through 599, and so forth, through row 31).

For sectors 1 and 3, which are adjacent to sectors 0 and 2, respectively, on tape, the data are read out with a 16-row offset relative to sectors 0 and 2. In addition, there is a further variation of the row address over a 4-field sequence. Table 10 summarizes the row address modification necessary, depending on field and sector number.

Let p designate the inner block number on tape, 0 ≤ p ≤ 319.

Let q designate the byte number within an inner block on tape, 0 ≤ q ≤ 59.

Then p = 10R+ int(Col/60).
q = Col mod 60.

The byte at location (Row, Col) in the sector array thus appears at location 60p + q on the tape. The sync block ID number written on tape for even p is (int(p/2)+3) base 14.

4.4.2.2 Algorithm 2, intrasector deshuffling (reference only)

Given the inner block number, p, and position within the block, q, on tape, calculate R,

R = int (p/10), 0 ≤ R ≤ 31.

Calculate Row according to table 11.

Calculate Col,
Col = 60 (p mod 10) + q.

Thus, the byte at location 60p + q on the tape appears at (Row,Col) in the sector array.

Calculate the 4-column group number, Jgrp,
Jgrp = int (Col/4), 0 ≤ Jgrp ≤ 149.

Calculate the inverse permuted 4-column group number, Igrp,
Igrp = (11 × Jgrp) mod 150.

Calculate Icnt,
Icnt = (Igrp × 4) + (Col mod 4), 0 ≤ Icnt ≤ 599.

Define u = 0 for (Icnt mod 4) = 0,1,2,
u = 1 for (Icnt mod 4) = 3

Calculate Rstart,
Rstart = (30 × Igrp + 5u) mod 32,

Table 10 – Four-field sequence intrasector shuffling

	Sectors 0, 2	Sectors 1, 3
Field 0:	R = Row	R = (16 + Row) mod 32
Field 1:	R = (31 – Row) mod 32	R = (15 – Row) mod 32
Field 2:	R = (8 + Row) mod 32	R = (24 + Row) mod 32
Field 3:	R = (7 – Row) mod 32	R = (23 – Row) mod 32

Table 11 – Four-field intrasector deshuffling

	Sectors 0, 2	Sectors 1, 3
Field 0:	Row = R	Row = (16 + R) mod 32
Field 1:	Row = (31 – R) mod 32	Row = (15 – R) mod 32
Field 2:	Row = (24 + R) mod 32	Row = (8 + R) mod 32
Field 3:	Row = (7 – R) mod 32	Row = (23 – R) mod 32

Calculate Rcnt,
Rcnt = (23 × Row) mod 32,

Calculate Obyt,
Obyt = (Rcnt −Rstart) mod 32,

Calculate Oblk,
Oblk = Icnt mod 12,

Calculate line number, m,
m = int(Igrp/3), $0 \leq m \leq 49$,

The intrasector mapping from (m, Oblk, Obyt) to the output order may be derived from the formula in 4.3 and 4.4.1.

4.5 Outer error protection

Two rows of each video subarray contain the error correction check data associated with each column of 8-bit bytes.

Type: Reed-Solomon

Galois field: GF(256)

Field generator polynomial: $x^8 + x^4 + x^3 + x^2 + x^0$ (x^i are place keeping variables in GF(2), the binary field.

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

Code generator polynomial: $G(x) = (x + \alpha^0)(x + \alpha^1)$, where α^1 is given by 02_H in GF(256).

Check characters: K_1 and K_0 in $K_1x^1 + K_0x^0$, the remainder after dividing $x^2 \times D(x)$ by G(x), where D(x) is the polynomial given by $D(x) = B_{29}x^{29} + B_{28}x^{28} + ... + B_1x^1 + B_0x^0$

Equation of full code: $B_{29}x^{31} + B_{28}x^{30} + ... + B_0x^2 + K_1x^1 + K_0x^0$

Table 12 shows an example of three possible patterns, where pattern 1 is the impulse function, where the values in the check location represent the expansion of the code generator polynomial.

5 Audio processing

5.1 Introduction

Audio in each of the four channels is processed independently and identically into two product blocks with dimensions of 60 x 7 for each channel. The audio samples of each channel are distributed alternately into these two blocks and are then shuffled after the addition of error correction data in the vertical (7) dimension. Error correction in the horizontal (60) dimension is common with video data, as are synchronization and channel coding. Control words are multiplexed with the audio data in the product block to provide housekeeping in the interface and in processing.

5.2 Source coding (AES/EBU)

Audio records are formed independently for each of four audio channels, from audio and ancillary data at the input interface that meet the requirements of ANSI S4.40-1985. These data include audio data, channel status data (C), user data (U), and validity data (V). Parity bits are checked for correctness of data and then discarded. The resulting bit positions in the audio data words are reserved (R) for future use. Block sync marks for ancillary data are also processed.

