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2005-10

Helical-scan digital video cassette recording format using 12,65 mm magnetic tape and incorporating MPEG-4 compression – Type D-16 format

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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HELICAL-SCAN DIGITAL VIDEO CASSETTE RECORDING FORMAT USING 12,65 mm MAGNETIC TAPE AND INCORPORATING MEPG-4 COMPRESSION – TYPE D-16 FORMAT (TA6)

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International Standard IEC 62141 has been prepared by IEC technical committee 100: Audio, video and multimedia systems and equipment.

The text of this standard is based on the following documents:

CDV	Report on voting
100/925/CDV	100/1004/RVC

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
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A bilingual version of this publication may be issued at a later date.

HELICAL-SCAN DIGITAL VIDEO CASSETTE RECORDING FORMAT USING 12,65 mm MAGNETIC TAPE AND INCORPORATING MEPG-4 COMPRESSION – TYPE D-16 FORMAT (TA6)

1 Scope

This International Standard specifies the track content, format, and recording method of the data blocks containing compressed video, AES3 audio data, and associated data which form the helical records on 12,65 mm tape in cassettes. This standard supports recording of source picture formats using 1920 × 1080 pixels with the 4:4:4 and 4:2:2 sampling structure specified in SMPTE 274M at the frame rate of 23,98 Hz, 24 Hz, 25 Hz and 29,97 Hz, and using 1280 × 720 pixels with the 4:2:2 sampling structure specified in SMPTE 296M at the frame rates of 50 Hz and 59,94 Hz (see note). This standard also supports recording of 12 channels of AES3 audio data and 3 lines of uncompressed blanking interval data. This standard includes packetizing and shuffling operations supporting picture compression using the DCT and DPCM encoding methods defined by ISO/IEC 14496-2 (MPEG-4 simple studio profile).

NOTE Early implementations of this standard might not comply to the frame rate of 50 Hz as specified in SMPTE 296M.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61213:1993, *Analogue audio recording on video tape – Polarity of magnetization*

IEC 61237-1:1994, *Broadcast video tape recorders – Methods of measurement – Part 1: Mechanical measurements*

ISO/IEC 14496-2:2004, *Information technology – Coding of audio-visual objects – Part 2 : Visual*

ITU-R Recommendation BT.709:2002, *Parameter values for the HDTV standards for production and international programme exchange*

SMPTE 12M:1999, *Television – Audio and Film – Time and Control Code*

SMPTE 274M:2003, *Television – 1920 × 1080 Scanning and Analog and Parallel Digital Interfaces for Multiple Picture Rates*

SMPTE 276M:1995, *Transmission of AES-EBU Digital Audio Signals Over Coaxial Cable*

SMPTE 292M:1998, *Bit-Serial Digital Interface for High-Definition Television Systems*

SMPTE 296 M:2001, *Television – 1280 × 720 Progressive Image Sample Structure – Analog and Digital Representation and Analog Interface*

SMPTE 299M:1997, *Television – 24-Bit Digital Audio Format for HDTV Bit-Serial Interface*

SMPTE 372M:2002, *Television – Dual Link 292M Interface for 1920 x 1080 Picture Raster*

SMPTE RP 188:1999, *Transmission of Time Code and Control Code in the Ancillary Data Space of a Digital Television Data Stream*

AES3-1997, *Serial transmission format for two-channel linearly represented digital audio data*

3 Terms, definitions and acronyms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

23,98, 29,97, 59,94:	When used as values of field or frame rates, exact values are respectively: 24/1.001, 30/1.001, 60/1.001.
alternate_scan:	A 1-bit flag, fixed to ‘1’ in this format, defined in ISO/IEC 14496-2.
Basic block:	The basic packing unit, comprising 4 block identifier (BID) bytes and 226 payload bytes containing auxiliary or compressed picture data.
BID:	Block identifier bytes in each basic block, BID0 to BID3.
bits_per_pixel:	A 4-bit integer, fixed to ‘10’ in this format, defined in ISO/IEC 14496-2.
block_mean:	A 10-bit unsigned integer, defined for DPCM encoding in ISO/IEC 14496-2.
Chroma_format:	A 1-bit value indicating YC_BC_R or RGB mode, defined in ISO/IEC 14496-2.
Chroma_intra_quantiser_matrix:	A list of 64 8-bit unsigned integers, defined in ISO/IEC 14496-2.
Coded sequence:	A group of 24 auxiliary basic blocks followed by 4080 compressed data basic blocks.
Coding channel:	The MBU encoding process, producing coded sequences.
Compression_mode:	A 1-bit flag indicating DCT or DPCM coding, defined in ISO/IEC 14496-2.
dct_precision:	A 2-bit integer, defined in ISO/IEC 14496-2.
dct_type:	A 1-bit flag, fixed to ‘1’ in this format, defined in ISO/IEC 14496-2.
dpcm_scan_order:	A 1-bit flag used in the DPCM coding, defined in ISO/IEC 14496-2.
frame_rate_code:	A 4-bit integer indicating the frame rate, defined in ISO/IEC 14496-2.
intra_dc_precision:	A 2-bit integer, fixed to ‘0’ in this format, defined in ISO/IEC 14496-2.
intra_quantizer_matrix:	A list of 64 8-bit unsigned integers, defined in ISO/IEC 14496-2.
Macro block	A 16×16 area of picture data, rearranged shuffle block. Note that this block is not equivalent to the ‘macroblock’ defined for ISO/IEC14496-2.
MBU:	Macro block unit, A group of 204 or 180 macro blocks, used for rate control and packing.
q_scale_type:	A 1-bit flag used in the Quantiser, defined in ISO/IEC 14496-2.
quantizer_scale_code:	A 5-bit unsigned integer, defined in ISO/IEC 14496-2.
Record unit:	For picture formats with 23,98 Hz, 24 Hz, 25 Hz and 29,97 Hz frame rates, equivalent to a frame, For picture format with 50 Hz and 59,94 Hz frame rate format, equivalent to a successive frame pair.

rgb_components:	A 1-bit flag indicating 4:2:2 or 4:4:4 data, defined in ISO/IEC 14496-2.
rice_parameter:	A 4-bit integer used in DPCM coding, defined in ISO/IEC 14496-2.
Sector:	A data unit that includes a preamble, sync blocks and a postamble, comprising the minimum record block in a helical track.
Segment:	A time interval that represents a field of video for I and PsF picture formats and a frame of video for P picture formats. A Segment has half the duration of a Record Unit.
Shuffle block	A 16 × 16 area of picture data from a field or frame.
VTR:	Video Tape Recorder. A Type D-16 tape recorder in this document.

3.2 Acronyms

For the purposes of this document, the following acronyms apply.

AUX:	Auxiliary
DCT:	Discrete cosine transform
DPCM:	Differential pulse code odulation
ECC:	Error correcting code
EOB:	End of block
I:	Interlace scan format
NRZ:	Non return to zero
MUX:	Multiplex
P:	Progressive scan format
PCM:	Pulse code modulation
PsF:	Progressive scan format with segmented frame structure.
RU:	Record unit
RS:	Reed-Solomon
TC:	Time code
VLC:	Variable length coding

4 Environment and test conditions

Tests and measurements made on the system to check the tape track recorder requirements of this standard shall be carried out under the following conditions:

- temperature: 20 °C ± 1 °C
- relative humidity: 50 % ± 2 %
- barometric pressure: from 86 kPa to 106 kPa
- tape tension: 0,3 N ± 0,05 N
- tape conditioning: not less than 24 h

4.1 Calibration tape

Calibration tapes meeting the tolerances specified below should be made available by manufacturers of digital television tape recorders and players in accordance with this standard.

4.2 Record locations and dimensions

Geometrical location and dimensions of the recordings on the tape and their relative positions with regard to timing relations of the recorded signals shall be as specified in Figure 27 and Table 2. Tolerances shown in Table 2 should, however, be reduced by 50 % for calibration tapes.

5 Tape and cassette physical specifications

5.1 Magnetic tape specifications

5.1.1 Base

The base material shall be polyester or equivalent.

5.1.2 Tape width and width fluctuation

The tape width shall be 12,650 mm ± 0,005 mm. Tape width fluctuations shall not exceed 6 μm peak to peak. The value of tape width fluctuation shall be evaluated by measuring 10 points, each 20 mm apart, over a tape length of 200 mm.

5.1.3 Tape thickness

The tape thickness shall have a minimum value of 10,1 μm and a maximum value of 11,3 μm.

5.1.4 Offset yield strength

The offset yield strength shall be greater than 13 N.

5.1.5 Magnetic coating

The magnetic tape used shall have a coating of metal particles or equivalent, longitudinally oriented. The coating coercivity shall be in the range of 190 000 A/m to 240 000 A/m, with an applied field of 800 000 A/m (10 000 oersted) as measured by a 50 Hz or 60 Hz BH meter or vibrating sample magnetometer (VSM).

5.2 Cassette specifications

5.2.1 Cassette dimensions

Two sizes of cassettes shall be identified as follows.

S cassette:	96 × 156 × 25 mm	(as shown in Figures 1 to 13)
L cassette:	145 × 254 × 25 mm	(as shown in Figures 14 to 26)

5.2.2 Tape length and recording time

Maximum tape length and recording time are recommended as follows.

S cassette:	293 m $^{+2}_{-0}$ m	40 min for 29,97 Hz RU rate	48 min for 25 Hz RU rate	50 min for 23,98 Hz and 24 Hz RU rates
L cassette:	893 m $^{+2}_{-0}$ m	124 min for 29,97 Hz RU rate	148 min for 25 Hz RU rate	155 min for 23,98 Hz and 24 Hz RU rates

5.2.3 Datum planes

Datum plane Z shall be determined by three datum areas A, B and C, as shown in Figures 3a and 16a. Datum plane X shall be orthogonal to datum plane Z and shall include the centres of datum holes (a) and (b). Datum plane Y shall be orthogonal to both datum plane X and datum plane Z and shall include the centre of the datum hole (a) as shown in Figures 2 and 15.

5.2.4 Tape winding

The magnetic coating side of the magnetic tape shall face outside on both the supply reel and the take-up reel as shown in Figures 4 and 17.

5.2.5 Label area and window area

The hatched areas shown in Figures 1 and 14 are for the label and window. Labels attached to the cassette shall not protrude above the outside cassette surface plane.

5.2.6 Guiding groove

For correct insertion into the VTR, four guiding grooves for S cassettes, as shown in Figures 1 and 2, and three guiding grooves for L cassettes, as shown in Figure 15, shall be provided.

5.2.7 Safety tab and safety plug for recording inhibition

For S cassettes, a safety plug at the supply reel side and a hole of a minimum depth of 10 mm from datum plane Z at the take-up reel side shall be provided as shown in Figure 2.

For L cassettes, a safety plug shall be provided at the take-up reel side as shown in Figure 15.

The safety plug shall not be deformed by 0,3 mm or more when a force of 2,0 N (204 gf) is applied to the centre of it, using a 2,5 mm diameter rod. See Figures 12 and 25.

5.2.8 Identification holes

Six identification holes (holes 1 to 6) shall be located as specified in Figures 2 and 15. For this format, holes 1, 3 and 6 shall be closed and holes 2, 4 and 5 shall be open.

5.2.9 Reels

The reels shall be automatically unlocked when the cassette is inserted into the video tape recorder and/or player unit and automatically locked when the cassette is ejected from it.

The locations of the reels, when in the unlocked position, are shown in Figures 4 and 17. The dimensions of the reels are shown in Figures 6 and 19 and the heights of the reels are shown in Figures 7 and 20.

The reel shall be completely released when the cassette lid is opened 23,5 mm min. from datum plane Z.

5.2.9.1 Reel spring force

The reels assembled in the cassette shall be pressed by the reel spring with a specified force under the conditions specified in Figures 11 and 24. The spring force shall be 1,5 N ± 0,5 N (153 gf ± 51 gf) for S cassettes and 3,5 N ± 0,5 N (357 gf ± 51 gf) for L cassettes when pressing on a reel 2,4 mm above datum plane Z, as shown in Figures 11 and 24.

5.2.9.2 Extraction force

The force (F1, F2) required to pull the tape out of the reel shall not exceed 0,17 N (17 gf), as specified in Figures 13a and 26a.

5.2.9.3 Friction torque

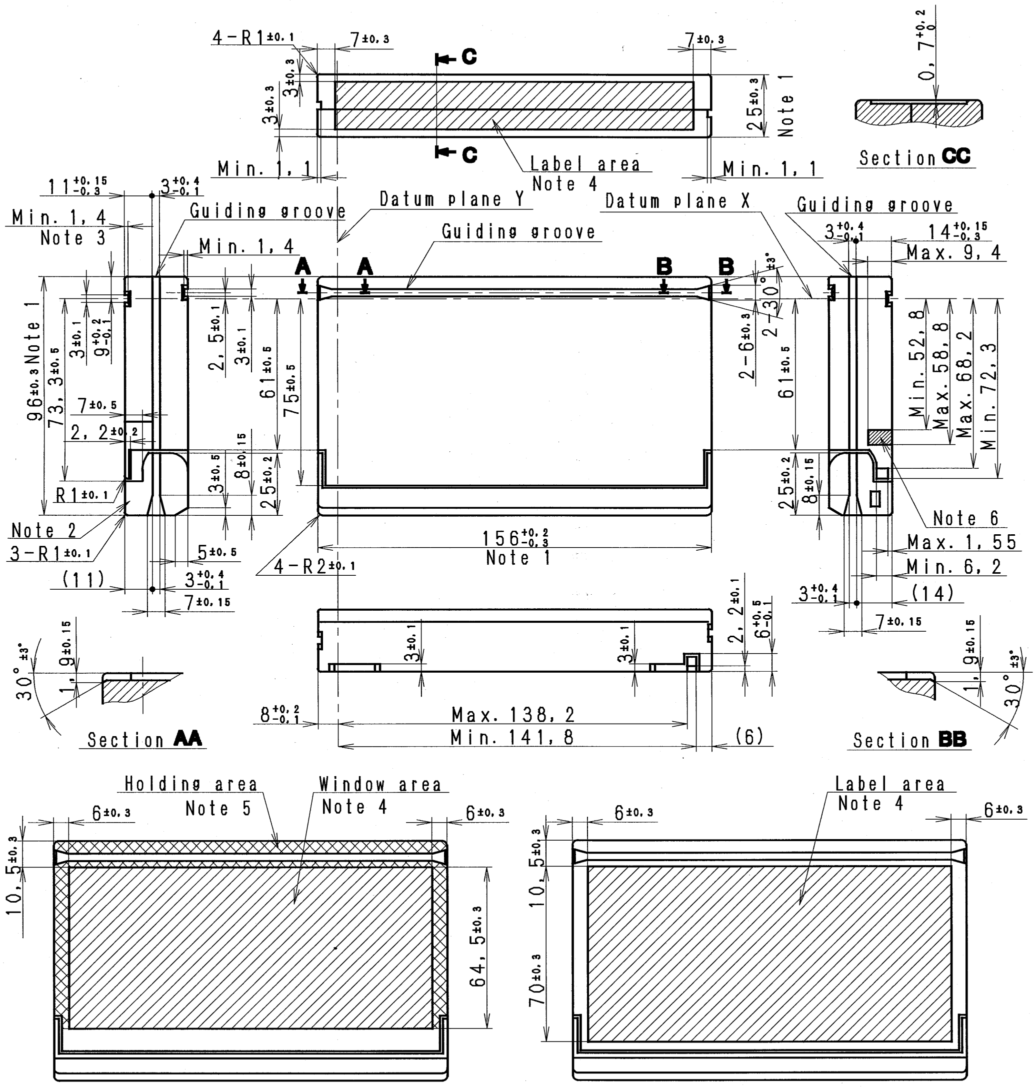
The torque required to wind the tape shall be less than 15 mN m (152 gf cm) for S cassettes and less than 30 mN m (305 gf cm) for L cassettes, as specified in Figures 13b and 26b.

5.2.10 Protecting lid

The cassette lid shall be automatically unlocked when the cassette is inserted into the video tape recorder and/or player unit and automatically locked when the cassette is ejected from it.

The unlocking lever insertion area is specified in Figures 8 and 21. The lid shall be unlocked when the lid-lock lever is shifted in either direction A or B, as illustrated in Figures 9 and 22. The force required to unlock the lid shall be less than 1 N (101 gf) in the A direction or less than 1,5 N (152 gf) in the B direction.

The lid shall open 29,0 mm with a force of 1,5 N (152 gf) or less as specified in Figures 10 and 23.



Dimensions in millimetres

NOTE 1 These dimensions are inspected by using limit gauges.

NOTE 2 No part of the lid should protrude beyond the bottom plane of the cassette when the lid opens nor when it closes.

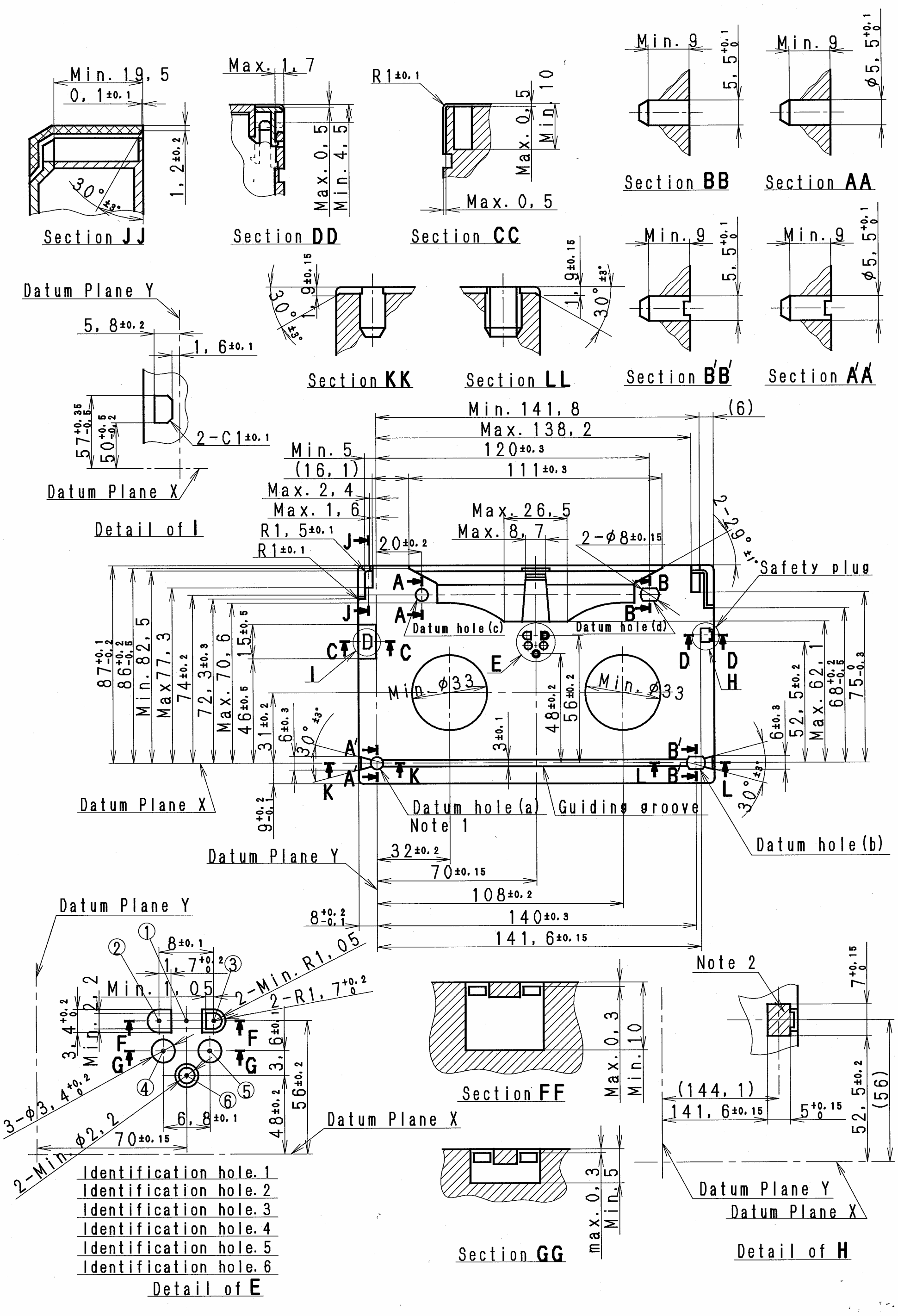
NOTE 3 These dimensions should be specified on the basis of datum plane Z.

NOTE 4 Label and/or window area, shown by the hatched area, is available for the label and/or window.

NOTE 5 The cassette may be held in position by the recorder and/or player unit on the holding area shown by the cross-hatched area.

NOTE 6 The fine-hatched area shows the acceptable range of plug notch position and depth at the side.

Figure 1 – Top- and side-view dimensions (S-cassette)



Dimensions in millimetres

NOTE 1 Datum hole (a) is primary.

NOTE 2 The cross-hatched area shows the VTR detection area.

NOTE 3 Datum holes (a) and (b) may be utilized for screw holes.