Table 12 – Outer error protection patterns

	Data symbols — D (x)						Check symbols			
Symbol position	0	1	2	3	4	5	28	29	30	31
Pattern 1	00	00	00	00	00	00	00	01	03	02
Pattern 2	00	01	02	03	04	05	1C	1D	6B	6A
Pattern 3	CC	CC	CC	CC	CC	CC	CC	CC	4D	4D
Symbol identify	B_{29}	B_{28}	B_{27}	B_{26}	B_{25}	B_{24}	B_1	B_0	K_1	K_0

Source data is defined as follows:

5.2.1 Audio data

Sampling frequency: 48 kHz = 3 parts in 10^6, synchronous with video;

Sample timing: The first audio sample shall be time-coincident with line 9 of the video signal ± 6 lines (20 samples);

Word length: 20 + 4 bits;

Coding: Twos complement linear PCM.

5.2.2 Channel status data

Bit rate: 48 kbit/sec (nominal);

Word rate: 6 kbyte/sec;

Word length: 8 bits;

Block length: 192 bits, 24 words;

Coding: See ANSI S4.40-1985.

NOTES
1 Bytes 0 and 1 of status data only are selected for special processing in the digital television tape recorder. The contents of bytes 0 and 1 are shown in figures 11 and 12.
2 Bytes 22 and 23 of the status data contain protection and validity information for bytes 0-21 and may be used in some source decoders.

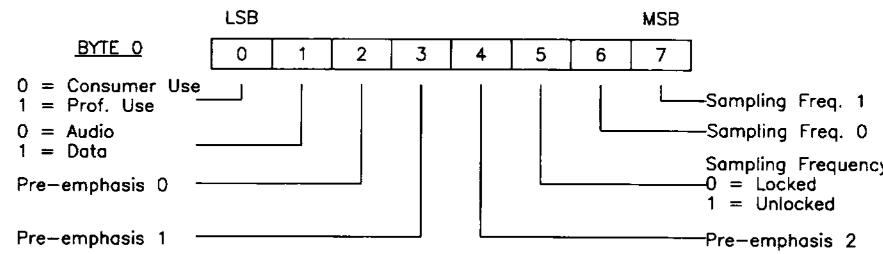
5.2.3 User data

As status data but data coding is undefined.

5.2.4 Validity data

Bit rate: One bit associated with each audio word;

Coding: 0 = sample valid; 1 = sample defective.



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

Figure 11 – Channel status data – Byte 0

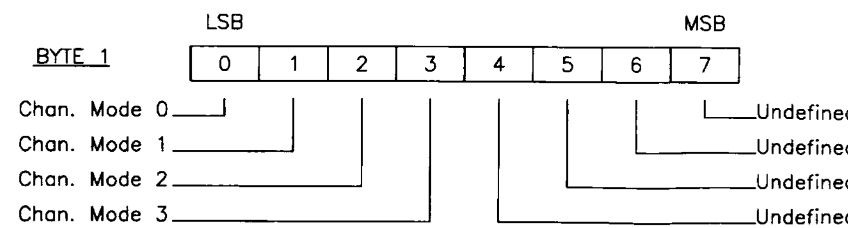


Figure 12 – Channel status data – Byte 1

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Table 13 – Byte status

Mode	0	1	2	3	
0	0	0	0	0	Undefined – 2 channel
1	0	0	0	1	2 channel
2	0	0	1	0	Single channel
3	0	0	1	1	Primary/secondary 2 channel
4	0	1	0	0	Stereophonic
5	0	1	0	1	} Undefined
through		through			
F	1	1	1	1	

5.2.5 Parity bit

Bit rate: One bit associated with each audio word;

Coding: Even parity of associated word including audio, status, user, and validity data.

5.3 Source processing

5.3.1 Introduction

Audio data is processed in segments corresponding in duration to four helical tracks or one-fifth of a video frame. Each segment contains approximately 320 audio samples for an audio channel with associated status, user, and validity data. In addition, a number of control and user words are added to the data in the last complete block received.

5.3.2 Segment

Each segment of audio data is processed into two audio blocks of 10 x 60 bytes, each corresponding to a sector. One block contains even-numbered words and the other odd-numbered words. The data portion of the block is 7 x 60 with the balance being outer error correction words. For convenience, data is processed in four-bit words:

Audio data word: 318 to 322 data words with associated C, U, V, R bits (20 bits total per word)

Interface control words: 6 words of four bits and 2 words of eight bits. (For security, one word, LNGH, is written four times in each block.)

Processor control words: 9 words of four bits. (For security, two words, BCNT and SEQN, are written four times in each block.)

User control words: 8 words of eight bits are included in each block, giving a total of 16 bytes per segment for user data.

5.3.3 Audio data word processing

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

5.3.3.1 Assignment of the twenty-bit word to audio and associated data is controlled by user input in accord with table 14.

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

5.3.3.2 The twenty-bit words formed as in 5.3.3.1 are separated into two groups by selection of alternate words into EVEN (0, 2, 4, etc.) and ODD (1, 3, 5, etc.) beginning at the start of the sequence.

5.3.3.3 Each group of twenty-bit words is divided into 8-bit bytes as shown in figure 13, beginning with the LSB of the first word of the word group.