Figure 2 – Bottom-view dimensions (S-cassette)

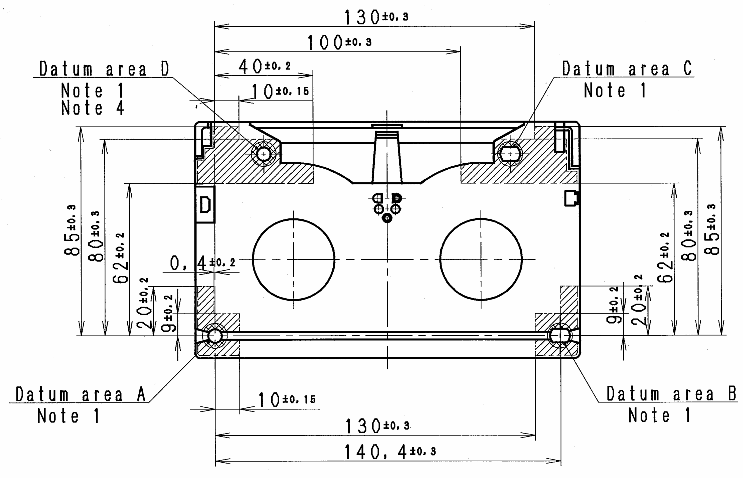


Figure 3a – Datum areas and supporting areas

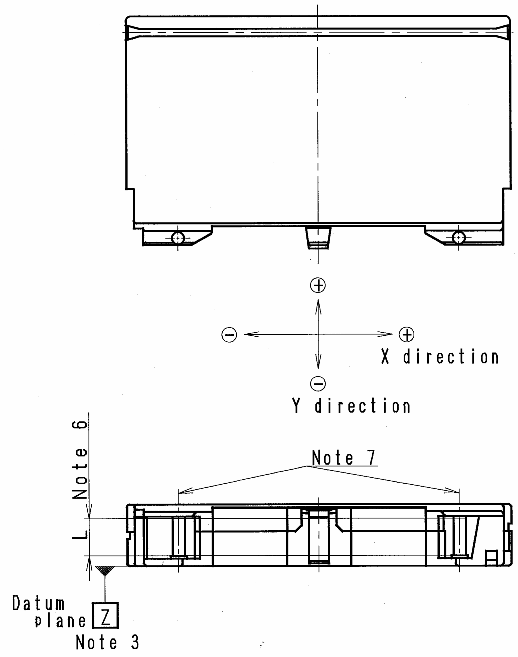


Figure 3b – Tape guides

Dimensions in millimetres

NOTE 1 The cross-hatched areas 10 mm in diameter are datum areas.

NOTE 2 The four supporting areas shown by the hatched areas should be coplanar with their corresponding datum areas within 0,05 mm of each of them.

NOTE 3 Datum plane Z should be defined by the three datum areas, A, B, C.

NOTE 4 Datum area D should be coplanar, within 0,3 mm, with datum plane Z.

NOTE 5 The areas within 1 mm of the edges of a cassette should not be included in the supporting areas.

NOTE 6 Measurement L: 15 mm

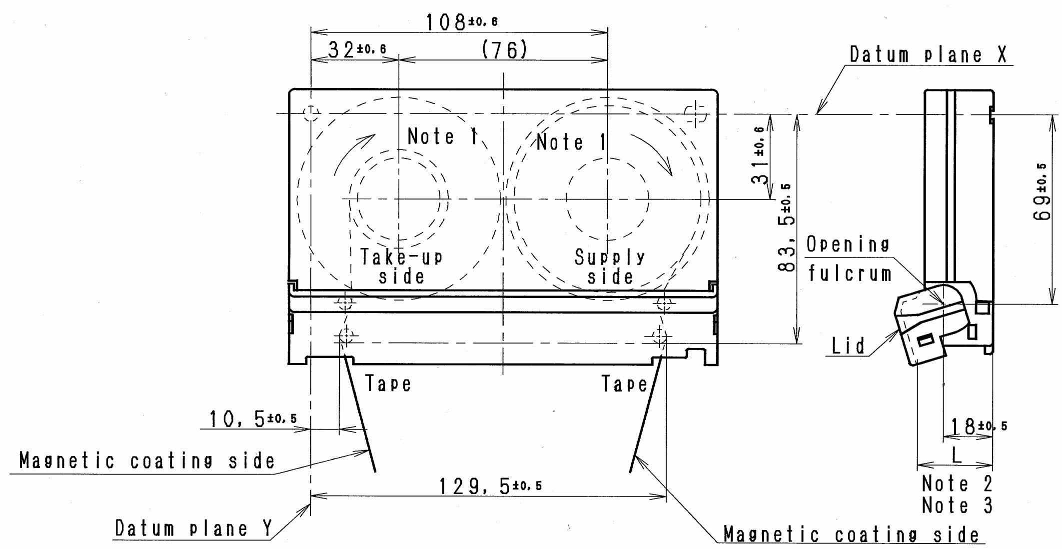
NOTE 7 The perpendicularity of tape guides is specified as follows (even if they themselves are tapered).

Direction / **Tape guide**	X	Y
Supply side	0 ± 0,15	0 ± 0,15
Take-up side	0 ± 0,15	0 ± 0,15

Dimensions in millimetres

Direction X: Parallel to the tape running direction.
Direction Y: Horizontally orthogonal to direction X.

Figure 3 – Datum areas, supporting areas, tape guides and associated dimensions (S-cassette)



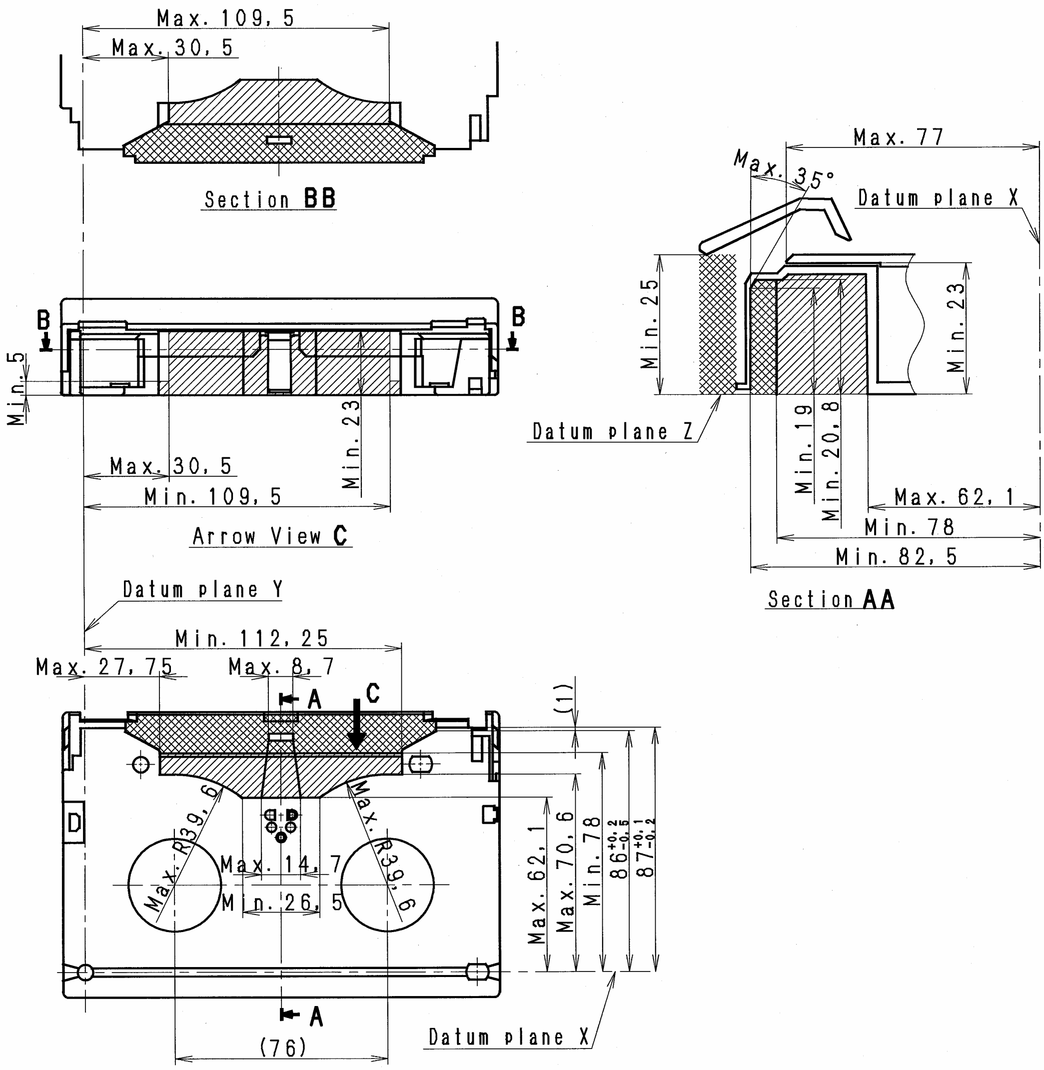
Dimensions in millimetres

NOTE 1 The rotating direction of reels during forward operation.

NOTE 2 The lid opening height L should be 29 mm or more.

NOTE 3 The reel should be reset completely when the lid opening height L is 23,5 mm.

Figure 4 – Reel location in the unlocked position (S-cassette)



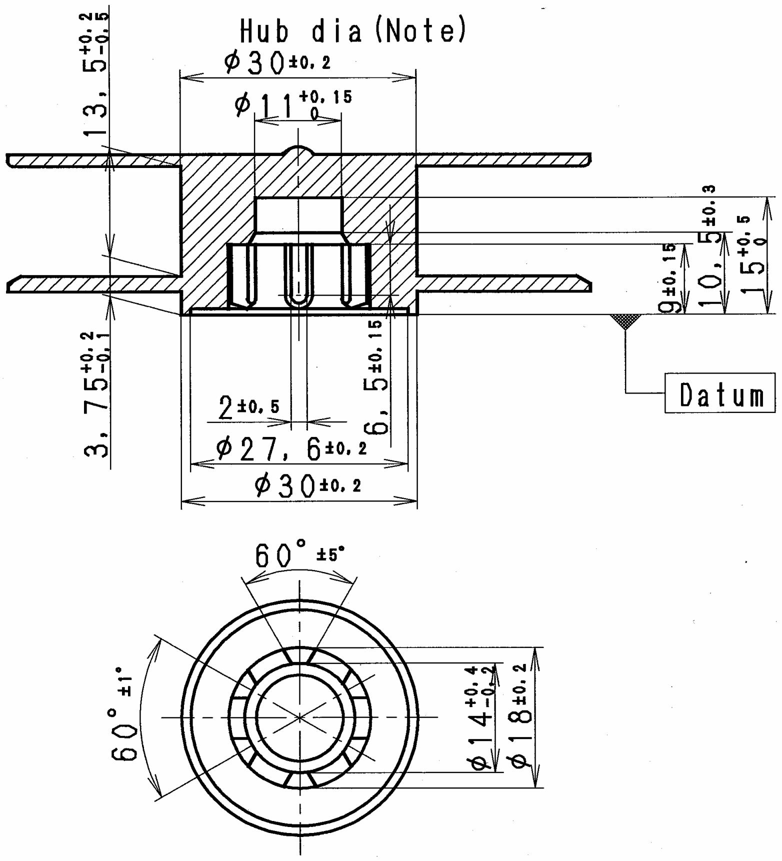
Dimensions in millimetres

NOTE 1 The hatched area is where the loading mechanism of the video tape recorder and/or player unit positions the video cassette when it is inserted.

NOTE 2 The hatched and cross-hatched areas are so designed that the loading mechanism of the video tape recorder and/or player unit unwinds and extends the magnetic tape towards the head drum after the lid opens.

NOTE 3 This condition is sometimes defined as “Minimum space for loading mechanism”.

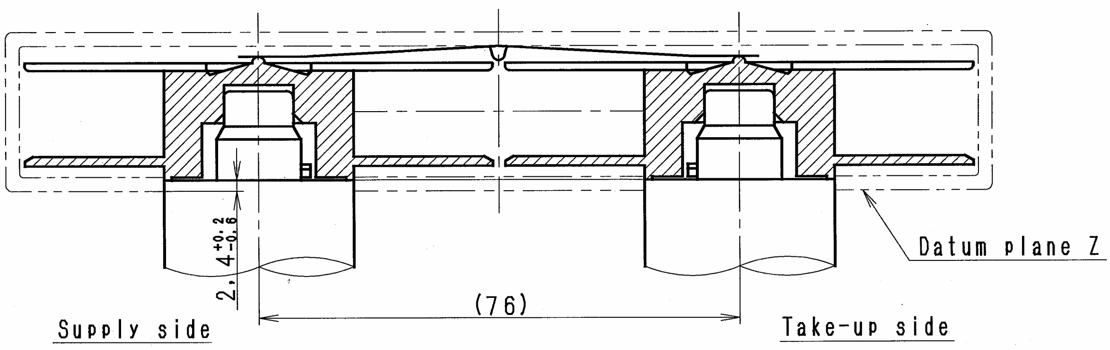
Figure 5 – Protecting lid dimensions (S-cassette)



Dimensions in millimetres

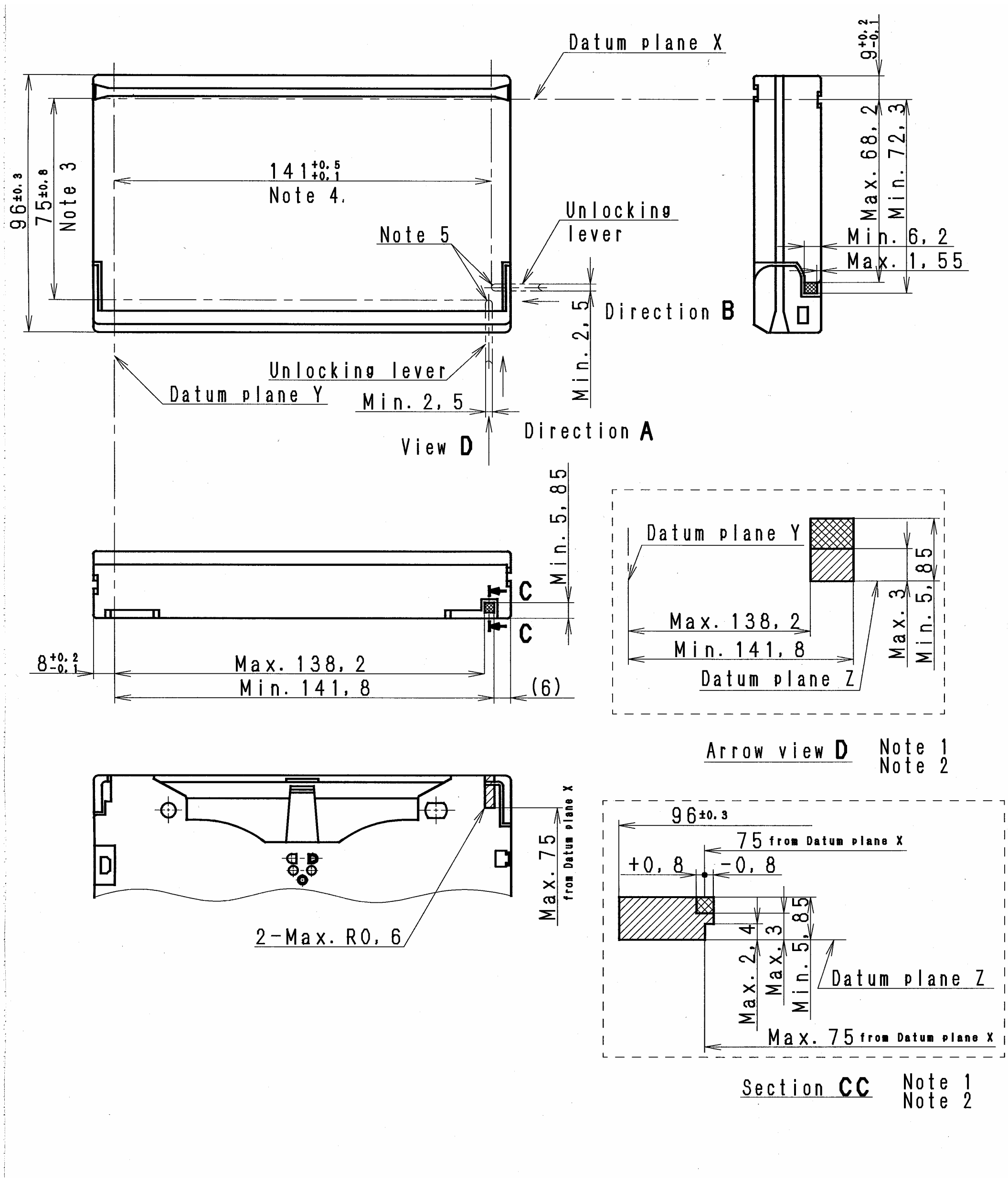
NOTE The reels with large hubs (hub diameter 53,3 ± 0,2 mm) can be used for cassettes whose recording time is less than 12 min.

Figure 6 – Reel dimensions (S-cassette)



Dimensions in millimetres

Figure 7 – Reel height in the unlocked position (S-cassette)



Dimensions in millimetres

NOTE 1 The cross-hatched and hatched areas show the allowable total area where the unlocking lever extending from the video tape recorder and/or player unit can be inserted into a cassette.

NOTE 2 The cross-hatched area shows the range of the unlocking lever insertion which permits the lid to be unlocked.

NOTE 3 Allowable range within which the unlocking lever can be inserted in the A direction.

NOTE 4 Allowable range within which the unlocking lever can be inserted in the B direction.

NOTE 5 The tip of the unlocking lever should be shaped into a semicircle or hemisphere whose radius is a half of the unlocking lever width.

Figure 8 – Unlocking lever insertion area (S-cassette)

Direction A

The force to unlock the lid shall be not greater than 1,0 N in the A direction.

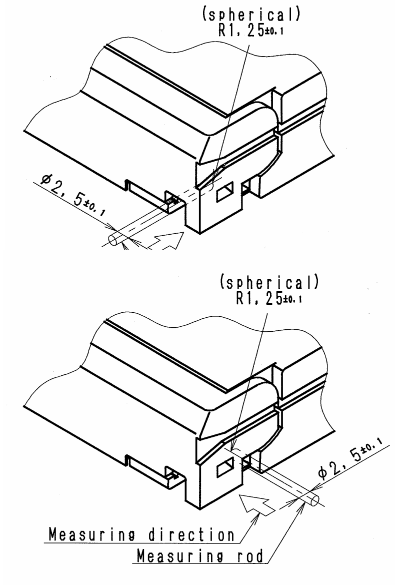
Refer to Figure 8 regarding the measuring ranges.

Direction B

The force to unlock the lid shall be less than 1,5 N in the B direction.

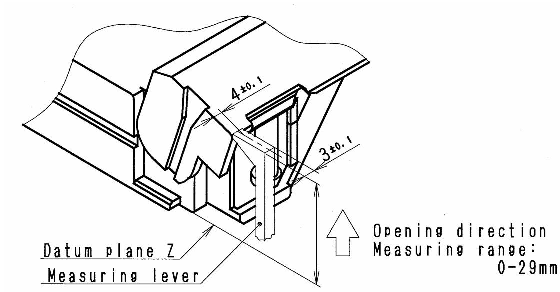
Refer to Figure 8 regarding the measuring ranges.

NOTE The maximum force to open the lid should be 1,5 N.



Dimensions in millimetres

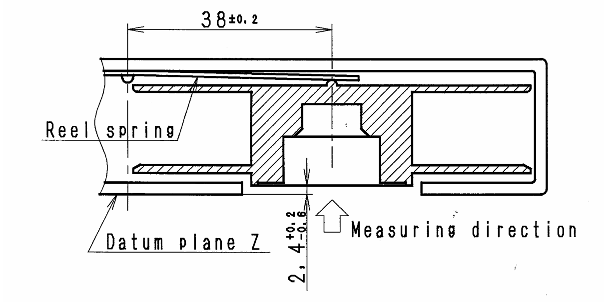
Figure 9 – Lid unlocking force (S-cassette)



Dimensions in millimetres

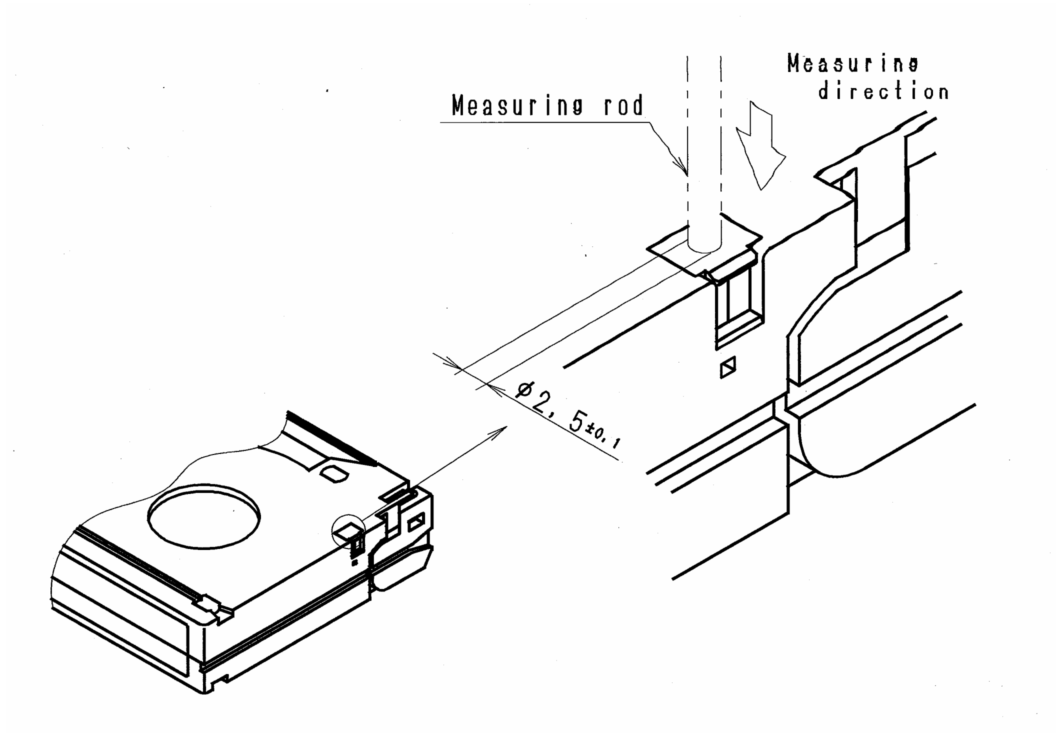
Figure 10 – Lid opening force (S-cassette)

NOTE The force of the spring for pushing down the reel should be (1,5 ± 0,5) N.



Dimensions in millimetres

Figure 11 – Reel spring force (S-cassette)



Dimensions in millimetres

Figure 12 – Safety plug strength (S-cassette)

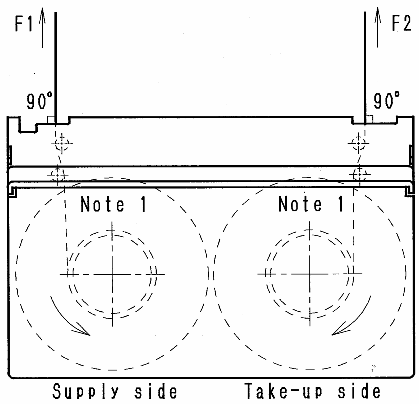


Figure 13a – Extraction force (F1, F2)

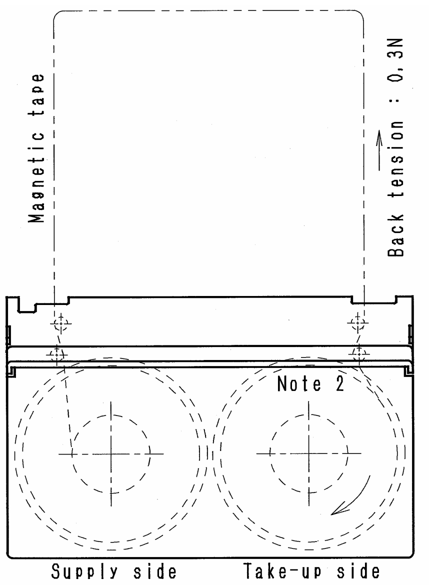
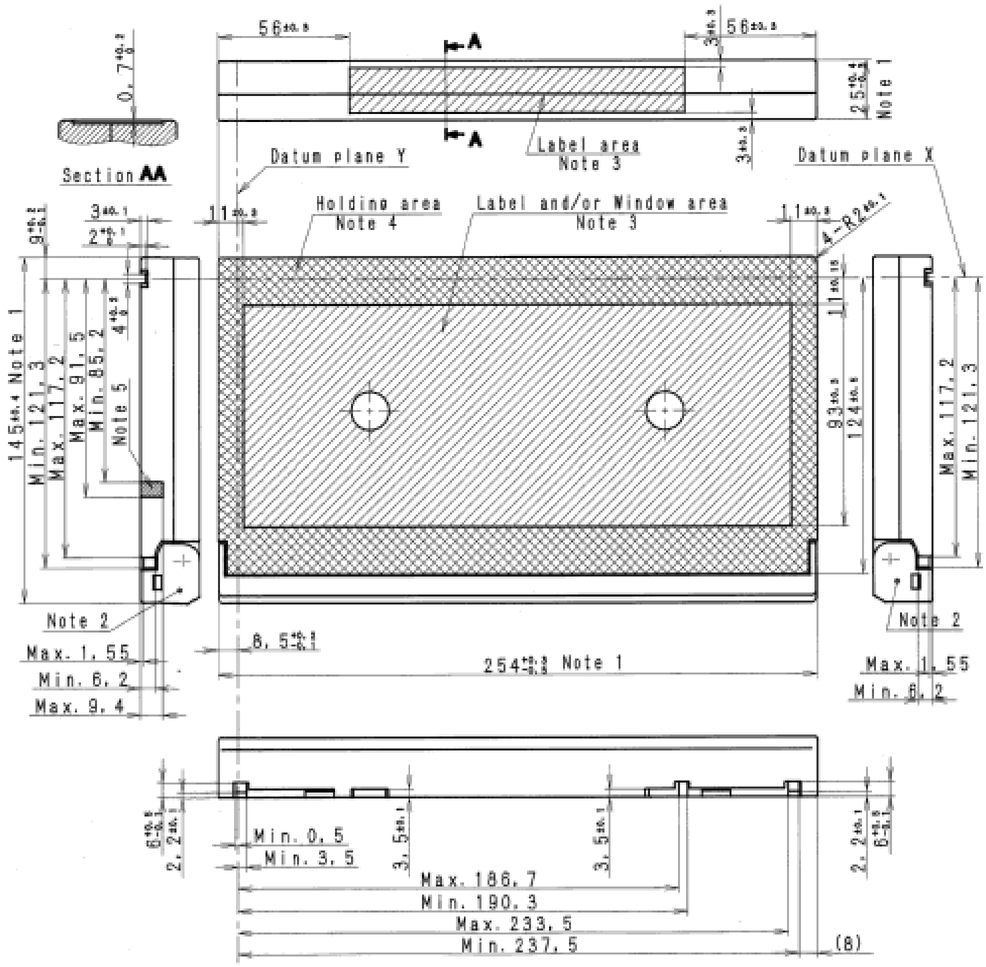


Figure 13b – Friction torque

NOTE 1 Holdback torque of 1 mN m.

NOTE 2 Friction torque to wind the tape.

Figure 13 – Extraction force (F1, F2) and friction torque (S-cassette)



Dimensions in millimetres

NOTE 1 These dimensions are inspected by using limit gauges.

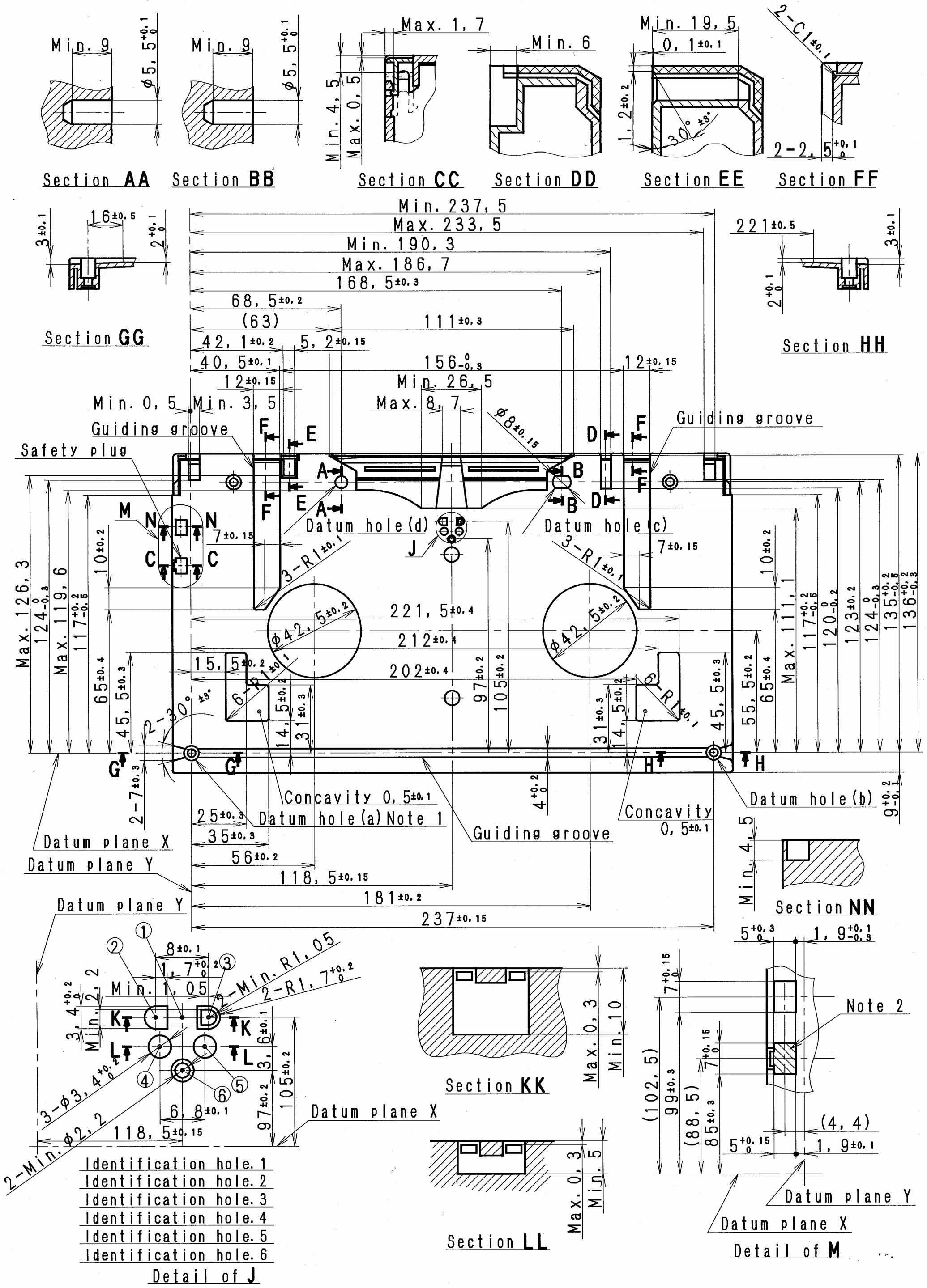
NOTE 2 No part of the lid shouldl protrude beyond the bottom plane of the cassette when the lid opens nor when it closes.

NOTE 3 Label and/or window area shown by the hatched area is available for the label and/or window.

NOTE 4 The cassette may be held in position by the recorder and/or player unit on the holding area shown by the cross-hatched area.

NOTE 5 The-fine hatched area shows the acceptable range of plug-notch positions and depths at the side.

Figure 14 – Top and side views (L-cassette)



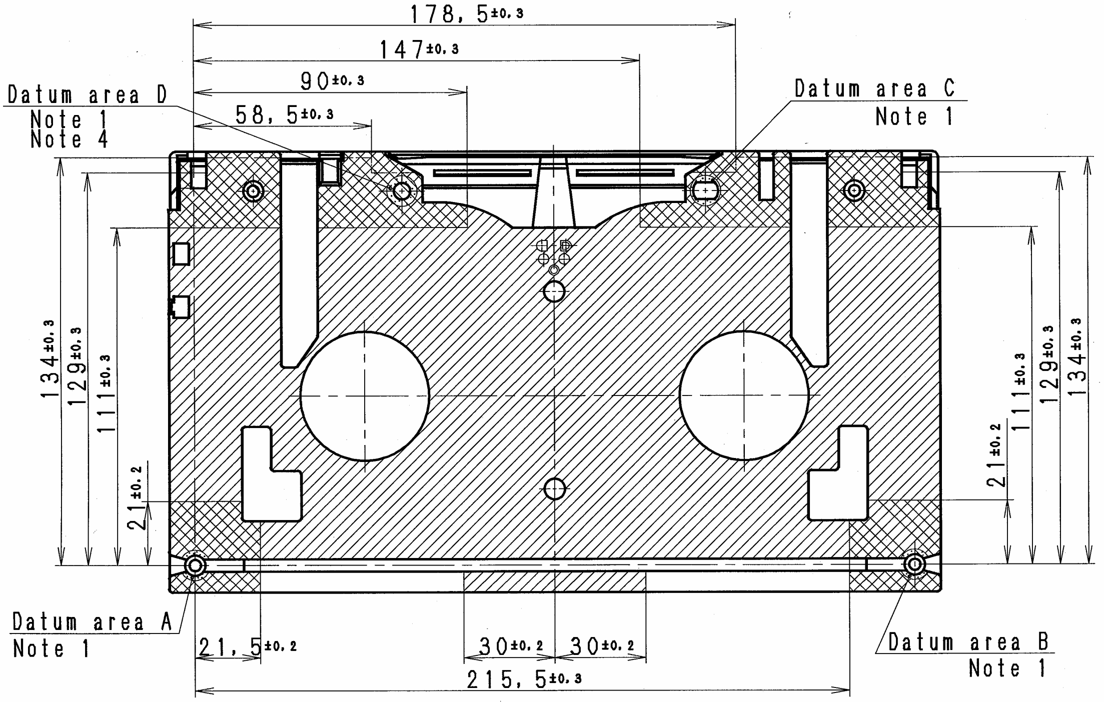
Dimensions in millimetres

NOTE 1 Datum hole (a) is primary.

NOTE 2 The cross-hatched area shows the VTR detection area.

NOTE 3 Datum holes (a) and (b) may be utilized for screw holes.

Figure 15 – Bottom view (L-cassette)



Dimensions in millimetres

Figure 16a – Datum areas and supporting areas

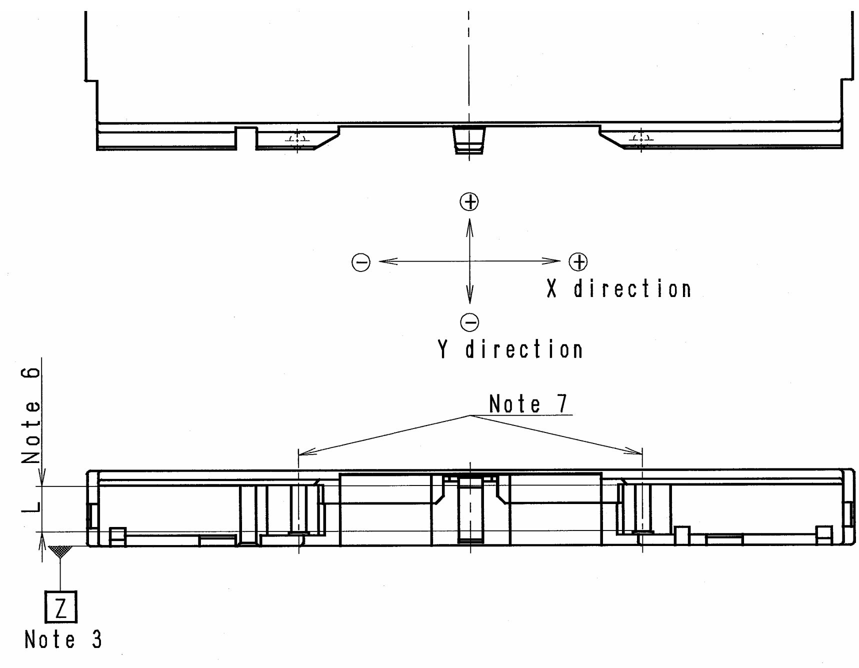


Figure 16b – Tape

NOTE 1 The four round areas 10 mm in diameter are datum areas.

NOTE 2 The four supporting areas shown by the cross-hatched areas should be coplanar with their corresponding datum areas within 0,05 mm of each of them and should be coplanar with the hatched areas.

NOTE 3 Datum plane Z should be defined by the three datum areas, A, B, C.

NOTE 4 Datum area D should be coplanar, within 0,3 mm with datum plane Z.

NOTE 5 The areas within 1 mm of the edges of the cassette should not be included in the supporting areas.

NOTE 6 Measurement L: 15 mm

NOTE 7 The perpendicularity of the tape guides is specified as follows (even if they themselves are tapered).

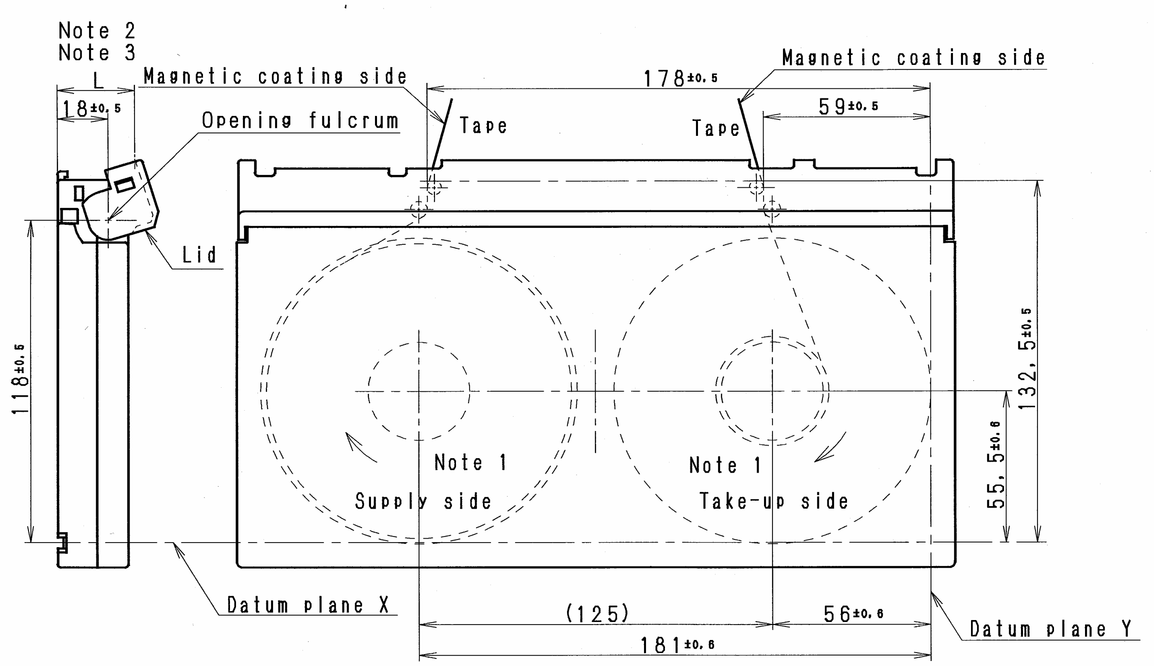
Direction / **Tape guide**	X	Y
Supply side	0 ± 0,15	0 ± 0,15
Take-up side	0 ± 0,15	0 ± 0,15

Dimensions in millimetres

Direction X: Parallel to the tape running direction.

Direction Y: Horizontally orthogonal to direction X.

Figure 16 – Datum areas, supporting areas and tape guides (L-cassette)



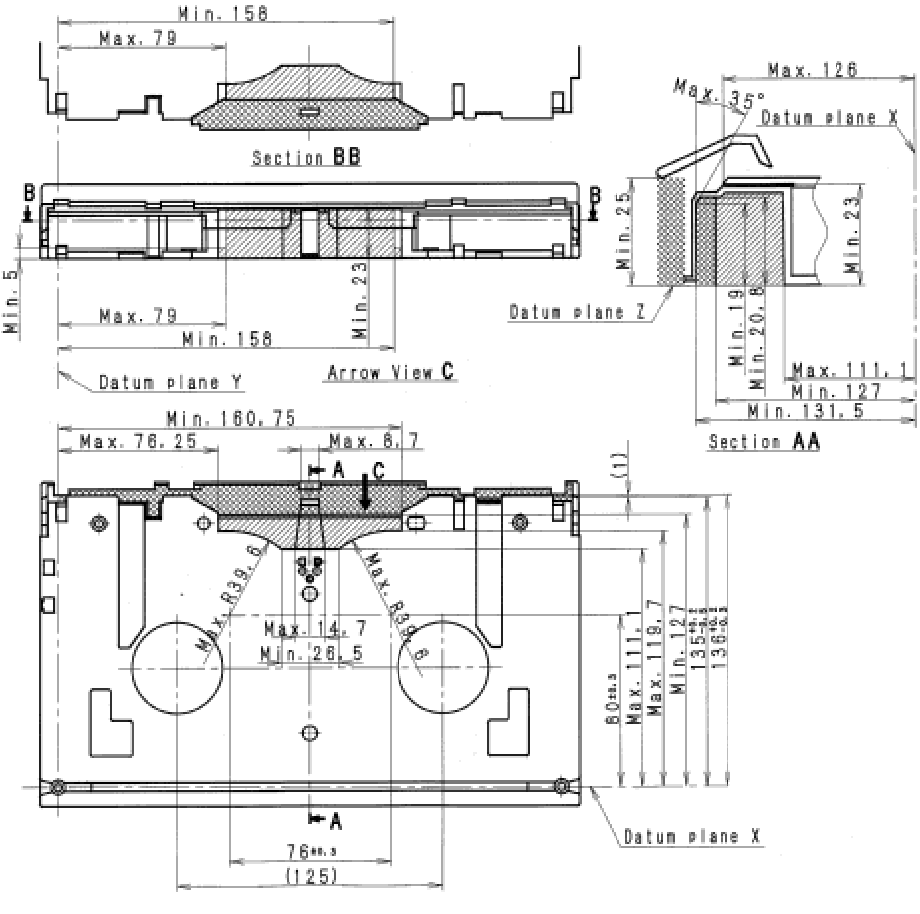
Dimensions in millimetres

NOTE 1 The rotating direction of reels during forward operation.

NOTE 2 The lid opening height L should be 29 mm or more.

NOTE 3 The reel should be reset completely when the lid opening height L is 23,5 mm.

Figure 17 – Reel location in unlocked position (L-cassette)



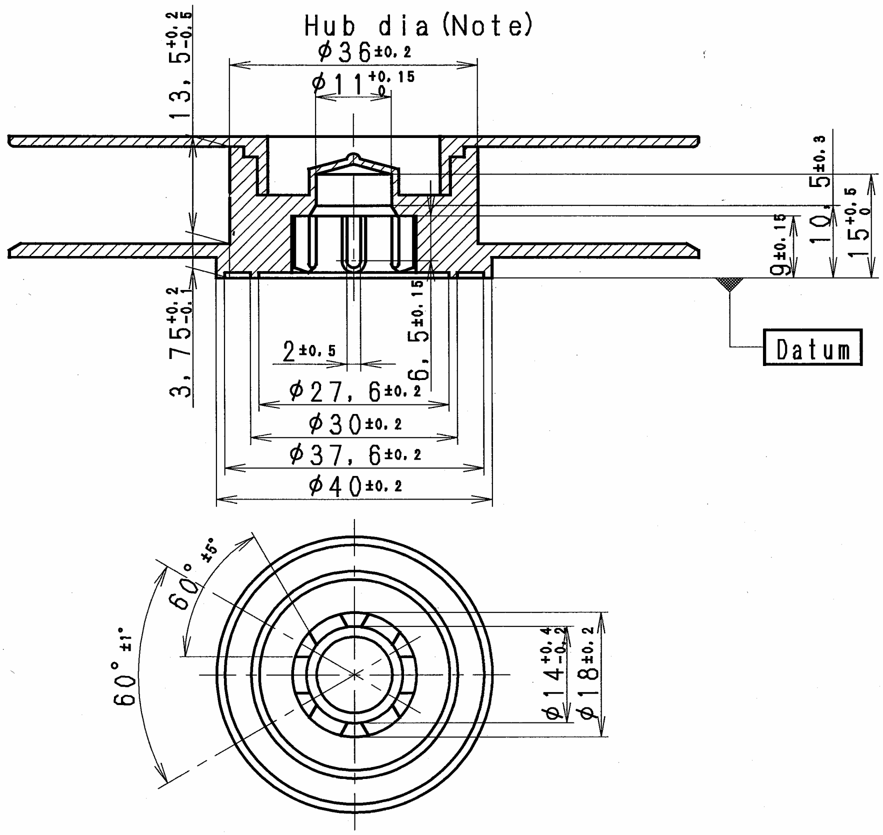
Dimensions in millimetres

NOTE 1 The hatched area is where the loading mechanism of the video tape recorder and/or player unit positions the video cassette when it is inserted.