5.3.3.4 Each group (ODD or EVEN) is distributed into the product block in accordance with figure 14. Word 159 (bytes 9,55; 9,56; 9,57) and word 160 (bytes 3,55; 3,56; 3,57) may not be present in all blocks depending on the current relationship between video and audio clock synchronization and phasing. When not used, this space is zero filled. The processing control word (PCW) B CNT specifies the length of the block between 397½ bytes (159 audio data words) and 402½ bytes (161 audio data words).

Table 14 – Audio interface control input

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

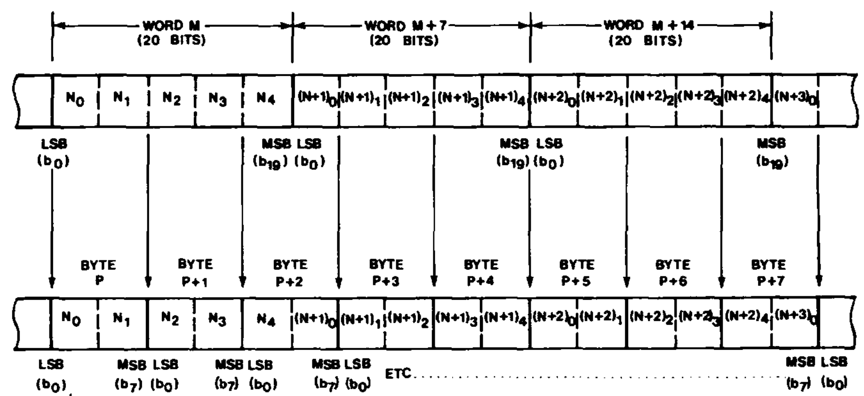
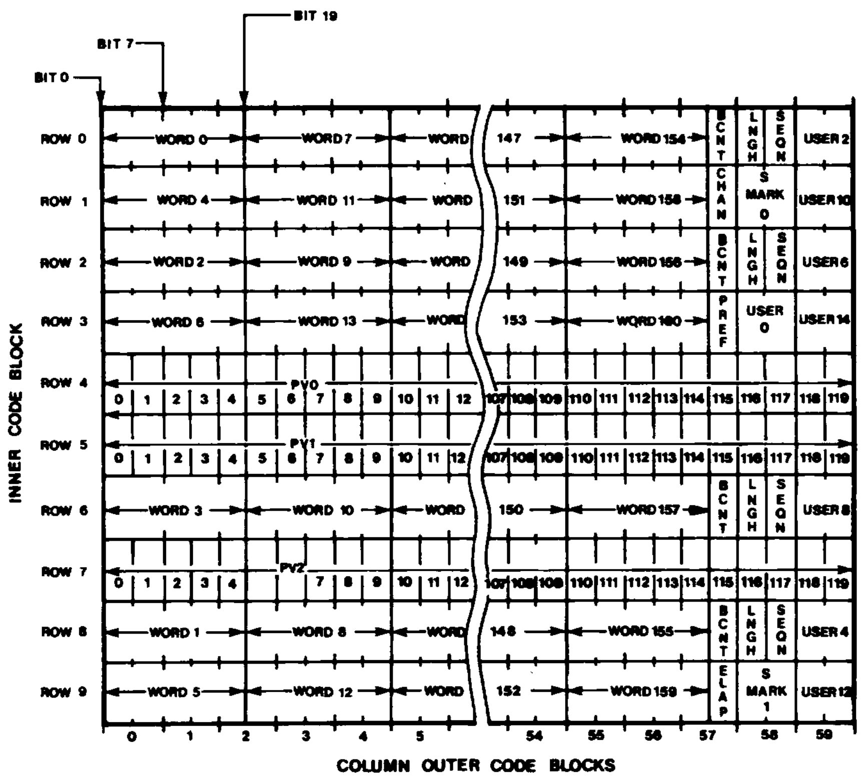


Figure 13 – Word to byte conversion for digital audio



NOTES
1 Words 159, 160 may not be data filled in all blocks.
2 Words 0, 1, 2, 3, etc., refer to a sequence of even audio data words in an even audio product block, and correspond to the odd audio data words in an odd audio product block.

Figure 14 – Audio data block layout (Even block shown – odd is similar)

5.3.3.5 Since audio data is synchronous with a 29.97 Hz video frame frequency, the sequence of blocks shall be in accordance with table 15.

The start of audio frame 0 is related to the control track reference pulse described in 6.7.

5.4 Interface control words

Interface control words (ICW) are generated at the input interface from incoming data or user selection and serve to signal this information to the output interface. ICWs have a length of four or eight bits.

5.4.1 Channel use (CHAN) — 4 bits

CHAN specifies the usage of the two input channels in an interface data stream. CHAN is derived from AES/EBU channel status byte 1. (See figure 15 and table 16.)

When CHAN bits are recorded on tape, they shall be put on the tape in the order of B0, B1, B2, and B3.

CHAN is inserted in bits 4-7 of byte (1,57) of both audio product blocks.

Table 15 – 525/60 audio frame block sequence

Frame No.	Segment No.	Audio sample count		
		Even block	Odd block	Frame
	00	160	160	
	01	161	160	
0	02	160	160	1602
	03	161	160	
	04	160	160	
	05	160	160	
	06	160	160	
1	07	161	160	1601
	08	160	160	
	09	160	160	
	0A	160	160	
	0B	161	160	
2	0C	160	160	1602
	0D	161	160	
	0E	160	160	
	0F	160	160	
	10	160	160	
3	11	161	160	1601
	12	160	160	
	13	160	160	
	14	160	160	
	15	161	160	
4	16	160	160	1602
	17	161	160	
	18	160	160	

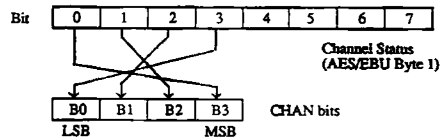


Figure 15 – Audio input channel status

Table 16 – Audio input channel status

	CHAN				
Mode	B3	B2	B1	B0	Value
0	0	0	0	0	2 channel – default
1	0	0	0	1	2 channel
2	0	0	1	0	Single channel
3	0	0	1	1	Primary/secondary 2 channel
4	0	1	0	0	Stereophonic
5	0	1	0	1	} Undefined
through		through			
F	1	1	1	1	

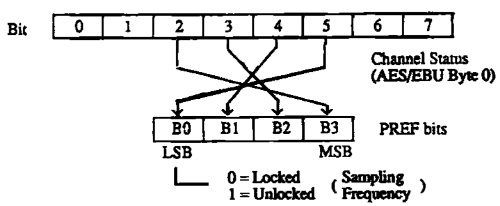


Figure 16 – Audio input preemphasis status

Table 17 – Audio input preemphasis status

	PREF bit			
Mode	B3	B2	B1	Value
0	0	0	0	Preemphasis off – (default)
1	0	0	1	Reserved
2	0	1	0	Reserved
3	0	1	1	Reserved
4	1	0	0	Preemphasis off
5	1	0	1	Reserved
6	1	1	0	50 / 15 microsec (CD type)
7	1	1	1	–6.5 dB at 800 Hz (CCITT J17)

5.4.2 Preemphasis (PREF) — 4 bits

PREF specifies the usage of preemphasis in the audio coding. Pref is derived from AES/EBU channel status byte 0. (See figure 16 and table 17).

When PREF bits are recorded on tape, they shall be put on the tape in the order of B0, B1, B2, and B3.

PREF is inserted in bits 4–7 of byte (3,57) of both audio product blocks.

5.4.3 Audio data word mode (LNGH) — 4 bits

LNGH specifies the audio word length and the usage of the ancillary bits Status, User, and Validity. LNGH is derived from user control inputs. (See figure 17 and table 18.) LNGH is inserted in bits 0–3 in column 58, rows 0,2,6,8.

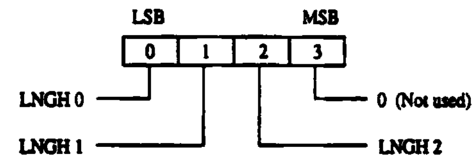


Figure 17 – Audio data word length

Table 18 – Audio data word length

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

5.4.4 Block sync location S MARK 0, S MARK 1 — 8 bits

Specifies the location of the first and last block sync associated with channel status and user data as defined in clause 6 of ANSI S4.40-1985. S MARK 0 contains the word count, in the current block, of the first block sync detected; i.e., the word address in the ODD or EVEN block pointing to the first sample after the block sync mark. S MARK 1 identifies the last block sync detected. Where multiple marks are encountered, only the last one will be stored. (See figure 18.)

S MARK 0, S MARK 1 = AA_H if no mark is found within the defined range.

S MARK 1 = AA_H if only one mark is found within the defined range.

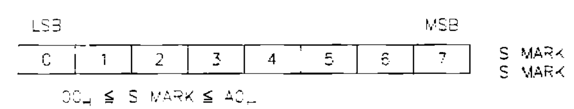


Figure 18 – Audio block sync

S MARK 0 is inserted in byte 1,58 of each block, with the default value AA_H placed in corresponding location in the block (ODD or EVEN) not containing the mark. S MARK 1 is inserted similarly in byte (9,58).

5.5 Processing control words

Processing control words (PCW) are employed to pass control information from the record processor to the playback processor. They consist of 4-bit or 8-bit words.

5.5.1 Word count (B CNT) — 4 bits

B CNT specifies the number of useful data words in the current block, a number lying between 159 and 161 words (397.5 to 402.5 bytes). (See figure 19.)

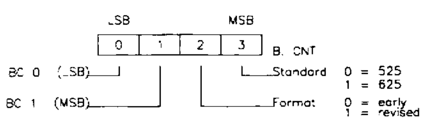


Figure 19 – Audio word block count

B CNT is inserted in bits 4-7 of bytes (0,57), (2,57), (6,57), (8,57) of the associated block.