NOTE 2 The hatched and cross-hatched areas are so designed that the loading mechanism of the video tape recorder and/or player unit unwinds and extends the magnetic tape towards the head drum after the lid opens.

NOTE 3 This condition is sometimes defined as “Minimum space for loading mechanism”.

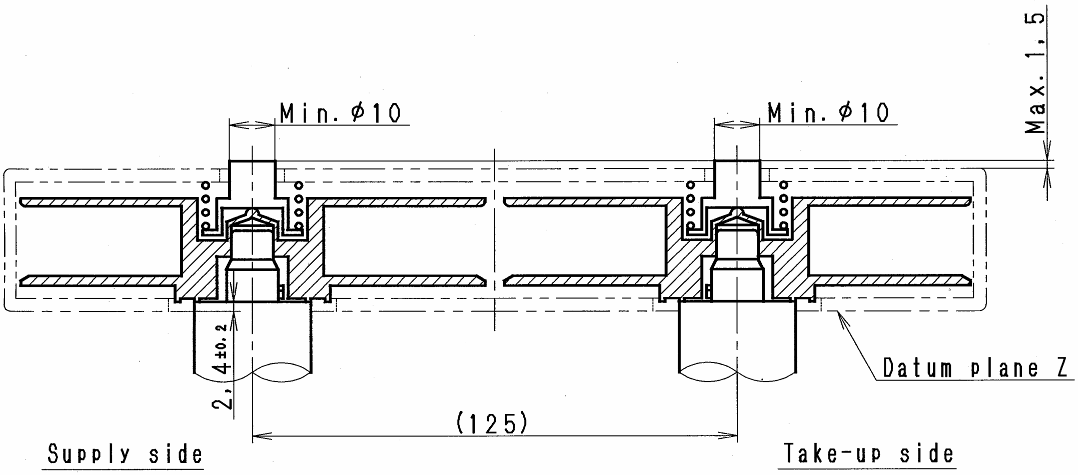
Figure 18 – Protecting lid (L-cassette)



Dimensions in millimetres

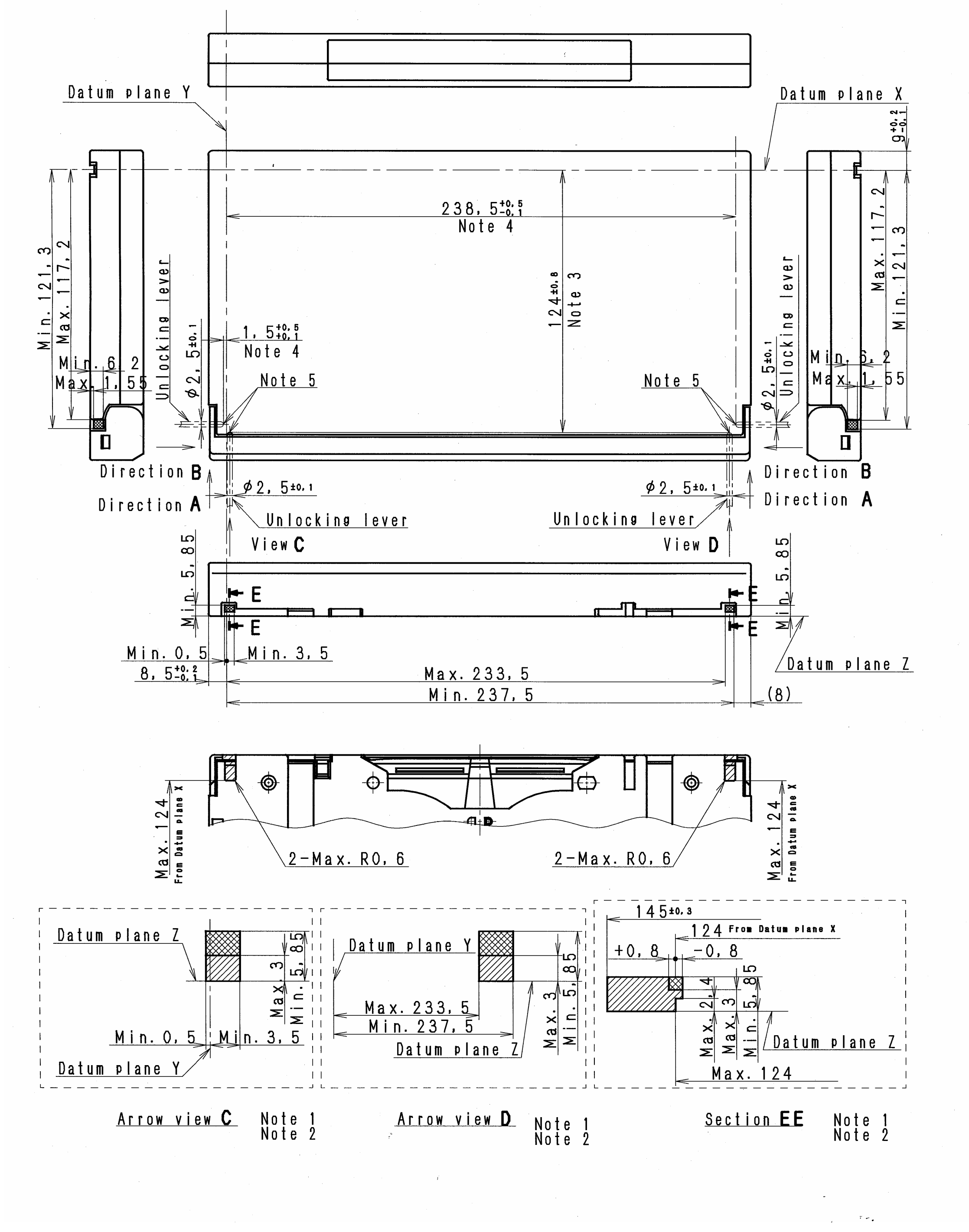
NOTE The reels with large hubs (hub diameter 53,3 mm ± 0,2 mm) can be used for cassettes whose recording time is less than 34 min.

Figure 19 – Reel dimensions (L-cassette)



Dimensions in millimetres

Figure 20 – Reel height in unlocked operation (L-cassette)



Dimensions in millimetres

NOTE 1 The cross-hatched and hatched area shows the allowable total area where the unlocking lever extending from the video tape recorder and/or player unit can be inserted into a cassette.

NOTE 2 The cross-hatched area shows the range of the unlocking lever insertion which permits the lid to be unlocked.

NOTE 3 Allowable range within which the unlocking lever can be inserted in the A direction.

NOTE 4 Allowable range within which the unlocking lever can be inserted in the B direction.

NOTE 5 The tip of the unlocking lever should be shaped into a semicircle or hemisphere whose radius is half of the unlocking lever width.

Figure 21 – Unlocking lever insertion area (L-cassette)

Direction A

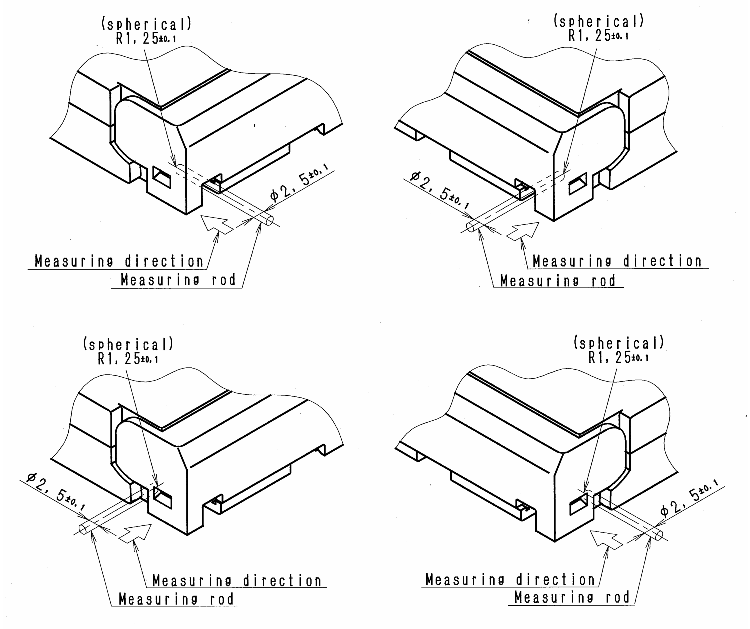
The force to unlock the lid shall be not greater than 1,0 N in the A direction.

Refer to Figure 21 regarding the measuring ranges.

Direction B

The force to unlock the lid shall be less than 1,5 N in the B direction.

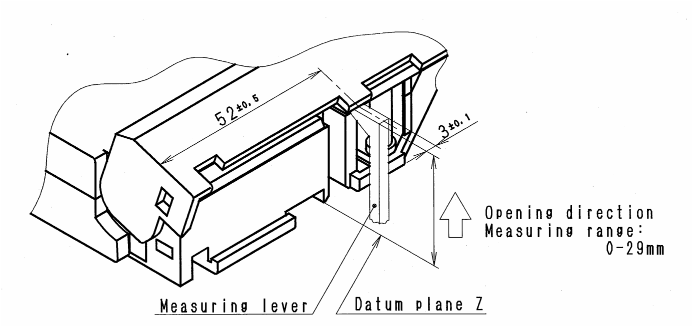
Refer to Figure 21 regarding the measuring ranges.



Dimensions in millimetres

Figure 22 – Lid unlocking force (L-cassette)

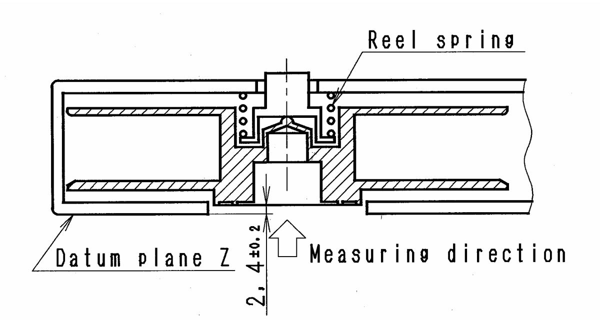
The maximum force to open the lid shall be 1,5 N.



Dimensions in millimetres

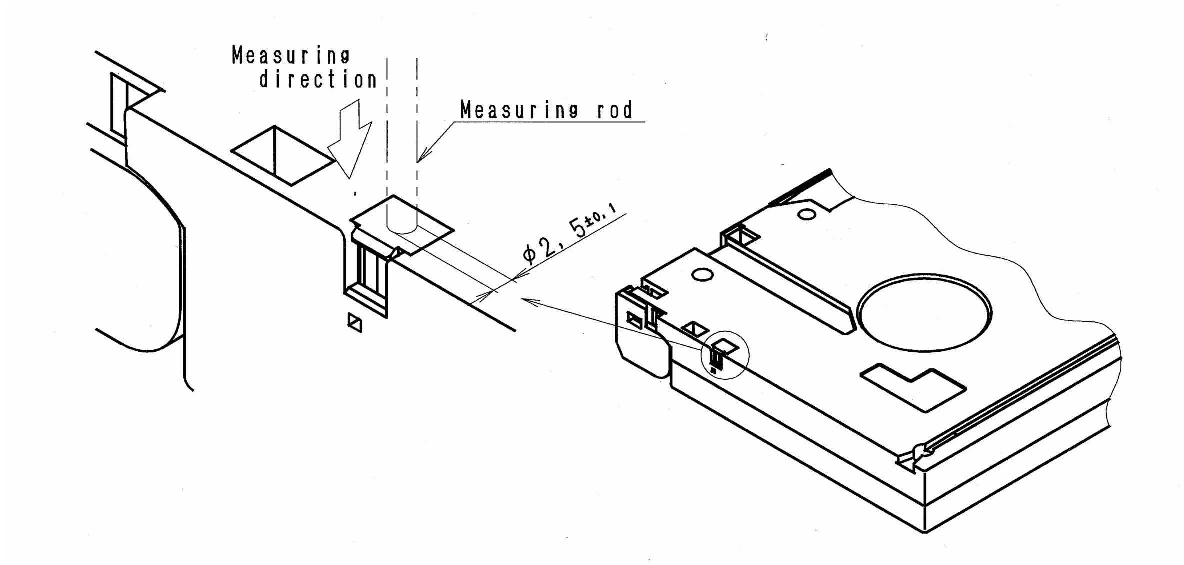
Figure 23 – Lid opening force (L-cassette)

The force of the spring for pushing down the reel shall be (3,5 ± 0,5) N.



Dimensions in millimetres

Figure 24 – Reel spring force (L-cassette)



Dimensions in millimetres

Figure 25 – Safety plug strength (L-cassette)

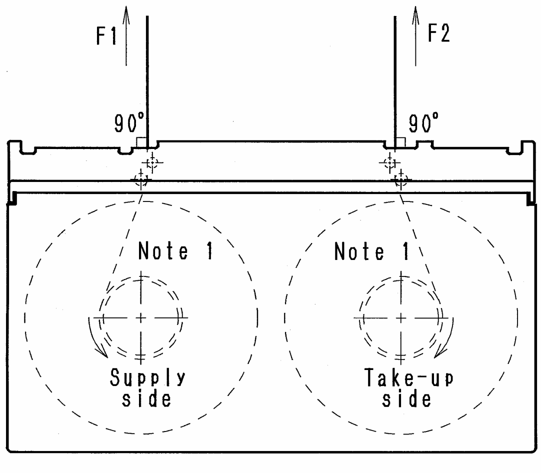


Figure 26a – Extraction force (F1, F2)

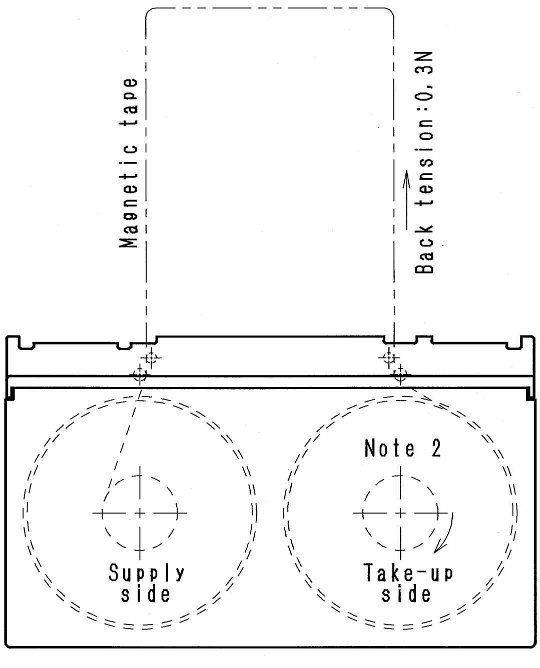


Figure 26b – Friction torque

NOTE 1 Holdback torque of 1 mN m.

NOTE 2 Friction torque to wind the tape.

Figure 26 – Extraction force (F1, F2) and friction torque (L-cassette)

6 Tape record physical parameters

6.1 Input reference signal

An input reference signal shall be used to provide synchronization of the tape recorder in both frequency and timing. This reference signal shall conform to SMPTE 292M and the appropriate sampling structures defined in SMPTE 274M and SMPTE 296M as required to support the source picture coding.

Where the input reference signal has a frame rate of 50 Hz or 59,94 Hz only alternate frames are used for synchronization.

6.2 Tape speed

The tape speed shall be as defined in Table 1. The tape-speed tolerance for all record unit rates shall be ±0,2 %.

Table 1 – Tape speeds for each record unit rate

Record unit rate	Tape speed
23,98 Hz	94,096 mm/s
24 Hz	94,190 mm/s
25 Hz	98,115 mm/s
29,97 Hz	117,62 mm/s

6.3 Helical record physical parameters

6.3.1 Helical record location and dimensions

The reference edge of the tape for the dimensions specified in this standard shall be the lower edge as shown in Figure 27. The magnetic coating, with the direction of tape travel as shown in Figure 27, is on the side facing the observer.

The programme reference point for each video frame of 23,98 Hz, 24 Hz, 25 Hz and 29,97 Hz frame rates (or the first fame of a frame pair for 50 Hz and 59,94 Hz frame rates) is determined by the intersection of a line which is parallel to the reference edge of the tape at the distance Y from the reference edge and the centre line of the first track in each record unit; that is track 0 of segment 0. The programme reference point defines the start of the first video sector in the record unit.

The physical locations and dimensions of the helical recordings on the tape and their relative positions in regard to the time-code start bit and the reference edge shall be as specified in Figure 27 and Table 2.

6.3.2 Helical track record tolerance zones

The lower edges of all eight consecutive tracks shall be contained within the pattern of the eight tolerance zones defined in Figure 28.

Each zone is defined by two parallel lines which are inclined at an angle of 4,63066° with respect to the tape-reference edge.

The centre-lines of all zones shall be spaced apart by 0,0132 mm. The width of zones 2, 3, 4, 5, 6, 7 and 8 shall be 0,005 mm. The width of zone 1 shall be 0,003 mm. These zones are established to contain track-angle errors, track-straightness errors and vertical head offset tolerance.

The measuring techniques shall be as shown in Clause 7 of IEC 61237-1.

6.3.3 Helical track gap azimuth

The azimuth angle of the head gaps used for recording the helical tracks shall be at an angle of α_0 or α_1 to the line perpendicular to the helical tracks, as specified in Figure 27 and Table 2.

The azimuth of the first track of every record unit, that is the programme reference point, shall be orientated in the counter-clockwise direction with respect to the line perpendicular to the track direction when viewed from the side of the tape carrying the magnetic recording.

6.4 Longitudinal record physical parameters

6.4.1 Longitudinal record location and dimensions

The track widths and tolerances of the control and time code tracks shall be as defined in Figure 27 and Table 2.

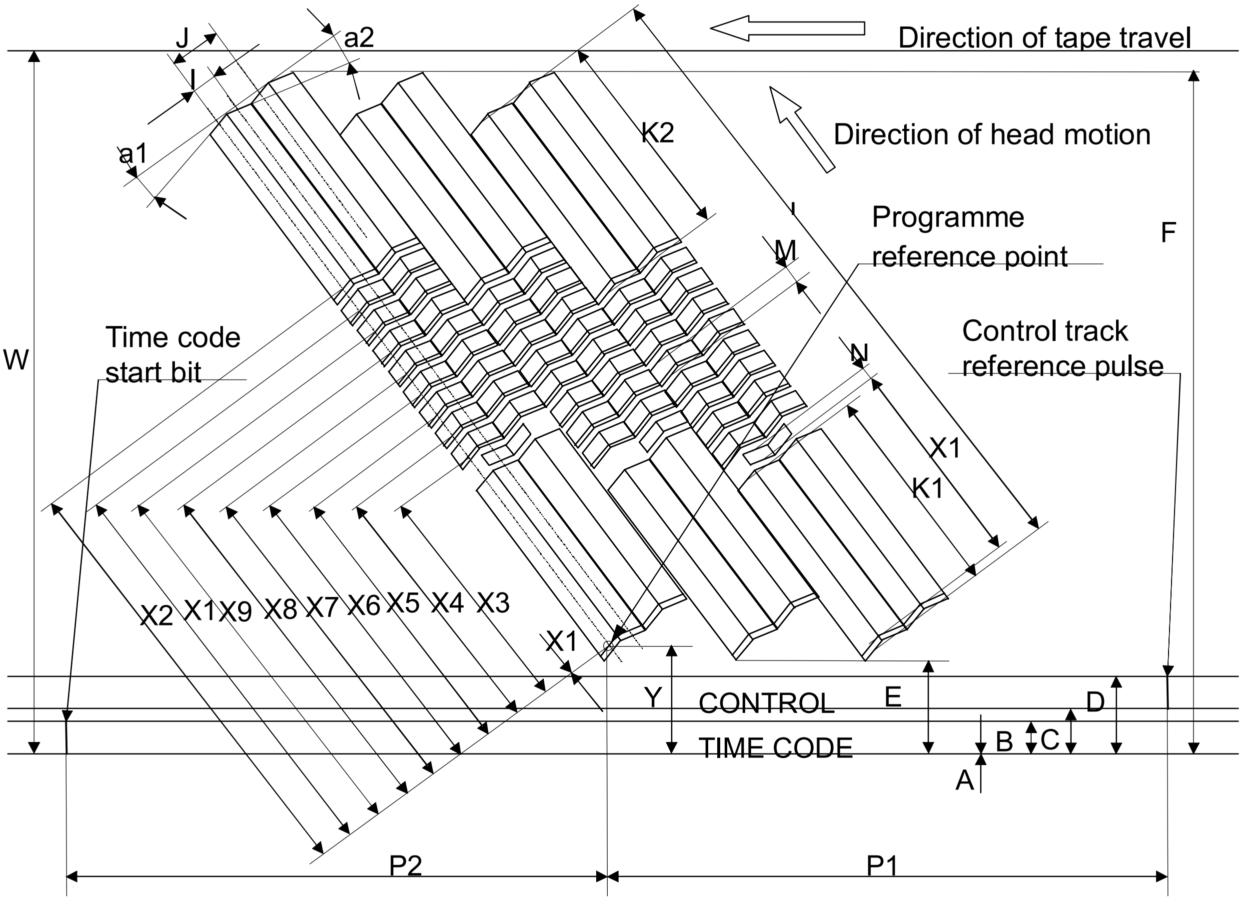
6.4.2 Longitudinal track gap azimuth

The azimuth angle of the head gaps used for recording the longitudinal tracks shall be perpendicular to the tracks.