5.5.2 Overlap edit (E LAP) — 4 bits

E LAP specifies the segment associated with an overlap edit transition, during which time the new (downstream) audio data replaces the old (upstream) audio data only in the duplicate audio sector rows 2 and 3.

LSB MSB
0 1 2 3 E LAP

E LAP = F_H for an overlap segment

E LAP = 0_H otherwise

E LAP is inserted in bits 4–7 of byte (9,57) of both blocks.

5.5.3 Sequence (SEQN) — 4 bits

SEQN specifies a sequence of 15 blocks (each of 4 fields) to aid processing in high-speed data recovery.

LSB MSB
0 1 2 3 SEQN

SEQN advances in binary count, modulo 15 from an arbitrary origin; is inserted in bits 4–7 of column 58 rows 0, 2, 6, 8, and may be discontinuous after editing operations.

5.6 User control words (UCW)

User control words serve to pass user information from the record processor to the playback processor. They are of 8-bit length. Their contents are not specified herein. UCWs are provided in table 19. UCW 0 is undefined and reserved by SMPTE for future use.

Table 19 – User control words

UCW	BLOCK	BYTE
0	EVEN	(3,58)
2	EVEN	(0,59)
4	EVEN	(8,59)
6	EVEN	(2,59)
8	EVEN	(6,59)
10	EVEN	(1,59)
12	EVEN	(9,59)
14	EVEN	(3,59)
1	ODD	(3,58)
3	ODD	(0,59)
5	ODD	(8,59)
7	ODD	(2,59)
9	ODD	(6,59)
11	ODD	(1,59)
13	ODD	(9,59)
15	ODD	(3,59)

5.7 Outer error protection

Rows 4, 5, 7 of the blocks contain the error protection data associated with each column.

Type: Reed-Solomon

Galois field: GF(16)

Field generator polynomial: $x^4 + x^1 + x^0$; (x^i are place keeping variables in GF(2), the binary field.)

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

Code generator polynomial (in GF(16)): $G(x) = (x + \alpha^0)(x + \alpha^1)(x + \alpha^2)$. α^1 is given by 02_H in GF(16).

Check characters: K_2, K_1, K_0 (identified respectively as PV_2, PV_1, PV_0) in $K_2x^2 + K_1x^1 + K_0x^0$, the remainder after dividing the polynomial $x^3 \times D(x)$ by G(x), where D(x) is the polynomial given by $D(x) = B_6x^6 + B_5x^5 + ... + B_1x^1 + B_0x^0$

Equation of full code: $B_6x^9 + B_5x^8 + ... + B_0x^3 + K_2x^2 + K_1x^1 + K_0x^0$

Outer-code check characters in each column of the 60 x 10 blocks are calculated using the data order existing prior to the rearrangement into the pattern shown in figure 14; i.e., in ascending sample order.

The check characters K_2 through K_0 are used as the vertical protection characters PV_2 through PV_0, respectively, and inserted in their associated column at rows 4, 5, 7.

Table 20 shows an example of three possible patterns, where pattern 1 is the impulse function, where the values in the check locations represent the expansion of the code generator polynomial.

5.8 Inner protection and channel coding

Generation of the inner code check characters PH_0 through PH_3 is fully described in clause 3 of this standard. This coding is common with the video processor.

5.9 Order of transmission to inner coding

The block of data shown in figure 15 is passed sequentially to the inner coding process as follows:

Row 0 — col 0 to 59
Row 1 — col 0 to 59
|
Row 9 — col 0 to 59

5.10 Sector usage

Audio data from each of the four recording channels is placed on tape as shown in figure 20. Each data block (ODD and EVEN) from a channel (1,2,3,4) is recorded twice. During the overlap period of an edit, the new data is recorded only in audio sector rows 2 and 3 and the existing data is retained in audio sector rows 0 and 1.

6 Tracking control record

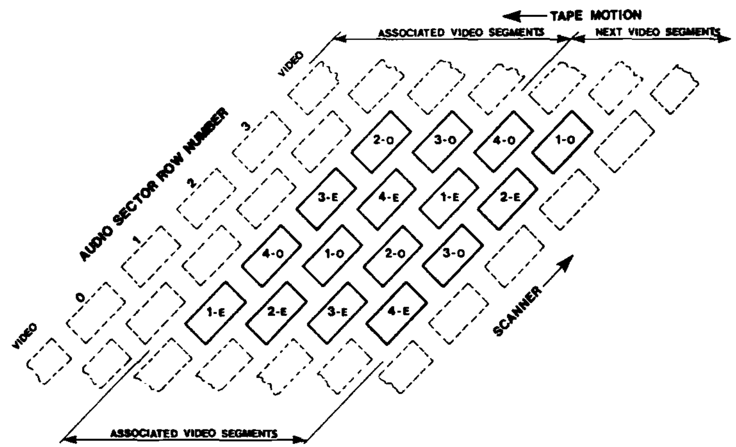
6.1 The tracking control record shall be a series of pulse doublets recorded on the track as shown in figure 21. The location of the tracking control record and its positioning relative to video information is defined in SMPTE 224M.

6.2 During time interval A of the record, the polarity of the tracking-control flux shall be such that the south pole of the magnetic domain points in the direction of normal tape travel and, similarly, during time interval B, the north pole shall be similarly oriented.

Table 20 – Outer error protection patterns

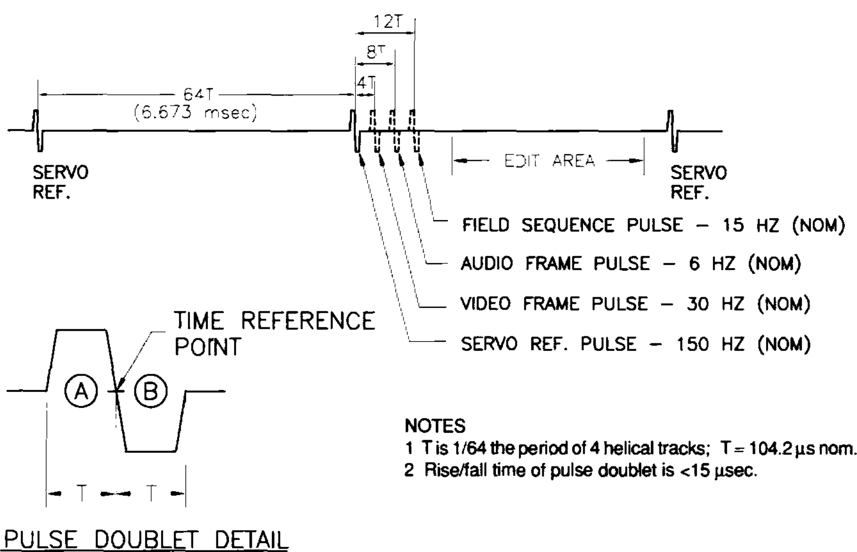
	Data symbols – D(x)							Check symbols		
Symbol position	0	1	2	3	4	5	6	7	8	9
Pattern 1	0	0	0	0	0	0	1	7	E	8
Pattern 2	0	1	2	3	4	5	6	B	0	C
Pattern 3	C	C	C	C	C	C	C	6	9	3
Symbol identify	B_6	B_5	B_4	B_3	B_2	B_1	B_0	K_2	K_1	K_0

SMPTE 227M



NOTE – 1, 2, 3, 4, indicate channel numbers.
O = ODD samples; E = EVEN samples.

Figure 20 – Audio sector arrangement



NOTES
1 T is 1/64 the period of 4 helical tracks; T = 104.2 μs nom.
2 Rise/fall time of pulse doublet is <15 μsec.

Figure 21 – Recorded control record waveform timing

6.3 The recorded peak-to-peak flux shall correspond to an RMS magnetic short circuit flux level of 185 nwb/m ± 20 nWb/m of track width.

6.4 The recorded pulse doublets shall each have a half-width T, where T is 1/64 times the period of four helical tracks. The record current rise and fall times shall be less than 15 microseconds (10-90 percent), and be matched within 5 microseconds.

6.5 Servo reference pulse doublets shall be separated by a pitch distance equivalent to four helical tracks (150 Hz nominal frequency). They are aligned with the end of the preamble for video section 0, as shown in SMPTE 224M.

6.6 A second pulse doublet shall indicate the first segment of the video frame. It shall be located a distance 4T after the servo reference pulse doublet. (The video frame begins when F = 0 in the end of active video [EAV] timing reference signal, as shown in CCIR Report AG/11, that occurs in segment 0 of field 0).

6.7 A third pulse doublet shall, when present, indicate the start of an audio frame sequence. It shall be located at a distance 8T after the servo reference pulse doublet.

6.8 A fourth pulse doublet shall indicate the start of a field sequence. It shall be located at a distance 12T after the servo reference pulse doublet. This pulse doublet may be referenced to an external 15-Hz (nominal) signal.

6.8.1 If the signal being recorded has been decoded from an NTSC source, the field sequence pulse should identify field 1.

6.8.2 For a continuous recording, the field sequence pulse should not change its place.

6.9 Any edit shall take place in the unmagnetized space between pulse groups.

Annex A (informative)
Bibliography

SMPTE 125, Television — Bit-Parallel Digital interface — Component Video Signals 4:2:2

SMPTE 225M, Television Digital Component Recording — 19-mm Type D-1 — Magnetic Tape

SMPTE 226M, Television Digital Component and Composite Recording — 19-mm Type D-1 and D-2 — Tape Cassette

SMPTE 228M, Television Digital Component Recording — 19-mm Type D-1 — Time and Control Code and Cue Records

SMPTE 244M, Television Digital Recording — Representation of NTSC Encoded (System M) Video Signal — Active Video Portion

SMPTE EG 10, Tape Transport Geometry Parameters for 19-mm Type D-1 Television Digital Component Recording

SMPTE EG 21, Nomenclature for Television Digital Recording, 19-mm Type D-1 Component and Type D-2 Composite Formats

CCIR Report AG/11, The Filtering, Sampling and Multiplexing of Colour Component Signals for Systems Using Digital Modulation

CCITT Blue Book Vol III.6, Line Transmission of Non-telephone Signals. Transmission of Sound-Programme and Television Signals. Series H and J Recommendations (Study Group XV)

PROPOSED SMPTE STANDARD

SMPTE 228M

for Television Digital Component Recording — 19-mm Type D-1 — Time and Control Code and Cue Records

1 Scope

This standard specifies the content, format, and modulation method of the longitudinal records contained in the cue track and the time-code track in 19-mm type D-1 television digital component recording. Track dimensions and locations are specified in SMPTE 224M. The document applies to recorders operating in the 525-line television system with a frame frequency of 29.97 Hz.