Table 2 – Record location and dimensions

	Dimensions	**Dimensions in mm**	
		Nominal	**Tolerance**
A	Time code track lower edge	0	Basic
B	Time code track upper edge	0,4	±0,065
C	Control track lower edge	0,7	±0,065
D	Control track upper edge	1,1	±0,065
E	Programme area lower edge	1,603	Derived
F	Programme area upper edge	11,458	Derived
I	Helical track pitch (+/- azimuth)	0,0132	Ref.
J	Helical track pitch (+/+ azimuth)	0,0264	Ref.
K1	Video sector 1 length	55,042	Derived
K2	Video sector 2 length	54,894	Derived
L	Helical track total length	121,416	Derived
M	Audio sector length	1,107	Derived
N	Tracking data area length	0,695	Derived
P1	Control track reference to programme reference	50,374	±0,1
P2	TC start bit to programme reference	175,624	±0,2
X1	Location of start of video sector 0	0	±0,07
X2	Location of start of video sector 1	66,374	±0,07
X3	Location of start of audio sector 0	56,486	±0,07
X4	Location of start of audio sector 1	57,716	±0,07
X5	Location of start of audio sector 2	58,947	±0,07
X6	Location of start of audio sector 3	60,177	±0,07
X7	Location of start of audio sector 4	61,408	±0,07
X8	Location of start of audio sector 5	62,638	±0,07
X9	Location of start of audio sector 6	63,869	±0,07
X10	Location of start of audio sector 7	65,099	±0,07
X11	Location of start of tracking data	55,037	±0,07
Y	Programme area reference	1,633	Basic
W	Tape width	12,65	±0,01
Dimensions		Angles (°)	
		Nominal	Tolerance
θ	Track angle	4,630663	Basic
a1	Azimuth angle of track 0	-25,0237	±0,17
a2	Azimuth angle of track 1	24,9763	±0,17

NOTE The above measurement should be made under the condition specified in Clause 4.



NOTE Not to scale.

Figure 27 – Locations and dimensions of recorded tracks

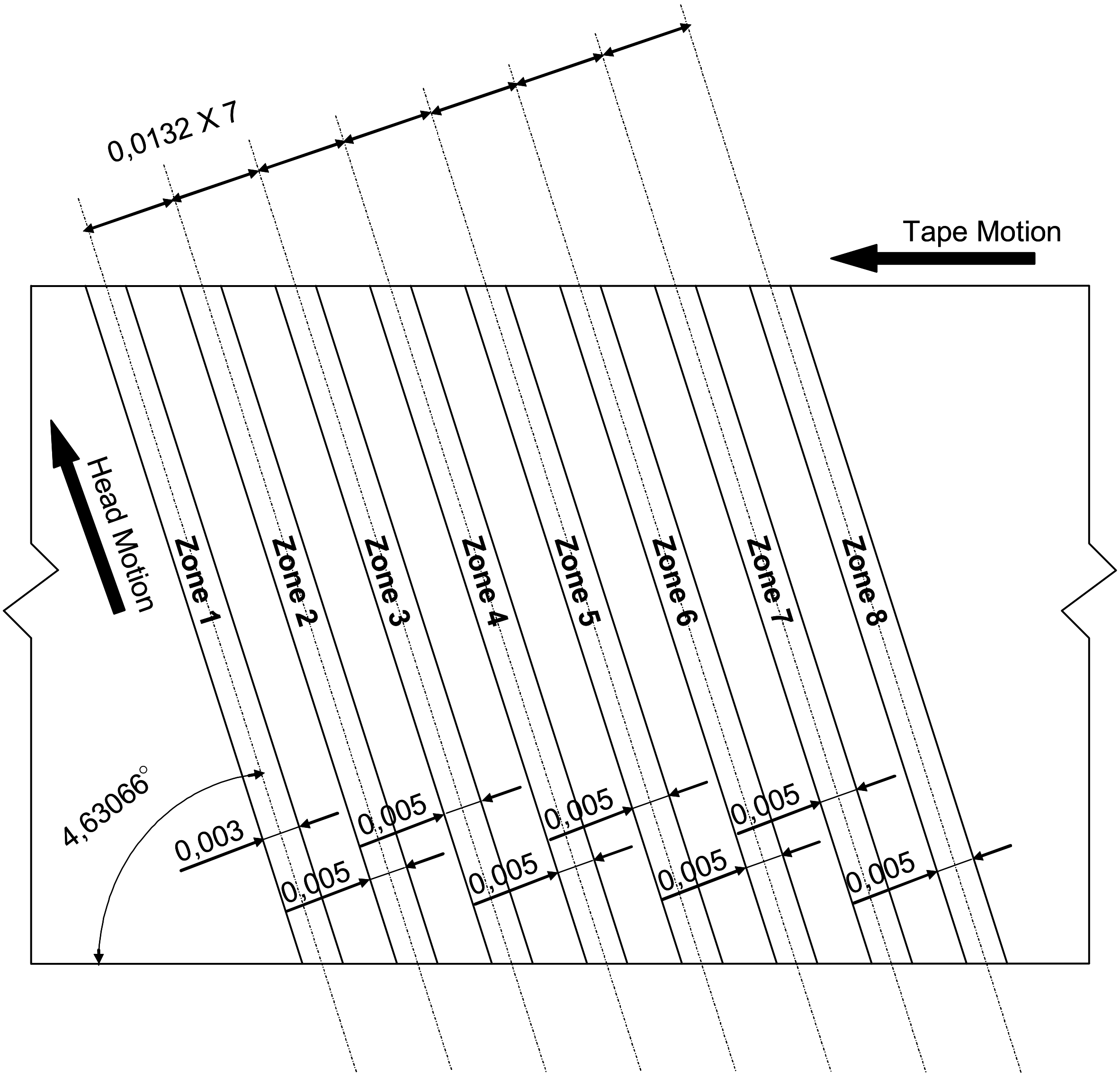


Figure 28 – Locations and dimensions of tolerance zones of helical track records

7 Longitudinal track signal and magnetic parameters

7.1 Longitudinal track record parameters

7.1.1 Method of recording

The control track and time-code track signals shall be recorded using the hysteretic (non-bias) recording method.

7.1.2 Flux level

The recording level shall be at saturation of the magnetic domains which is defined as that point above which a 0,5 dB increase in output level results from 1 dB increase of input level as indicated on an r.m.s. level meter.

7.2 Control track record parameters

7.2.1 Control track pulse period

The control track pulse, at the point of recording, shall be a series of pulses as shown in Figure 29. The period of the pulses for each record unit rate shall be as defined in Table 3.

Table 3 – Control track pulse widths

Record unit rate	Control track pulse period
23,98 Hz	20,854 ms ± 6 μs
24 Hz	20,833 ms ± 6 μs
25 Hz	20,000 ms ± 6 μs
29,97 Hz	16,683 ms ± 6 μs

7.2.2 Control track pulse definition

The rising edge of all control track pulses should be timed to coincide with the input reference signal.

The frame start point is defined as the midway point of the leading sync edge position which identifies the start of line 1 of the video signal represented by the input reference signal.

The control track pulses shall have nominal periods of 35 T, 50 T or 65 T between the rising and falling edges where T is equal to 0,1668 ms (for 29,97 Hz record unit rates), 0,200 ms (for 25 Hz record unit rates), 0,20833 ms (for 24 Hz record unit rates) or 0,20854 ms (for 23,98 Hz record unit rates) as shown in Figure 29.

The sequence of the control track pulse width shall be locked to the segment information included in the corresponding video data.

7.2.3 Flux polarity

The polarity of the tracking-control recording flux shall be as defined by Clause 5 of IEC 61213 and Figure 29.

7.3 Time and control code track record parameters

The signal format recorded on the time code track shall be in accordance with SMPTE 12M.

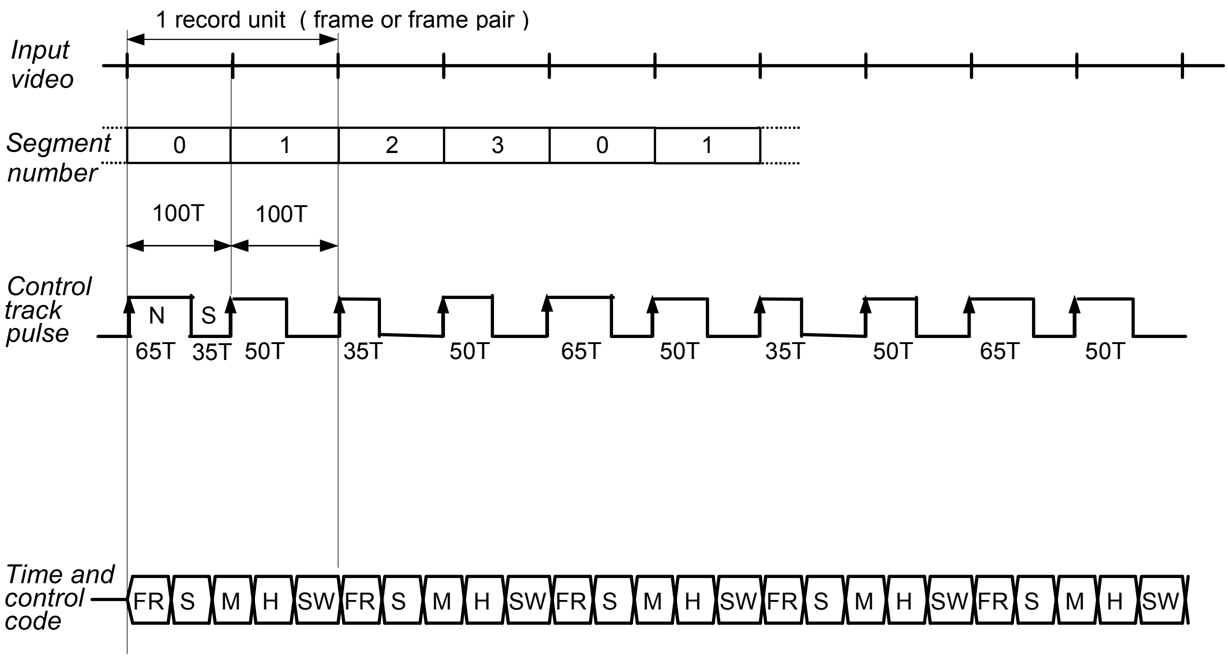
Source pictures that have frame rates of 50 Hz or 59,94 Hz are coded in such a way that each frame pair is recorded in the appropriate record unit.

7.3.1 Relationship to the helical track records

The time and control code information need to be co-timed with the recorded video frame (or video frame pair in the case of 50 Hz or 59,94 Hz progressive sources). Since each video frame (or frame pair) is formatted into "shuffle block data" as defined in 8.3.1, the time and control code information shall both be co-timed with the associated shuffle block data.

7.3.2 Time and control code signal timing

An external record time and control code input that meets the specifications described in SMPTE 12M or a time and control code that is internally generated within the recorder shall be timed for recording in such a way that the relationship between the "start of address" of the time and control code and the programme reference point of a track with an even field address (count) for the video data is as defined by Figure 27 and Table 2.



NOTE1 The following definitions are used in Figure 29: FR: frame; S: second; M: minute; H: hour; and SW: Sync Word.

NOTE 2 The segment number is defined in 9.4.2.

Figure 29 – Recorded control code waveform

8 Source picture and audio processing

This clause specifies the encoding of ancillary data and picture formats via compression into a bit rate in the range 353~442 Mbps in a packetized format for recording on a Type D-16 digital tape recorder. The compression methods used are constrained implementations of the MPEG-4 studio profile DCT and DPCM I-frame compression methods defined by ISO/IEC 14496-2 (MPEG-4 studio profile).

The compressed data format specified by the output of the compression encoder is of a form which allows direct mapping into the basic block structure as defined in Clause 9.

This clause also defines the input format and packing of twelve audio channels conforming to AES3.

8.1 Introduction

Figure 30 shows the recorder block diagram, identifying the basic schematic signal processing blocks used to map the Type D-16 picture compression data and 12 channels of AES3 audio data to create the helical track data records. The “MPEG-4 SP encoder/MB shuffling” block in the video data path is defined in this clause as are the “channel demux switch” and “data packing” blocks in the audio data path. Figure 30 also includes helical data packing and ECC processing for the Type D-16 tape format which is defined in Clause 9 of this standard.

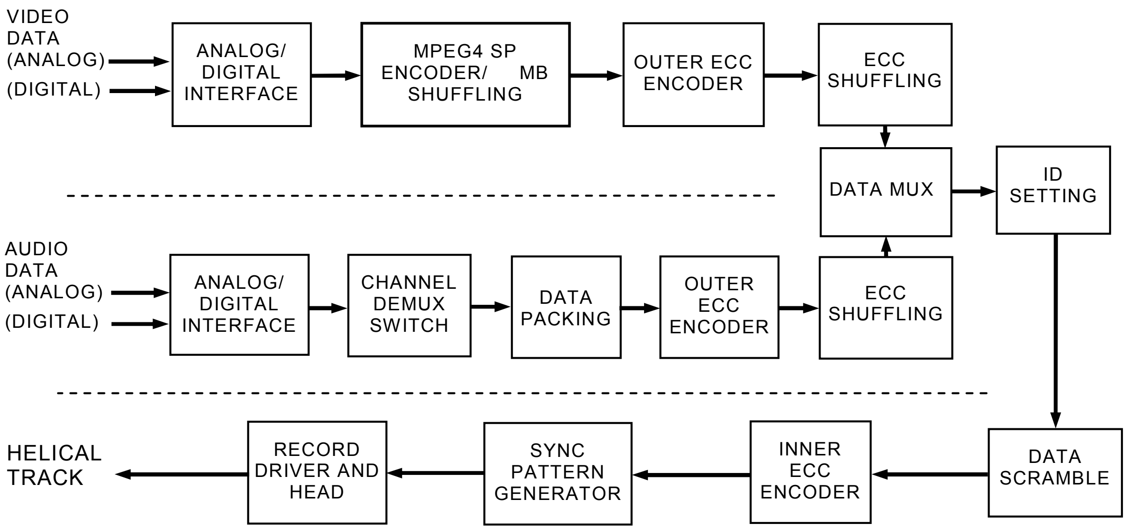


Figure 30 – Overall recording block diagram

Figure 31 shows the playback block diagram, identifying the basic schematic signal processing blocks used to map the helical track records to the source picture data stream and 12 AES3 audio data streams. Figure 31 also includes a type D-16 decoder/deshuffling block.

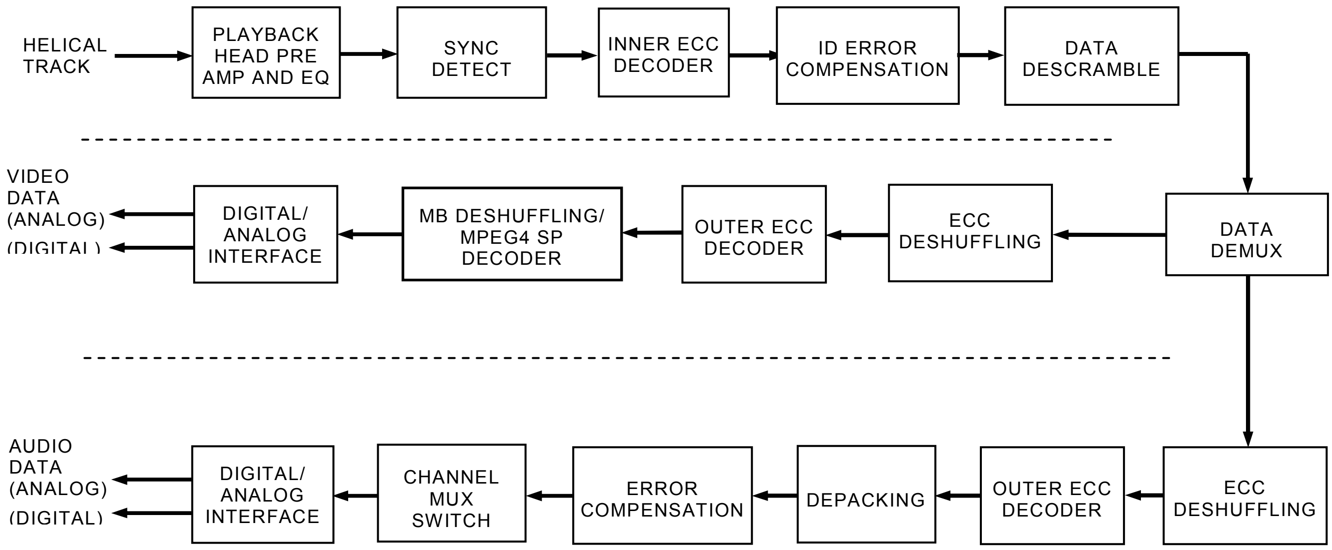


Figure 31 – Overall playback block diagram

8.1.1 Introduction to Type D-16 compression

Type D-16 compression specifies the process for encoding 1920 × 1080 I and PsF frames plus 3 1 920-word lines of ancillary data per segment. It may also encode of 1280 × 720 P frames plus 3 lines of 1 280-word ancillary data per segment.

The recorded bit rate is related to the source picture format and rate as shown in Table 4. Note that all 4:2:2 sampling formats use the single-link interface according to SMPTE 292M and all 4:4:4 sampling formats use the dual-link interface according to SMPTE 372M.

Table 4 – Data rates associated with source picture rates

Picture format	Sampling format	Record unit rate/format	Base data rate (Mbps)
1920 × 1080	4:2:2 YC_BC_R	23,98/PsF	353,529
	4:4:4 RGB		
	4:2:2 YC_BC_R	24/PsF	353,883
	4:4:4 RGB		
	4:2:2 YC_BC_R	25/PsF	368,628
	4:4:4 RGB		
	4:2:2 YC_BC_R	29,97/PsF	441,912
	4:4:4 RGB		
	4:2:2 YC_BC_R	50/I	368,628
	4:4:4 RGB		
	4:2:2 YC_BC_R	59,94/I	441,912
	4:4:4 RGB		
1280 × 720	4:2:2 YC_BC_R	50/P	368,628
	4:2:2 YC_BC_R	59,94/P	441,912

Source pictures for encoding are divided into 16 × 16 shuffle blocks, which are then shuffled and grouped into macro block units on an intra-field or intra-frame shuffle pattern for interlace and progressive pictures respectively. Each 1920 × 1080 picture or pair of 1280 × 720 pictures is shuffled to produce 40 macro block units.

Macro block units are encoded using the DCT or DPCM methods of MPEG-4 studio profile compression, as defined by ISO/IEC 14496-2, subject to the constraints defined in this standard.

Each MPEG-4 compressed macro block unit is then packed with segmented uncoded ancillary data into 204 fixed length basic blocks. Complete macro block units should be grouped into coded sequences comprising 24 auxiliary basic blocks followed by 4 080 compressed data basic blocks.

The encoding process uses one or more coding channels to process the source pictures and ancillary data. Each coding channel produces two sequential coded sequences.

Figure 32 shows a block diagram of a Type D-16 encoder using one coding channel.

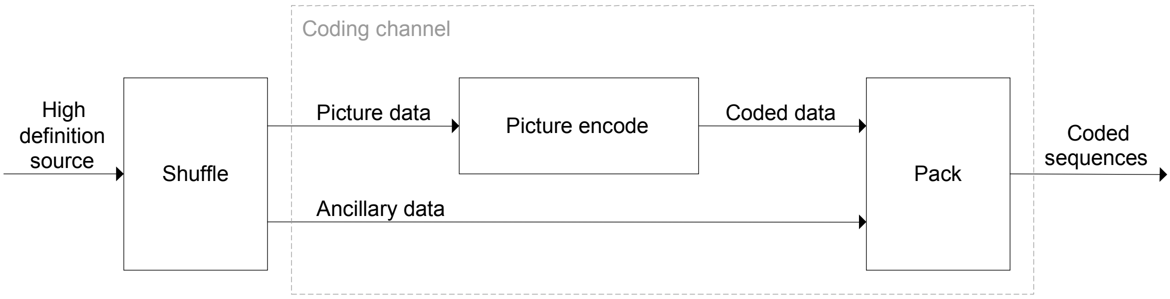


Figure 32 – Type D-16 encoding, one coding channel

Figure 33 shows a block diagram of a Type D-16 encoder using two coding channels.

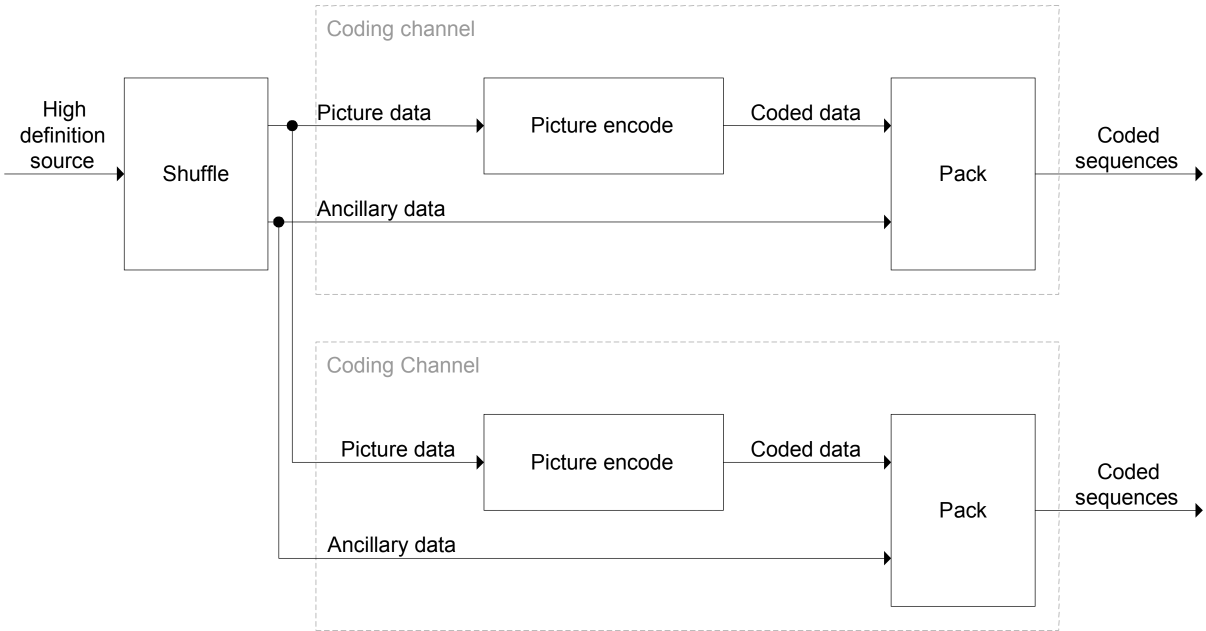


Figure 33 – Type D-16 encoding, two coding channels

In this standard, 8.2 describes the source picture data formats; 8.3 describes the source picture segmentation and shuffling; 8.4 describes the picture data encoding and 8.5 describes the encoded data packing. Subclause 8.6 defines the audio input format and the audio data packing.

The compressed picture and audio data packet formats specified by this clause are used as the source data stream for the helical track data processing which maps the Type D-16 packetized data stream format for recording to the Type D-16 tape format.

Annex A defines the digital interfaces that are required to create the full Type D-16 specification.

8.2 Input formats

Source ancillary and picture data for processing with Type D-16 encoding shall comprise one of two picture sizes as defined in 8.2.1 and 8.2.2.

8.2.1 1920 × 1080 format pictures

Type D-16 encoding shall process each complete 1920 × 1080 picture with the sample structure and line numbers as defined in SMPTE 274M for I and PsF frame formats. The image representations allowed shall be 4:2:2 YC_BC_R or 4:4:4 RGB, both with 10-bit component resolution.

Each encoded field or segmented frame shall be packed with 3 1920-word lines of 10-bit ancillary data. These 3 lines shall be selected from the allowed ranges as shown in Table 5. Only the values corresponding to the luminance or green (Y or G) picture component shall be encoded.

Table 5 – 1920 × 1080 ancillary data line number ranges

Field or segmented frame	Ancillary line number range
First field	9 to 20
Second field	572 to 583

NOTE The range of ancillary data lines and video components that can be encoded represents a subset of those provided for by the SMPTE-274M standard.

Type D-16 1920 × 1080 source picture rates for compression shall be constrained to the values specified in Table 6 and those defined in SMPTE 274M. Note that all 4:2:2 sampling formats use the single-link interface according to SMPTE 292M and all 4:4:4 sampling formats use the dual-link interface according to SMPTE 372M.

Table 6 – 1920 × 1080 source picture rates

Record unit (frame) rate	Sampling format	Picture format
23,98	4:2:2 YC_BC_R	One progressive segmented frame (PsF)
	4:4:4 RGB	
24	4:2:2 YC_BC_R	One progressive segmented frame (PsF)
	4:4:4 RGB	
25	4:2:2 YC_BC_R	One progressive segmented frame (PsF)
	4:4:4 RGB	
	4:2:2 YC_BC_R	Two interlaced fields (I)
	4:4:4 RGB	
29,97	4:2:2 YC_BC_R	One progressive segmented frame (PsF)
	4:4:4 RGB	
	4:2:2 YC_BC_R	Two interlaced fields (I)
	4:4:4 RGB	

8.2.2 1280 × 720 format pictures

Type D-16 encoding shall process 2 complete 1 280 × 720 pictures as a sequential pair with the sample structure and line numbers as defined in SMPTE-296M for the progressive frame format. The image representation shall be 4:2:2 YC_BC_R with 10-bit component resolution.

Each encoded picture shall be packed with 3 1 280-word lines of 10-bit ancillary data. These 3 lines shall be selected from the ranges allowed in Table 7. Only the values corresponding to the luminance (Y) picture component shall be encoded.

Table 7 – 1280 × 720 ancillary data line number ranges

Frame	Ancillary line number range
First frame	9 to 25
Second frame	9 to 25

NOTE The range of ancillary data lines and video components that can be encoded represents a subset of those provided for by the SMPTE-296M standard.

Type D-16 1280 × 720 source picture rates for compression shall be constrained to the values specified in Table 8 and defined by SMPTE 296M.

Table 8 – 1280 × 720 source picture rates

Record unit rate	Sampling format	Picture format
25	4:2:2 YC_BC_R	Two progressive frames (P)
29,97	4:2:2 YC_BC_R	Two progressive frames (P)

8.3 Input data segmentation and shuffling

8.3.1 Picture segmentation to shuffle blocks

The active picture area defined by SMPTE 274M for 1920 × 1080 pictures and SMPTE 296M for 1280 × 720 pictures shall be divided into shuffle blocks comprising data for the 3 video components representing a 16 × 16 pixel area of the source picture.

8.3.1.1 1920×1080/PsF 4:2:2 YC_BC_R pictures

Each 4:2:2 YC_BC_R 1920 × 1080 source picture in the PsF format shall be reconstituted to a progressive 1920 × 1080 frame, and the frame shall be divided into 8160 16 × 16 shuffle blocks as shown in Figure 34.

To allow the creation of complete shuffle blocks, each frame shall be extended by the addition of 8 lines at the end of the picture to create a 1920 × 1088 extended frame. The 8 extension lines shall comprise luminance (Y) black levels with the decimal value 64, and chrominance (C_B and C_R) achromatic levels with the decimal value 512.

Each shuffle block shall comprise one 16 × 16 luminance block and the 2 co-sited 8 × 16 chrominance blocks.

Each 16 × 16 luminance block shall comprise 16 consecutive samples of 16 consecutive lines in the 1920 × 1088 extended frame.

Each 8 × 16 chrominance block shall comprise 8 consecutive samples of 16 consecutive lines in the 1920 × 1088 extended frame.

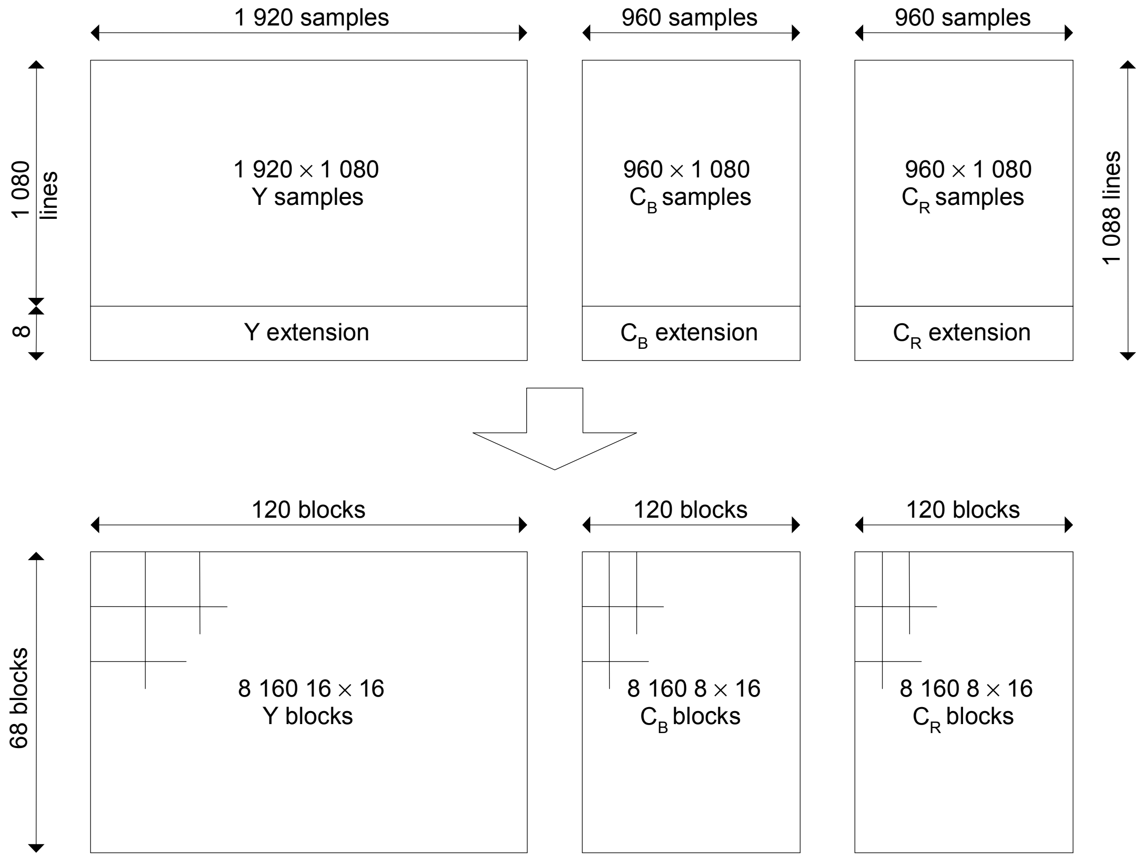


Figure 34 – 1920×1080/PsF 4:2:2 YC_BC_R shuffle blocks

8.3.1.2 1920 × 1080/PsF 4:4:4 RGB pictures

Each 4:4:4 RGB 1920 × 1080 source picture in the PsF format shall be reconstituted to a progressive 1920 × 1080 frame, and the frame shall be divided into 8160 16 × 16 shuffle blocks as shown in Figure 35.

To allow the creation of complete shuffle blocks each frame shall be extended by the addition of 8 lines at the end of the picture to create a 1920 × 1088 extended frame. The 8 extension lines shall comprise red, green and blue (R, G, B) black levels with the decimal value 64.

Each shuffle block shall comprise 3 co-sited 16 × 16 red, green and blue (R, G, B) blocks.

Each 16 × 16 R, G or B block shall comprise 16 consecutive samples of 16 consecutive lines in the 1920 × 1088 extended frame.

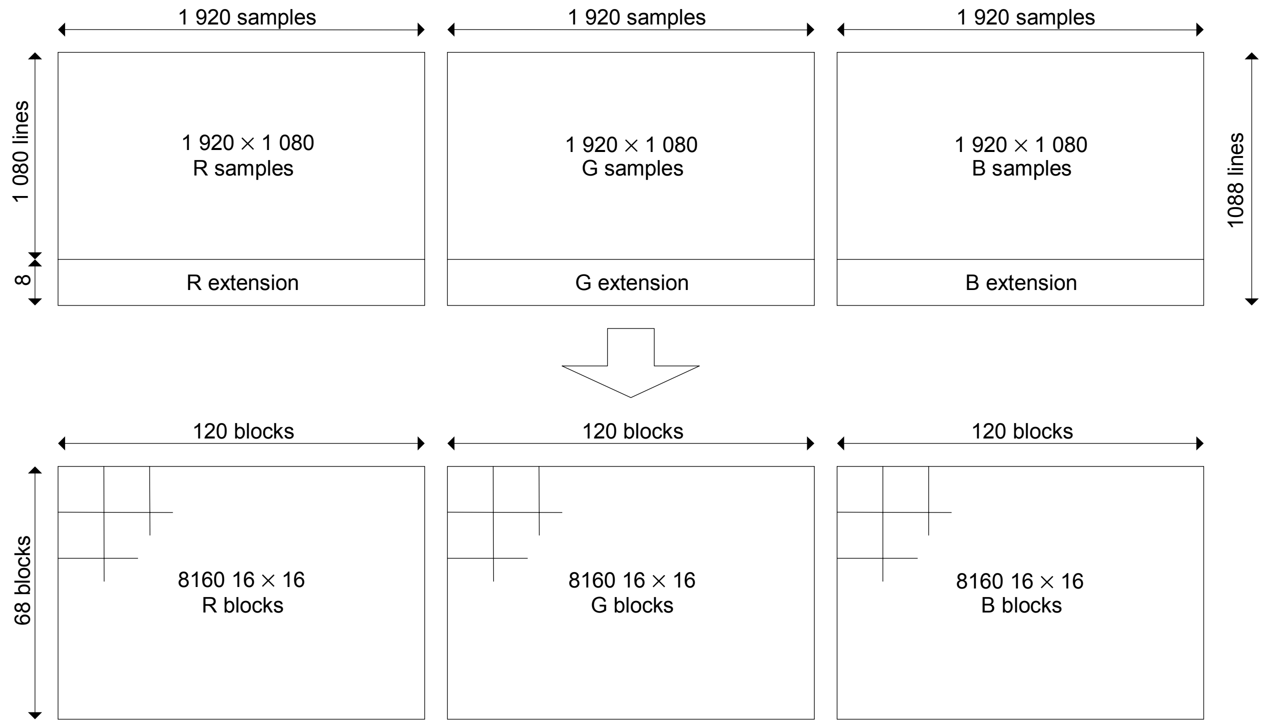


Figure 35 – 1920 × 1080/PsF 4:4:4 RGB shuffle blocks

8.3.1.3 1920 × 1080/I 422 YC_BC_R pictures

Each 4:2:2 YC_BC_R 1920 × 1080 source picture in the interlaced format shall be processed as 2 independent 1920 × 540 fields, and each field shall be divided into 4 080 16 × 16 shuffle blocks as shown in Figure 36.

To allow the creation of complete shuffle blocks each field shall be extended by the addition of 4 lines at the end of the field to create a 1920 × 544 extended field. The 4 extension lines shall comprise luminance (Y) black levels with the decimal value 64, and chrominance (C_B and C_R) achromatic levels with the decimal value 512.

Each shuffle block shall comprise one 16 × 16 luminance block and the 2 co-sited 8 × 16 chrominance blocks.

Each 16 × 16 luminance block shall comprise 16 consecutive samples of 16 consecutive lines in the extended 1920 × 544 field.

Each 8 × 16 chrominance block shall comprise 8 consecutive sample of 16 consecutive lines in the extended 1920 × 544 field.

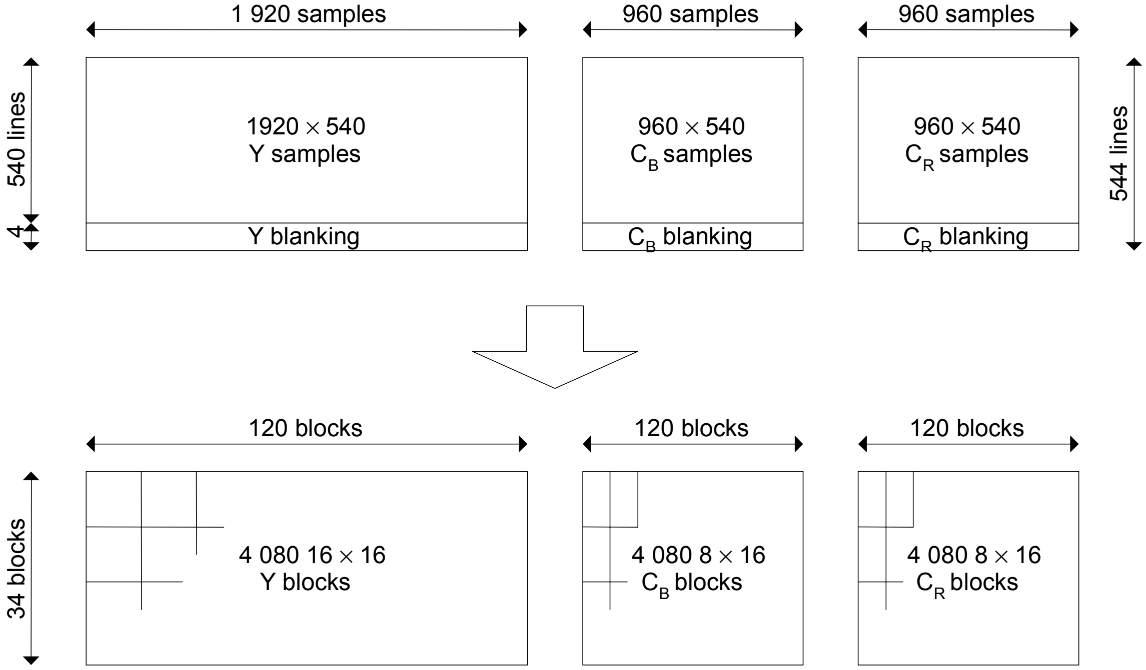


Figure 36 – 1920 × 540/I 4:2:2 YC_BC_R shuffle blocks

8.3.1.4 1920 × 1080/I 4:4:4 RGB pictures

Each 4:4:4 RGB 1920 × 1080 source picture in the interlaced format shall be processed as 2 independent 1920 × 540 fields, and each field shall be divided into 4 080 16 × 16 shuffle blocks as shown in Figure 37.

To allow the creation of complete shuffle blocks each field shall be extended by the addition of 4 lines at the end of the field to create a 1920 × 544 extended field. The 4 extension lines shall comprise red, green and blue (R, G, B) black levels with the decimal value 64.

Each shuffle block shall comprise three co-sited 16 × 16 red, green and blue (R, G, B) blocks.

Each 16 × 16 Y, R, G or B block shall comprise 16 consecutive samples of 16 consecutive lines in the extended 1920 × 544 field.

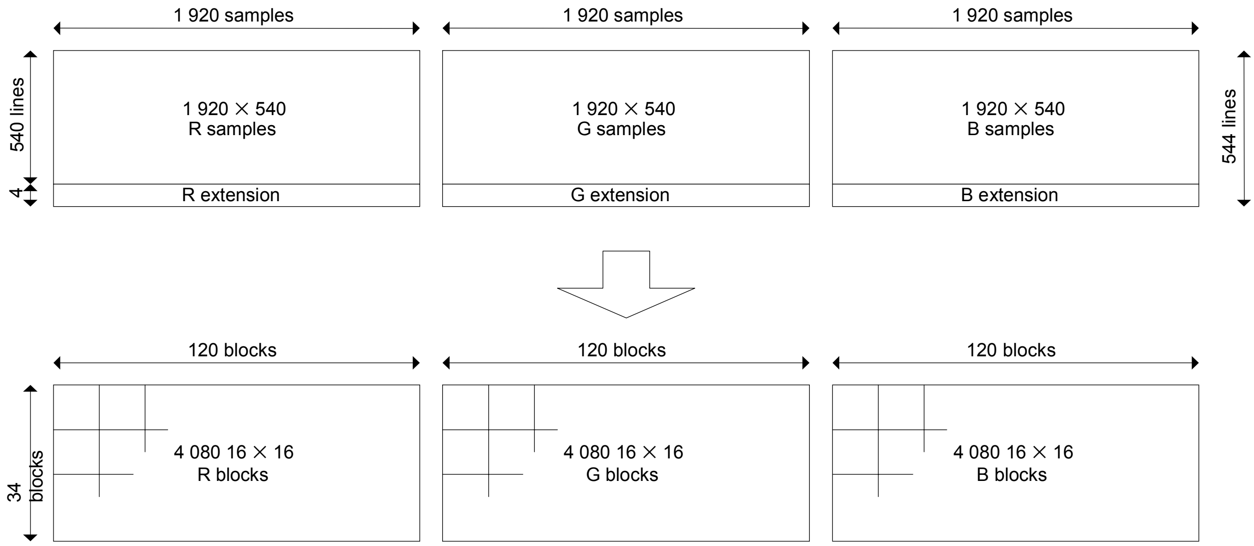


Figure 37 – 1920 × 540/I 4:4:4 RGB shuffle blocks

8.3.1.5 1280 × 720/P 4:2:2 YC_BC_R pictures

Each 1280 × 720 4:2:2 YC_BC_R source picture for compression shall be split into 3 600 16 × 16 shuffle blocks as shown in Figure 38.

Each shuffle block shall comprise 1 16 × 16 luminance (Y) block and the 2 co-sited two 8 × 16 chrominance (C_B and C_R) blocks.

The Y, C_B and C_R blocks shall comprise 8 or 16 consecutive samples of 16 consecutive lines in the 1280 × 720 frame.

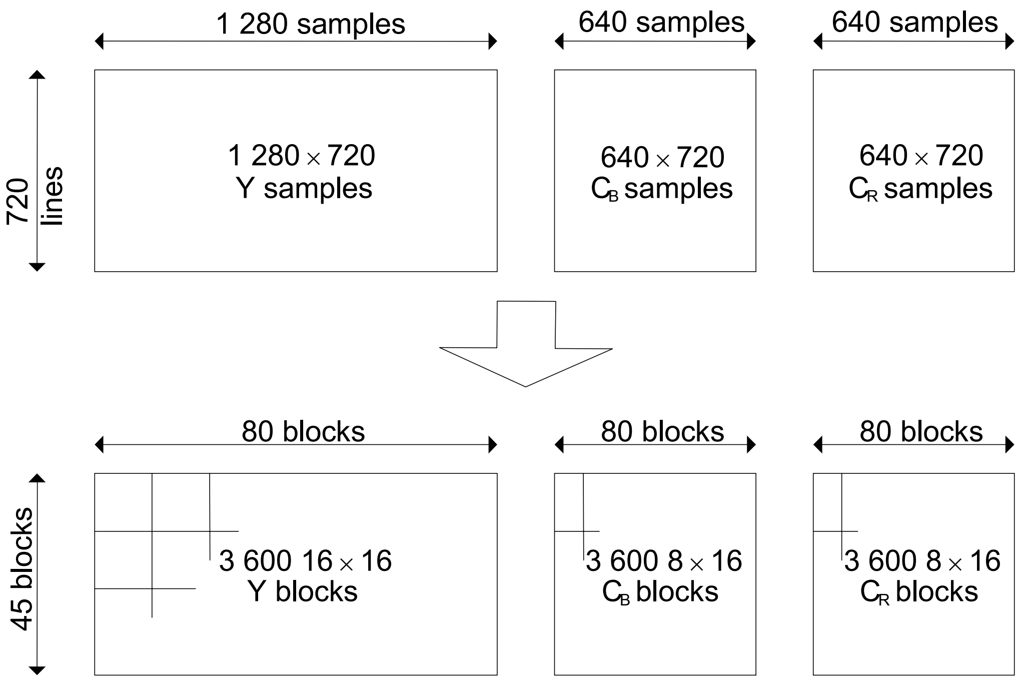


Figure 38 – 1280 × 720/P 4:2:2 YC_BC_R frame shuffle blocks

8.3.2 Mapping shuffle blocks to shuffle sets

The shuffle blocks defined in 8.3.1 shall be allocated to a number of shuffle sets according to the process defined in this subclause. The shuffle blocks within each shuffle set shall be assigned an interim block number, indicating the order in which the shuffle blocks were allocated to the shuffle set.

8.3.2.1 1920 × 1080/PsF 4:2:2 YC_BC_R pictures

The 120 × 68 shuffle block data for each 1920 × 1080/PsF 4:2:2 YC_BC_R source picture shall be divided into 4 shuffle sets numbered 0 to 3 by the application of a repeating allocation pattern to the progressive shuffle block structure of one extended frame defined in 8.3.1.1.

The shuffle blocks in the frame shall be scanned in a raster scan order from the top left to bottom right of the frame, and allocated to the shuffle set number defined by the pattern in Figure 39.