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 editions of the standards indicated below.

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

SMPTE 224M, Television Digital Component Recording — 19-mm Type D-1 — Tape Record

3 Cue record

3.1 Method of recording

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

3.2 Flux level

The recorded standard operating audio level shall correspond to an rms magnetic short-circuit flux level of 70 nWb/m ± 10 nWb/m of track width at 1000 Hz.

3.3 Recorded flux characteristics

When a tape record is recorded from a constant voltage level applied to the input terminals of the recording system, the short-circuit tape flux level on the record versus frequency shall remain constant.

3.4 Relative timing

Cue information shall be recorded on the tape at a point referenced to the associated video information as defined by dimension P of SMPTE 224M. (Cue audio may be up to 100 TV lines early.)

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4 Time and control code record

4.1 Code

The longitudinal time and control code specified in ANSI/SMPTE 12M-1986 shall be used.

4.2 Method of recording

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

4.3 Flux level

The recorded peak flux shall correspond to an rms magnetic short-circuit flux level of 185 nWb/m ± 20 nWb/m of track width.

4.4 Channel code

Time and control code data shall employ bi-phase mark coding.

4.5 Bit zero

The location of bit zero of the time code on tape shall be a distance, P (see SMPTE 224M), ahead of the upper video sector of field 1 of the associated video data, as defined in SMPTE 125M.

Annex A (informative)
Bibliography

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

SMPTE 225M, Television Digital Component Recording — 19-mm Type D-1 — Magnetic Tape

SMPTE 226M, Television Digital Component and Composite Recording — 19-mm Type D-1 and D-2 — Tape Cassettes

SMPTE 227M, Television Digital Component Recording — 19-mm Type D-1 — Helical Data and Control Records

SMPTE EG 10, Tape Transport Geometry Parameters for 19-mm Type D-1 Television Digital Component Recording

SMPTE EG 21, Nomenclature for Television Digital Recording, 19-mm Type D-1 Component and Type D-2 Composite Formats

SMPTE Journal, March 1992

PROPOSED SMPTE ENGINEERING GUIDELINE

EG 10

Tape Transport Geometry Parameters for 19-mm Type D-1 Television Digital Component Recording

1 Scope

This guideline describes three feasible examples of mechanical designs and test conditions for achieving the record dimensions specified in SMPTE 224M. The parameters are for reference purposes only.

2 Definitions

2.1 scanner: A mechanical assembly containing a drum, rotating pole tips, and tape-guiding elements used to record and reproduce digital audio and video data.

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

2.3 helix angle: An angle formed between the path of the rotating pole tips and the tape reference edge-guiding system on the scanner of the helical-scan digital audio and video recording system.

2.4 track angle: An angle of the helical track record with respect to the reference edge of the tape.

2.5 effective wrap angle: An angle at the center of the drum subtended by the start and endpoint of the track.

2.6 total wrap angle: An angle at the center of the drum subtended by the lines of contact between the drum and the reference edge of the tape.

2.7 tape tension: Tape tension is defined by the tension after the entrance guide and before the exit guide scanner.

2.8 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 the digital audio and video recording system.

3 General specifications

3.1 Dimensions are in the metric system.

3.2 Tests and measurements made on the recorder to check the requirements of this guideline shall be made under the following atmospheric conditions:

– Temperature	20°C ± 1° C
– Relative humidity	(50 ± 2)%
– Barometric pressure	96 kPa ± 10 kPa
– Conditioning of the recorder before testing	Not less than 24 hours

4 Scanner parameters

4.1 The effective drum diameter, tape tension, helix angle, and tape speed taken together determine the track angle. Different methods of design and/or variations in drum diameter and tape tension can produce equivalent recordings for interchange purposes.

4.2 Three possible design examples are specified in the tables and figures.

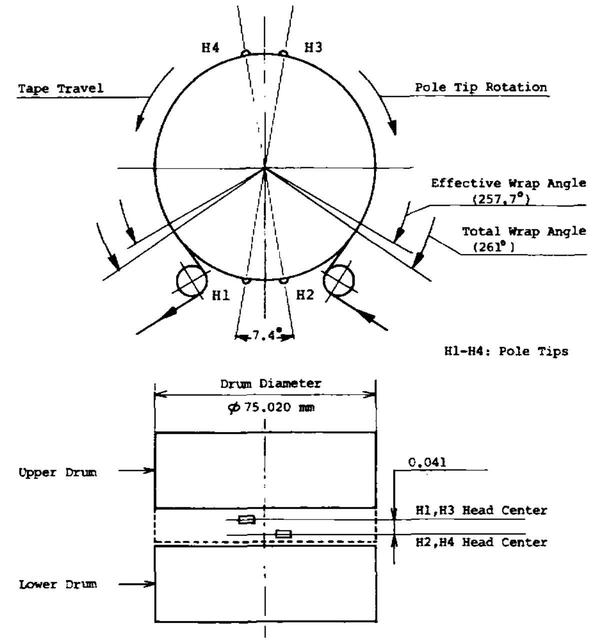

Figure 1 – Scanner configuration for design I

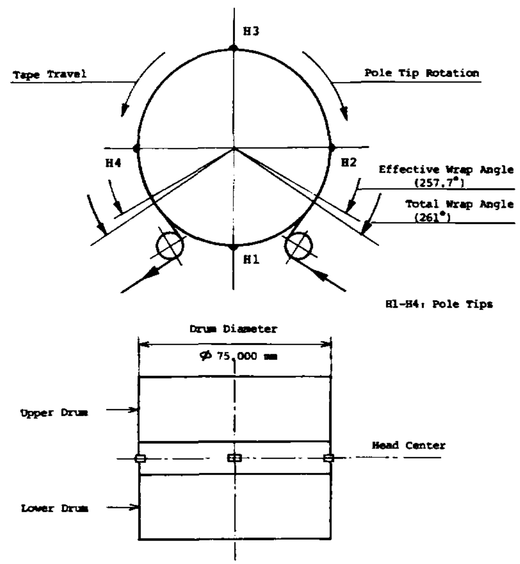

Figure 2 – Scanner configurtion for design II

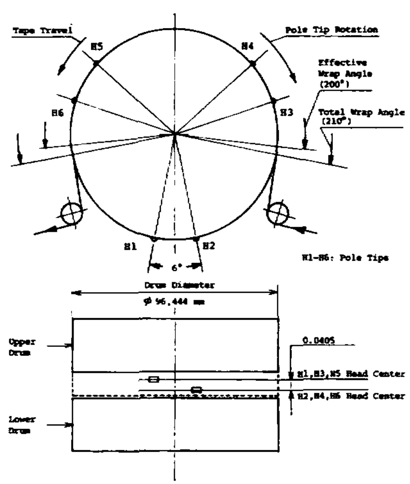

Figure 3 – Scanner configuration for design III

Table 1 – Pole tip relationships for design I, II and III

Parameters	Design I	Design II	Design III
Relevant figures	Figure 1	Figure 2	Figure 3
Minimum number of pole tips	4	4	6
Angular relationship	H1 – H2: 7.4° H3 – H4: 7.4° H1 – H3: 180° H2 – H4: 180°	H1, H2, H3, and H4 equispaced 90° ± .00833°	H1 – H2: 6.0° H3 – H4: 6.0° H5 – H6: 6.0° H1 – H3: 120.0° H3 – H5: 120.0° H5 – H1: 120.0°
Vertical displacement (mm)	H1 – H2: 0.041 H3 – H4: 0.041	± 0.002 max	H1 – H2: 0.0405 H3 – H4: 0.0405 H5 – H6: 0.0405
Maximum tip projection (μm)	45	45	60

Table 2 – Scanner design parameters

Parameters		Design I	Design II	Design III
Scanner rotation speed (r.p.s.)		150/1.001	150/1.001	100/1.001
Number of tracks per rotation		4	4	6
Drum diameter Upper (mm) Lower (mm)		 75.020 ± 0.005 75.000 ± 0.005	 75.000 ± 0.005 75.000 ± 0.005	 96.444 96.400
Tape tension	IN	NA	0.6 ± 0.005	NA
	OUT	NA	1.0 ± 0.1	NA
Center span tension	(N)		0.8 ± 0.2	
Helix angle		5.4444° ± .0028°	5.4441° ± .0002°	5.4517°
Effective wrap angle		257.7°	257.7°	200.0°
Total wrap angle		261.0°	261.0°	210.0°
Scanner circumferential speed (m/sec)		35.3	35.3	30.3

NA = Not available at this time.

Annex A (informative)
Bibliography

SMPTE 224M, Television Digital Component Recording — 19-mm Type D-1 — Tape Record

SMPTE 225M, Television Digital Component Recording — 19-mm Type D-1 — Magnetic Tape

SMPTE 226M, Television Digital Component and Composite Recording — 19-mm Type D-1 and D-2 — Tape Cassette

SMPTE 227M, Television Digital Component Recording — 19-mm Type D-1 — Helical Data and Control Records

SMPTE 228M, Television Digital Component Recording — 19-mm Type D-1 — Time and Control Code and Cue Records

SMPTE EG 21, Nomenclature for Television Digital Recording, 19-mm Type D-1 Component and Type D-2 Composite Formats

CCIR Recommendation 601, Encoding Parameters of Digital Television for Studios