The first shuffle block allocated to each shuffle set shall have the interim block number '0'.

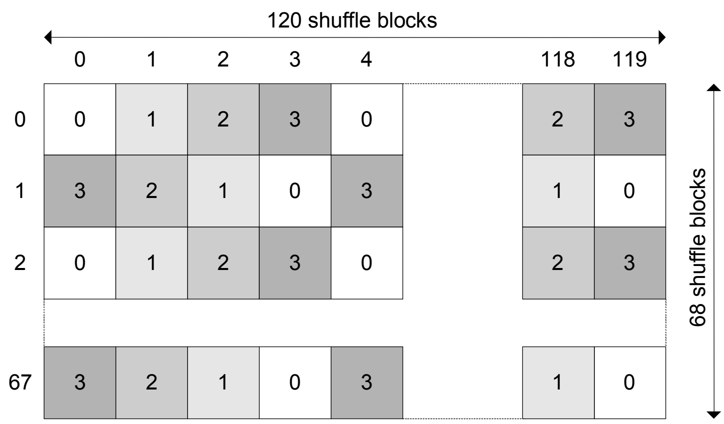


Figure 39 – 1920 × 1080/PsF 4:2:2 YC_BC_R shuffle sets

Each shuffle set shall contain 2 040 shuffle blocks with interim block numbers from 0 to 2039. These 2 040 shuffle blocks shall be allocated to the macro blocks of 10 macro block units, as defined in 8.3.3.

8.3.2.2 1920 × 1080/PsF 4:4:4 RGB pictures

The 120 × 68 shuffle block data for each 1920 × 1080/PsF 4:4:4 RGB source picture shall be divided into 8 shuffle sets numbered 0 to 7 by the application of a repeating allocation pattern to the progressive shuffle block structure of one extended frame defined in 8.3.1.2.

The shuffle blocks in the frame shall be scanned in a raster scan order from the top left to the bottom right of the frame, and allocated to the shuffle set number defined by the pattern in Figure 40.

The first shuffle block allocated to each shuffle set shall have the interim block number '0'.

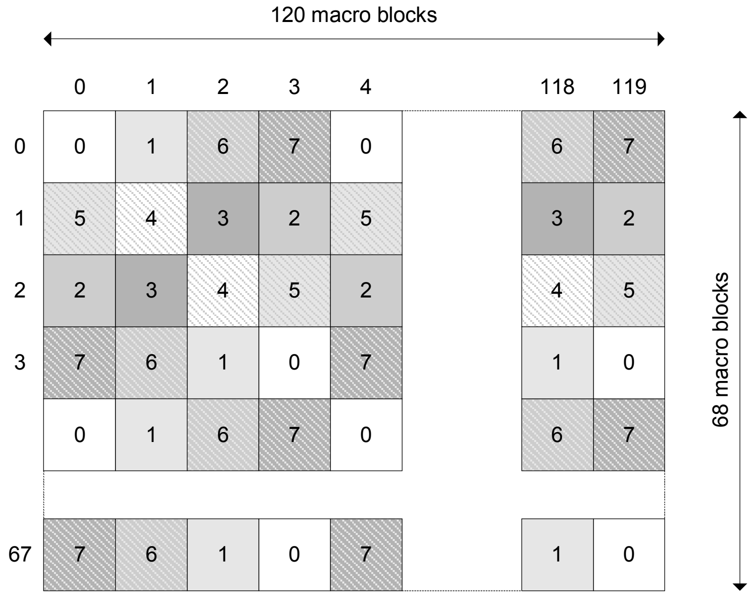


Figure 40 – 1920 × 1080/PsF 4:4:4 RGB shuffle sets

Each shuffle set shall contain 1 020 shuffle blocks with interim block numbers from 0 to 1019. These 1 020 shuffle blocks shall be allocated to the macro blocks of 5 macro block units, as defined in 8.3.3.

8.3.2.3 1920 × 1080/I 4:2:2 YC_BC_R pictures

The 120 × 68 shuffle block data for each 1920 × 1080/I 4:2:2 YC_BC_R source picture shall be divided into four shuffle sets numbered 0 to 3 by the application of a repeating allocation pattern to the progressive shuffle block structure of two extended fields defined in 8.3.1.3.

The shuffle blocks in the 2 fields shall be scanned in a raster scan order from the top left to the bottom right of each field, and allocated to the shuffle set number defined by the pattern in Figure 41. The first shuffle block allocated to each shuffle set shall have the interim block number ‘0’.

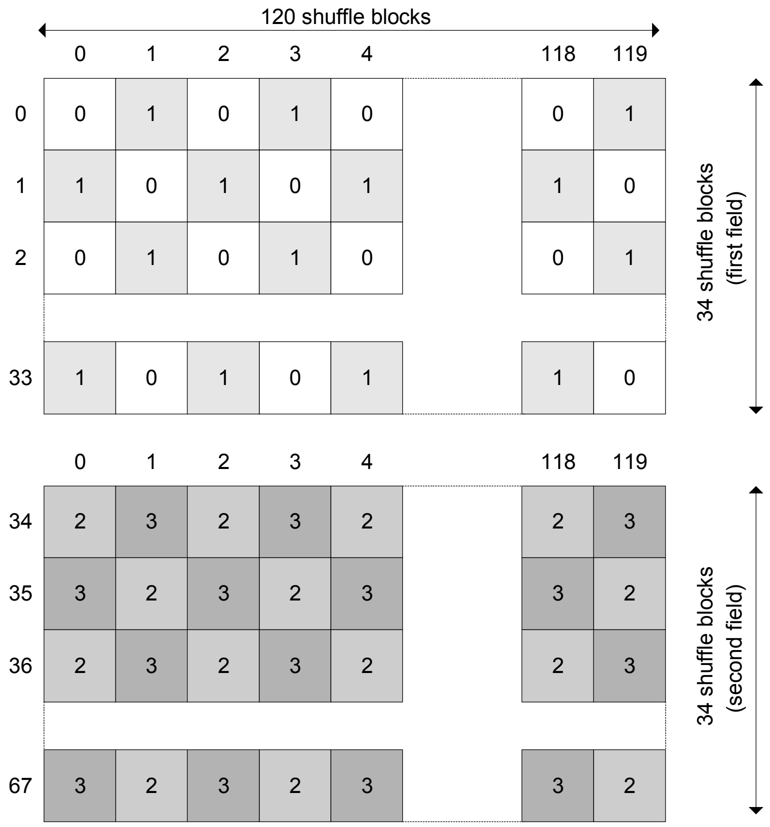


Figure 41 – 1920 × 1080/I 4:2:2 YC_BC_R shuffle sets

Each shuffle set shall contain 2 040 shuffle blocks with interim block numbers from 0 to 2039. These 2 040 shuffle blocks shall be allocated to the macro blocks of 10 macro block units, as defined in 8.3.3.

NOTE In the shuffle sets there is no sharing of data between the two fields.

8.3.2.4 1920 × 1080/I 4:4:4 RGB pictures

The 120 × 68 shuffle block data for each 1920 × 1080/I 4:4:4 RGB source picture shall be divided into 8 shuffle sets numbered 0 to 7 by the application of a repeating allocation pattern to the progressive shuffle block structure of 2 extended fields defined in 8.3.1.4.

The shuffle blocks in the 2 fields shall be scanned in a raster scan order from the top left to the bottom right of each field, and allocated to the shuffle set number defined by the pattern in Figure 42. The first shuffle block allocated to each shuffle set shall have the interim block number '0'.

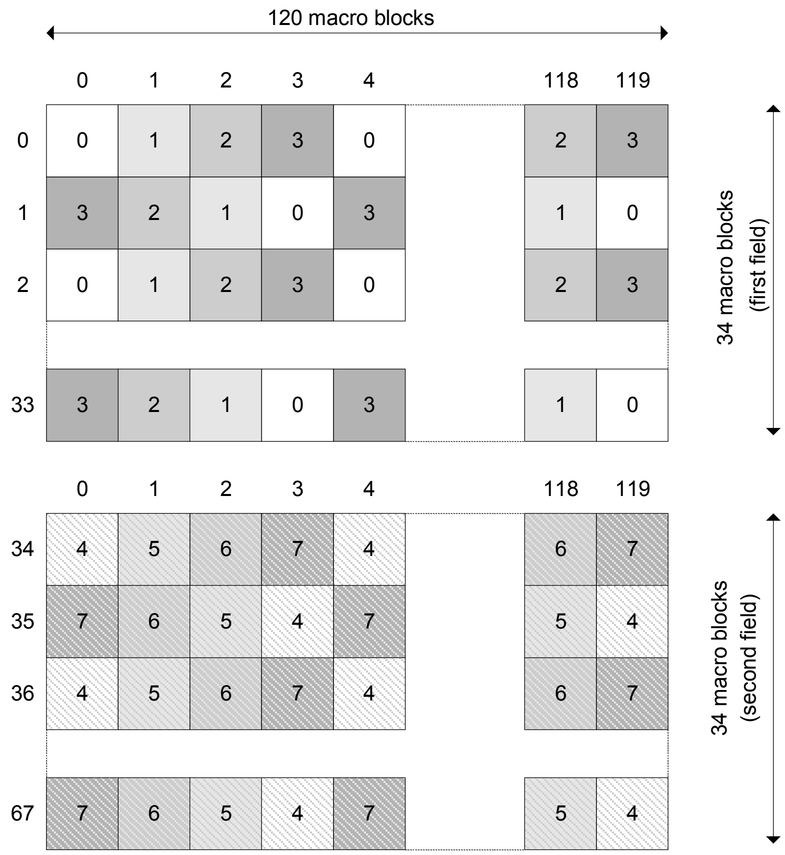


Figure 42 – 1920 × 1080/I 4:4:4 RGB shuffle sets

Each shuffle set shall contain 1 020 shuffle blocks with interim block numbers from 0 to 1019. These 1 020 shuffle blocks shall be allocated to the macro blocks of 5 macro block units, as defined in 8.3.3.

NOTE In the shuffle sets there is no sharing of data between the two fields.

8.3.2.5 1280 × 720/P 4:2:2 YC_BC_R pictures

The 80 × 90 shuffle block data for two successive 1280 × 720/P 4:2:2 YC_BC_R source pictures shall be divided into 4 shuffle sets numbered 0 to 3 by the application of a repeating allocation pattern to the progressive shuffle block structure of 2 frames defined in 8.3.1.5.

The shuffle blocks in the 2 frames shall be scanned in a raster scan order from the top left to the bottom right of each frame, and allocated to the shuffle set number defined by the pattern in Figure 43. The first shuffle block allocated to each shuffle set shall have the interim block number ‘0’.

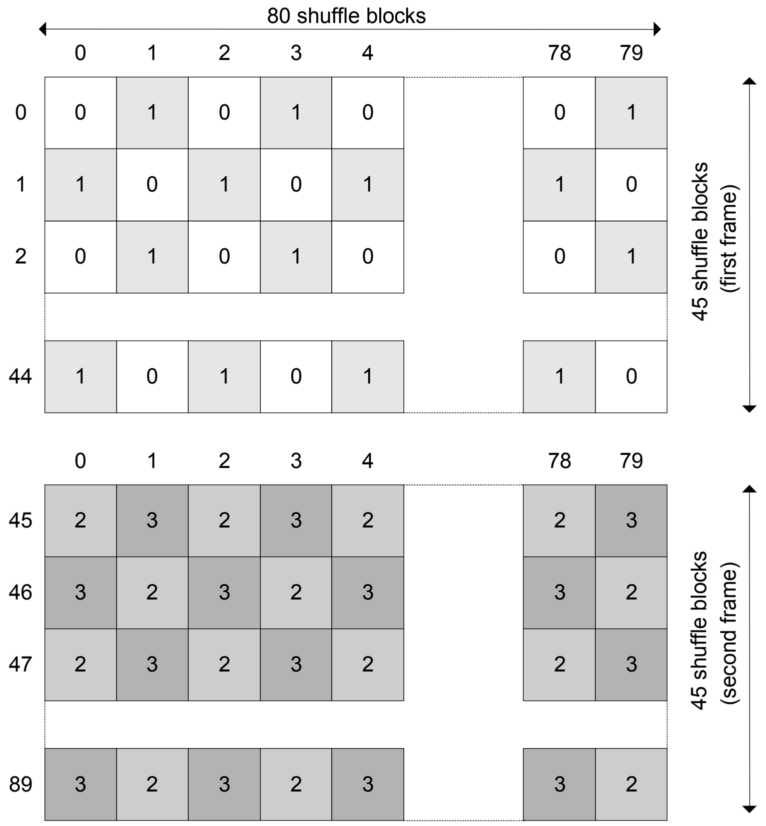


Figure 43 – 1280 × 720/P 4:2:2 YC_BC_R shuffle sets

Each shuffle set shall contain 1 800 shuffle blocks with interim block numbers from 0 to 1799. These 1 800 shuffle blocks shall be allocated to the macro blocks of 10 macro block units, as defined in 8.3.3.

NOTE In the shuffle sets there is no sharing of data between the two frames.

8.3.3 Shuffle-set allocation to macro block units

Each shuffle block in each shuffle set shall be allocated to a unique macro block in one of 40 macro block units, numbered from 0 to 39.

Macro block units generated from 1920 × 1080 pictures shall contain 204 macro blocks numbered from 0 to 203, and macro block units generated from 1280 × 720 pictures shall contain 180 macro blocks numbered from 0 to 179.

The macro block unit number shall be used to select a shuffle set ("set") and unit value from Table 9. For each macro block in the macro block unit, the macro block number shall be used to generate an interim block number according to the following pseudo-random mapping equation:

$$\text{Interim block number} = (49 \times ((\text{Unit} \times \text{SIZE}) + \text{macro block number}))\%\ \text{RANGE}$$

where % represents the remainder of a modulo division operation and the values for SIZE and RANGE shall be defined from Table 10.

Table 9 – Shuffle-set allocation

Macro block unit number	1080/I 4:2:2 720/P 4:2:2		1080/PsF 4:2:2		1080/I 4:4:4		1080/PsF 4:4:4	
	Set	Unit	Set	Unit	Set	Unit	Set	Unit
0	0	0	0	0	0	0	0	0
1	0	1	1	0	1	0	1	0
2	0	2	0	1	0	1	2	0
3	0	3	1	1	1	1	3	0
4	0	4	0	2	0	2	0	1
5	0	5	1	2	1	2	1	1
6	0	6	0	3	0	3	2	1
7	0	7	1	3	1	3	3	1
8	0	8	0	4	0	4	0	2
9	0	9	1	4	1	4	1	2
10	1	0	0	5	2	0	2	2
11	1	1	1	5	3	0	3	2
12	1	2	0	6	2	1	0	3
13	1	3	1	6	3	1	1	3
14	1	4	0	7	2	2	2	3
15	1	5	1	7	3	2	3	3
16	1	6	0	8	2	3	0	4
17	1	7	1	8	3	3	1	4
18	1	8	0	9	2	4	2	4
19	1	9	1	9	3	4	3	4
20	2	0	2	0	4	0	4	0
21	2	1	3	0	5	0	5	0
22	2	2	2	1	4	1	6	0
23	2	3	3	1	5	1	7	0
24	2	4	2	2	4	2	4	1
25	2	5	3	2	5	2	5	1
26	2	6	2	3	4	3	6	1
27	2	7	3	3	5	3	7	1
28	2	8	2	4	4	4	4	2
29	2	9	3	4	5	4	5	2
30	3	0	2	5	6	0	6	2
31	3	1	3	5	7	0	7	2
32	3	2	2	6	6	1	4	3
33	3	3	3	6	7	1	5	3
34	3	4	2	7	6	2	6	3
35	3	5	3	7	7	2	7	3
36	3	6	2	8	6	3	4	4
37	3	7	3	8	7	3	5	4
38	3	8	2	9	6	4	6	4
39	3	9	3	9	7	4	7	4

Table 10 – Pseudo-random SIZE and RANGE value

Picture size	Sampling format	SIZE	RANGE
1920 × 1080	4:2:2 YC_BC_R	204	2040
1280 × 720	4:2:2 YC_BC_R	180	1800
1920 × 1080	4:4:4 RGB	204	1020

The picture data in the shuffle block corresponding to the calculated interim block number in the shuffle set indicated by the macro block unit number is extracted from the shuffle set as the data to be encoded for the macro block in the macro block unit.

8.3.4 Grouping of macro block units in coded sequences

The 40 macro block units generated by the picture shuffling defined in the preceding subclauses shall be processed by coding channels to generate coded sequences of encoded macro block data.

The coded sequence forms the compressed picture part of a segment as defined in this standard. Each macro block unit shall contain 204 macro blocks numbered from 0 to 203.

8.3.4.1 1920 × 1080 4:2:2 YC_BC_R grouping

For each 4:2:2 YC_BC_R 1920 × 1080 picture, macro block units shall be allocated to one coding channel as shown in Figure 44. The coding channel shall produce 2 coded sequences, representing the 2 fields for interlaced source pictures or 2 half-frames for progressive source pictures.

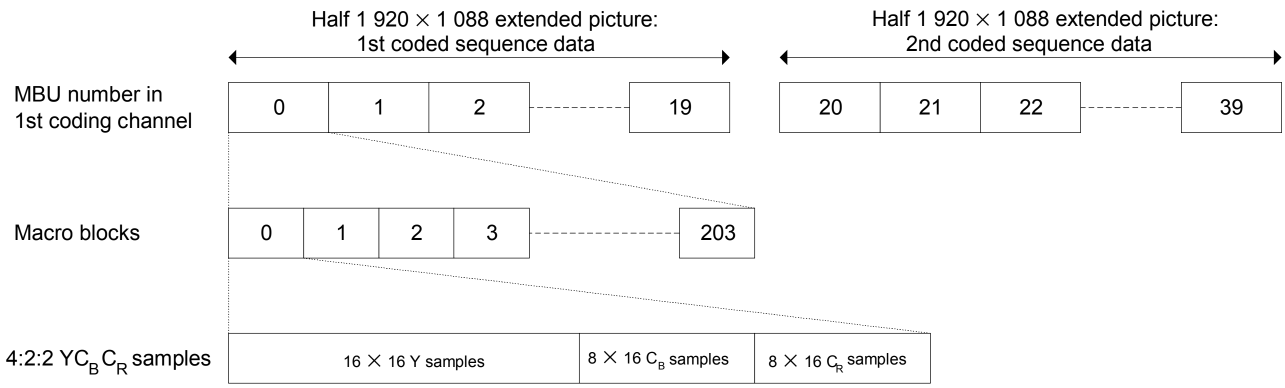


Figure 44 – 1920×1080 4:2:2 YC_BC_R macro block unit number allocation

8.3.4.2 1920 × 1080 4:4:4 RGB grouping

For each 4:4:4 RGB 1920 × 1080 picture, the 40 macro block units shall be allocated to 2 coding channels as shown in Figure 45. The coding channels shall each produce 2 coded sequences, representing the 2 fields for interlaced source pictures or 2 half-frames for progressive source pictures.

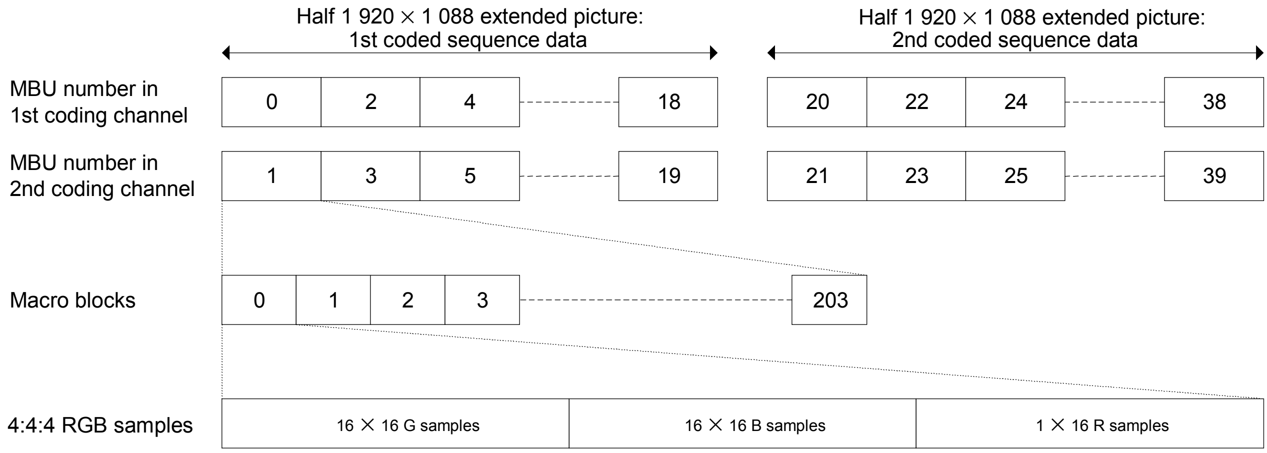


Figure 45 – 1920 × 1080 4:4:4 RGB macro block unit number allocation

8.3.4.3 1280 × 720 4:2:2 YC_BC_R grouping

For each pair of 4:2:2 YC_BC_R 1280 × 720 pictures, the 40 macro block units shall be allocated to 1 coding channel as shown in Figure 46. The coding channel shall produce 2 coded sequences, representing the 2 source frames.

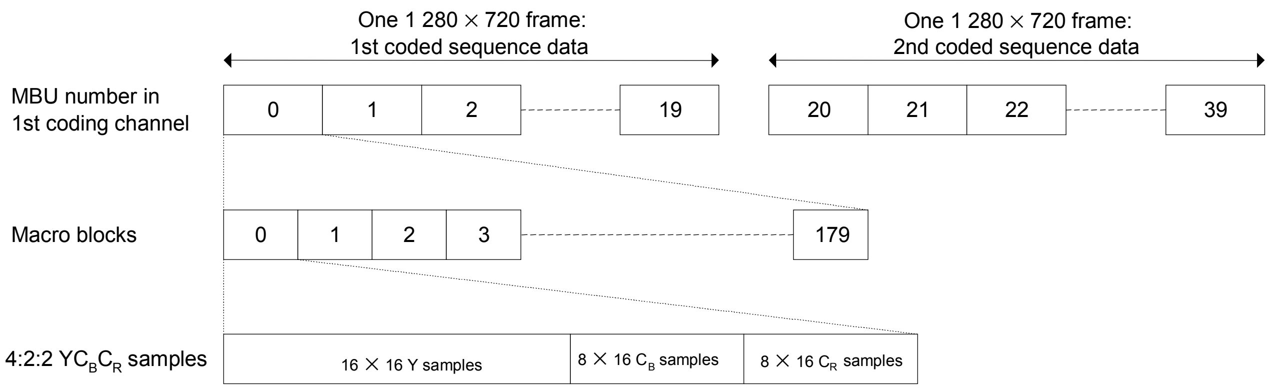


Figure 46 – 1280×720 4:2:2 YC_BC_R macro block unit number allocation

The fixed length picture data in each macro block unit shall be encoded as defined in 8.4 and packed into fixed length basic blocks as defined in 8.5.

8.3.5 Ancillary data segmentation

8.3.5.1 Ancillary data burst generation

The complete 10-bit raw data on each of 3 ancillary data lines selected from each field or segmented frame for 1920 × 1080 picture encoding shall be divided along their length into 16-word bursts, as shown in Figure 47. As defined in 8.2.1 the ancillary data will only comprise the Y or G component. The 3 lines of 120 bursts each shall be divided into ancillary data streams, with 1 stream for each coded sequence in each coding channel, as defined in 8.3.5.2.

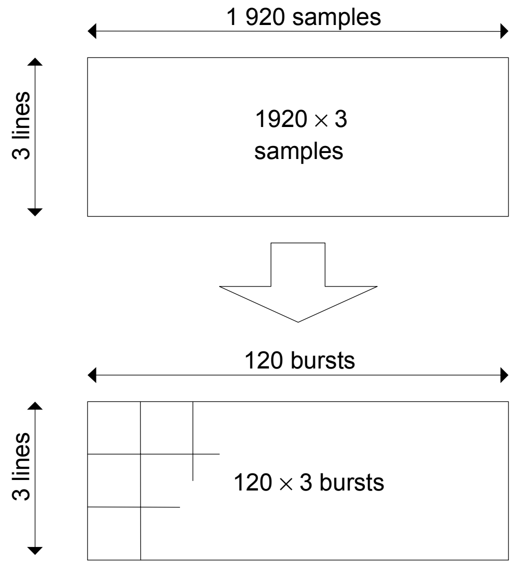


Figure 47 – 1920 × 1080 ancillary data bursts

The complete 10-bit raw data on each of three ancillary data lines selected from each frame for 1280 × 720 picture encoding shall be divided along their length into 16-word bursts, as shown in Figure 48. As defined in 8.2.2, the ancillary data will only comprise the Y component. The 3 lines of 80 bursts each shall be divided into ancillary data streams, with 1 stream for each coded sequence in each coding channel, as defined in 8.3.5.2.

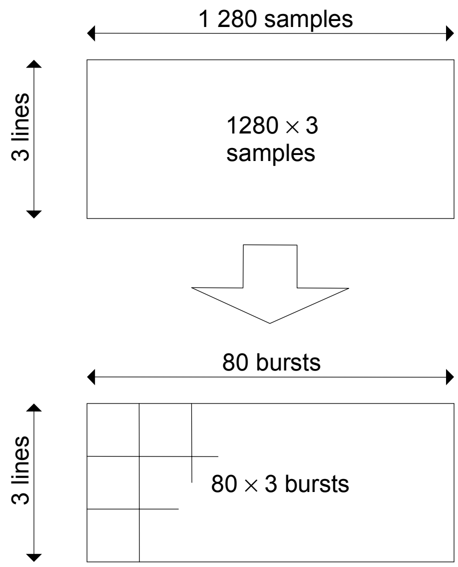


Figure 48 – 1280 × 720 ancillary data bursts

8.3.5.2 Ancillary data stream generation

The ancillary data bursts defined in 8.3.5.1 shall be divided between the coding channels defined in 8.3.4 with the addition of 2 10-bit header words for each ancillary line in each coding channel. The ancillary data bursts and associated header words for each coded sequence in each coding channel shall then be concatenated to form an ancillary stream, which is packed with the encoded data as defined in 8.5.

The 2 ancillary header words, AH_0 and AH_1, shall be as defined in Figure 49.

a) AH_0 Byte

LSB 0	1	2	3	4	5	6	7	8	9 MSB
LN_0	LN_1	LN_2	LN_3	LN_4	LN_5	1	1	1	1
Ancillary line ID						Fixed			

b) AH_1 Byte

LSB 0	1	2	3	4	5	6	7	8	9 MSB
1	0	0	0	0	0	1	1	1	1
Fixed									

Figure 49 – Ancillary data headers

When encoding 1920 × 1088 4:2:2 YC_BC_R extended pictures only one coding channel is used. The ancillary data bursts for each line shall be appended in sequence to the ancillary header words, generating three 1922-word sets for each coded sequence. These sets shall then be concatenated from the most to the least significant bit of each word and from the lowest numbered ancillary data line to the highest, giving a 57 660-bit ancillary data stream for each coded sequence.

When encoding 1920 × 1088 4:4:4 RGB extended pictures two coding channels are used. The ancillary data bursts are allocated alternately to the first or second coding channel on each line, with the left-most burst on each line being allocated to the first coding channel. Identical header words are included for each ancillary stream, generating three 962-word sets for each coded sequence in the two coding channels. The sets allocated to each coded sequence shall then be concatenated from the most to the least significant bit of each word and from the lowest numbered ancillary data line to the highest, giving a 28 860-bit ancillary data stream for each coded sequence in each coding channel.

When encoding pairs of 1280 × 720 4:2:2 YC_BC_R pictures only one coding channel is used. The ancillary data bursts for each line shall be appended to two ancillary header words, generating three 1 282-word sets for each coded sequence. These sets shall then be concatenated from the most to the least significant bit of each word and from the lowest numbered ancillary data line to the highest, giving a 38460-bit ancillary data stream for each coded sequence.

In the ancillary header word AH_0 each ancillary line ID shall be a 6-bit unsigned integer representing the line number of the ancillary line. The range of permissible ancillary line number values for 1920 × 1080 pictures is defined in Table 5 and for 1280 × 720 pictures in Table 7. The relationship between the line number in the source picture and the ancillary line ID shall be as defined in Table 11.

Table 11 – Ancillary line ID values

Ancillary line ID	1920 × 1080 format		1280 × 720 format	
	Field	Source line	Frame	Source line
0	First	9	Not allowed	
1	First	10	Not allowed	
2	First	11	First	9
3	First	12	First	10
4	First	13	First	11
5	First	14	First	12
6	First	15	First	13
7	First	16	First	14
8	First	17	First	15
9	First	18	First	16
10	First	19	First	17
11	First	20	First	18
12	Second	572	First	19
13	Second	573	First	20
14	Second	574	First	21
15	Second	575	First	22
16	Second	576	First	23
17	Second	577	First	24
18	Second	578	First	25
19	Second	579	Not allowed	
20	Second	580	Not allowed	
21	Second	581	Second	9
22	Second	582	Second	10
23	Second	583	Second	11
24	Not allowed		Second	12
25	Not allowed		Second	13
26	Not allowed		Second	14
27	Not allowed		Second	15
28	Not allowed		Second	16
29	Not allowed		Second	17
30	Not allowed		Second	18
31	Not allowed		Second	19
32	Not allowed		Second	20
33	Not allowed		Second	21
34	Not allowed		Second	22
35	Not allowed		Second	23
36	Not allowed		Second	24
37	Not allowed		Second	25
38 to 63	Not allowed		Not allowed	

The data in each ancillary stream is packed into basic blocks in 15-bit bursts, as defined in 8.5.4.2. When all the bits of an ancillary stream have been packed, subsequent 15-bit bursts shall be completed by padding the burst with default zero bits as required. There shall be no sharing of data between ancillary streams.

8.4 Picture data encoding

8.4.1 Overview

The macro blocks in each macro block unit shall be encoded in either DCT or DPCM mode using the operations defined for MPEG-4 studio profile (ISO/IEC 14496-2) subject to the constraints defined in this section. Figure 50 shows the MPEG-4 studio profile operations required for encoding macro blocks of picture data.

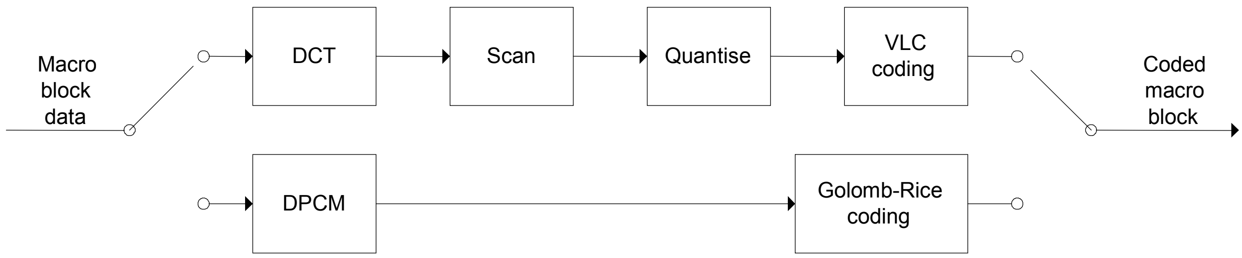


Figure 50 – Macro block encoding

The MPEG-4 studio profile parameters for DCT and DPCM encoding modes shall be constrained as defined in Table 12. Unless otherwise noted, all parameter names shall refer to those defined in the MPEG-4 studio profile document.

Table 12 – General coding constraints

Description	chroma_format	rgb_components	bits_per_pixel
4:2:2 YC_BC_R	10	0	10
4:4:4 RGB	11	1	10

After encoding, each macro block will comprise a number of variable length codes which shall be packed as defined in 8.5.

8.4.2 DCT coding

The encoding of DCT mode Type D-16 macro blocks shall follow the encoding operations defined for MPEG-4 studio profile intra macroblocks, when 'compression_mode' set to '1'. Subclause 7.16.4 of ISO/IEC 14496-2 defines the decoding operations for this mode.

8.4.2.1 Discrete cosine transform

Each macro block shall be processed by the MPEG-4 studio profile discrete cosine transform defined for MPEG-4 studio profile macroblocks. The format of the DCT coefficients is defined in 7.16.4.4 of ISO/IEC 14496-2.

The 'dct_type' parameter shall be constrained to the value '1', indicating frame DCT coding. This controls the method used to divide the 8 × 16 or 16 × 16 macro block data to 8 × 8 DCT blocks.

After the transform each 8 × 8 DCT block will comprise one DC and 63 AC coefficients, which shall be scanned and quantized as defined in 8.4.2.2 and 8.4.2.3.

8.4.2.2 Scan

The DC and AC coefficients of each macro block produced by the DCT process defined in 8.4.2.1 shall then be scanned according to the order defined in 7.16.4.2 of ISO/IEC 14496-2.

The 'alternate_scan' parameter shall be constrained to the value '0', indicating the zigzag scan pattern.

8.4.2.3 Quantize

Each macro block shall then be quantized by the MPEG-4 studio profile quantizer. The format of the quantized values is defined in 7.16.4.3 of ISO/IEC 14496-2.

The ‘intra_dc_precision’ parameter shall be constrained to the value ‘0’.

The ‘dct_precision’ and ‘q_scale_type’ parameters shall take the same value for all macro blocks sourced from the same interlaced field or progressive frame.

In addition to these constraints, the ‘quantizer_scale_code’ parameter shall be restricted to the ranges defined in Table 13 according to the ‘dct_precision’ and ‘q_scale_type’ parameter values.

Table 13 – Range for quantizer_scale_code

dct_precision	q_scale_type	quantizer_scale_code range
3	0	4 to 31
2	0	2 to 31
1	0	1 to 31
0	0	1 to 31
0	1	1 to 31

The quantized DC and AC coefficients for each DCT block in the macro block shall then be VLC encoded as defined in 8.4.2.4.

The parameters ‘dct_precision’, ‘q_scale_type’, ‘intra_quantizer_matrix’ and ‘chroma_intra_ quantizer_matrix’ are not restricted in Type D-16 compression.

8.4.2.4 VLC coding

The quantized DC and AC coefficients produced by the quantize process defined in 8.4.2.3 shall then be encoded by the MPEG-4 studio profile VLC method defined for intra macroblocks. The VLC format is defined in 7.16.4.1 of ISO/IEC 14496-2.

In Type D-16 compression the default ‘intra_vlc_tables’ shall be used.

The predictors used in the differential DC encoding shall be reset in every macro block.

8.4.3 DPCM coding

The encoding of DPCM mode Type D-16 macro blocks shall follow the encoding operations defined for MPEG-4 studio profile intra macroblocks, when ‘compression_mode’ is set to ‘0’. Subclause 7.16.5 of ISO/IEC 14496-2 defines the decoding operations for this mode.

8.4.3.1 DPCM transform

Each macro block to be encoded by the DPCM method shall be processed by the MPEG-4 studio profile DPCM transform.

The ‘dpcm_scan_order’ parameter shall take the same value for all macro blocks sourced from the same interlaced field or progressive frame.

The ‘rice_parameter’ value for each component shall be restricted to the range 1 to 10.

After the transform each component will comprise one 10-bit ‘block_mean’ value and 128 or 256 ‘dpcm_residual’ values, which shall be encoded as defined in 8.4.3.2.

NOTE The 'rice_parameter' may take a different value for each video component in the macro block, as allowed in ISO/IEC 14496-2.

8.4.3.2 Golomb-Rice coding

The 'dpcm_residuals' values produced by the DPCM transform defined in 8.4.3.1 shall then be encoded by the MPEG-4 studio profile Golomb-Rice coding.

NOTE After encoding, each macro block will comprise three 10-bit 'block_mean' values and three sets of encoded DPCM residuals. Each 'dpcm_residual' value produces one code word, so 16 × 16 components (luminance, red, green or blue) produce 256 code words and 8 × 16 components (chrominance) produce 128 code words.

8.5 Data packing

8.5.1 Overview

The encoding of each macro block unit in each coding channel produces a sequence of coded values for each macro block. The coded values for each macro block unit shall be packed into 204 basic blocks, with the addition of header data and ancillary data for each macro block. There shall be no sharing of encoded data between the basic blocks of different macro block units.

The encoded data for each block in a macro block shall be interleaved before packing. The interleaving will also include a transcoding operation on DCT blocks' coded DC coefficients.

The packed basic blocks for the macro block units in each coding channel shall be grouped into two coded sequences, each comprising 24 auxiliary basic blocks followed by 4 080 compressed data basic blocks.

8.5.2 Basic block format

Each basic block shall comprise 230 bytes, divided into 4 identifier bytes (BID_0 to BID_3) and 226 payload bytes, as shown in Figure 51.

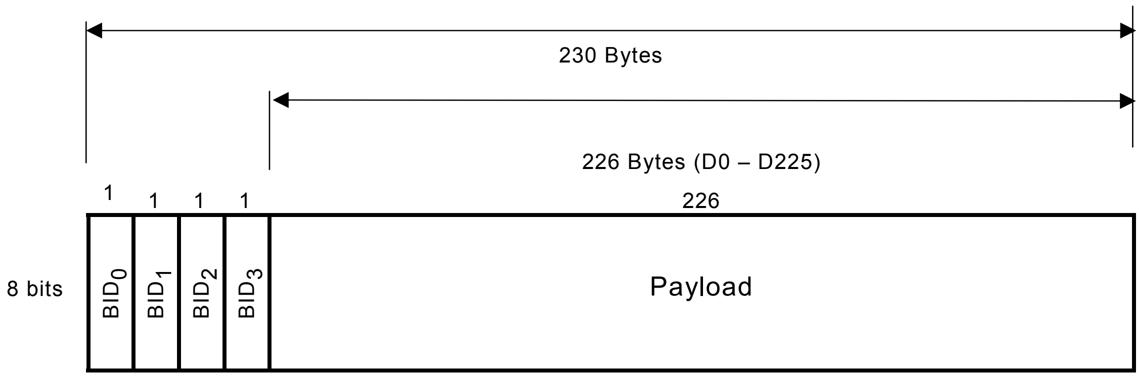


Figure 51 – Basic block format

The first identifier byte, BID_0, shall define a 1-bit basic block type and a 6-bit macro block unit number as shown in Figure 52a.

Bit 7 shall define a basic block type as coded data (value '0') or auxiliary (value '1')

Bit 6 shall have a default value '0'

Bits 5 to 0 shall define a macro block unit number as unsigned integer in the range 0 to 39.

The second identifier byte, BID_1, shall define a basic block number as an 8-bit unsigned integer in the range 0 to 203 as shown in Figure 52b.

The least significant bit of the third identifier byte, BID_2, shall define a basic block count flag as shown in Figure 52c. This bit shall have the value '0' unless otherwise specified. The remaining bits shall be default zero values.

The 4 most significant bits of the fourth identifier byte, BID_3, shall contain a 4-bit coded sequence segment number as an unsigned integer in the range 0 to 1 as shown in Figure 52d. The remaining bits shall be default zero values.

a) BID_0 Byte

LSB MSB

0	1	2	3	4	5	6	7
MBU_0	MBU_1	MBU_2	MBU_3	MBU_4	MBU_5	0	AUX
Macro block unit number						Fixed	Type

b) BID_1 Byte

LSB MSB

0	1	2	3	4	5	6	7
BB_0	BB_1	BB_2	BB_3	BB_4	BB_5	BB_6	BB_7
Basic block number							

c) BID_2 Byte

LSB MSB

0	1	2	3	4	5	6	7
CNT	0	0	0	0	0	0	0
Count	Fixed						

d) BID_3 Byte

LSB MSB

0	1	2	3	4	5	6	7
0	0	0	0	Seg_0	Seg_1	Seg_2	Seg_3
Fixed				Video segment number			

Figure 52 – Macro block identifier byte descriptions

The segment numbers in each coded sequence shall be determined from the macro block unit number as defined in Table 14.

Table 14 – Coded sequence segment numbers

Macro block unit number	Segment number
0 to 19	0
20 to 39	1

Bit 7 of the first payload byte (D0) shall have a default value of ‘0’ in all basic blocks and shall not be used for packing any data. Following this, the remaining payload bits shall be packed in order, from their most significant free bit to their least significant bit and from byte D0 to byte D225.

Packing for a macro block unit shall begin with basic block number ‘0’ and continue in sequence to basic block number ‘203’. The basic blocks shall be assembled into coded sequences comprising 24 basic blocks containing auxiliary data as defined in 8.5.3 followed by 4 080 basic blocks containing compressed picture data as defined in 8.5.4.

8.5.3 Auxiliary basic block packing

Compressed macro block units shall be grouped into coded sequences of 24 auxiliary basic blocks followed by 4 080 compressed data basic blocks. Each auxiliary basic block shall be of the format defined in 8.5.2. The 226 payload bytes shall be the same in each of the 24 auxiliary basic blocks in the same coded sequence.

Table 15 defines the content of the auxiliary basic block data.

The basic block type in BID_0 bit 7 shall be set to ‘1’ for all auxiliary basic blocks.

The macro block unit number in BID_0 shall be set to ‘0’ for all auxiliary basic blocks.

The basic block number in BID_1 shall be a value in the range ‘0’ to ‘23’ in number order, with auxiliary block ‘0’ being the first basic block in the packed coded sequence.

The basic block count in the BID_2 byte shall be set to ‘0’ for all auxiliary basic blocks.

The video segment number in BID_3 shall be the same as the video segment number of the first compressed data basic block in the coded sequence. This value depends on the macro block unit sequence defined in 8.3.4 and Table 14.

The values in Table 15 are unsigned decimal integers.

Table 15 – Auxiliary basic block data

Byte	Bits	Description	Value
BID0	7~0	BID$_0$ byte	Fixed value ‘128’
BID1	7~0	BID$_1$ byte	Value ‘0’ to ‘23’
BID2	7~0	BID$_2$ byte	Fixed value ‘0’
BID3	7~0	BID$_3$ byte	See above
D0	6~0	Reserved	Fixed value ‘0’
D1 to D64	7~0	intra_quantizer_matrix	As MPEG-4 studio profile format
D65 to D128	7~0	chroma_intra_quantizer_matrix	As MPEG-4 studio profile format
D129	7~6	Reserved	Fixed value ‘0’
	5	Double rate flag	See Table 16
	4~3	Frame rate	
	2	Processing Mode	1920 × 1080/I (value ‘0’) 1920 × 1080/PsF (value ‘1’) 1280 × 720/P (value ‘0’)
	1	Reserved	Fixed value ‘0’
	0	rgb_components	As MPEG-4 studio profile format
D130	7~2	Reserved	Fixed value ‘0’
	1~0	Picture format	1920 × 1080 (value ‘0’) 1280 × 720 (value ‘1’)
D131	7~0	Reserved	Fixed value ‘64’
D132	7~0	Reserved	Fixed value ‘49’
D133	7~0	Reserved	Fixed value ‘204’
D134	7	Two basic block packing flag	Fixed value ‘0’
	6~0	Macro block units per coding channel	4:2:2 YC$_B$C$_R$ format (value ‘40’) 4:4:4 RGB format (value ‘20’)
D135 to D152	7~0	Reserved	Fixed value ‘0’
D153	7~5	Interlace/PsF/progressive code	Interlace (value ‘0’) PsF (value ‘1’) Progressive (value ‘2’)
	4~0	Rate code	See Table 16
D154	7~5	Reserved	Fixed value ‘0’
	4	rgb_components	As MPEG-4 studio profile
	3~0	Input video format	1920 × 1080 (value ‘2’) 1280 × 720 (value ‘4’)
D155	7~0	Reserved	Fixed value ‘6’
D156 to D161	7~0	Reserved	Fixed value ‘0’
D162	7~0	REC_ID[7:0]	A random 16-bit number, unique to the frame
D163	7~0	REC_ID[15:8]	
D164	7~0	VITC TC data (frame)	See Figure 53
D165	7~0	VITC TC data (second)	See Figure 53
D166	7~0	VITC TC data (minute)	See Figure 53
D167	7~0	VITC TC data (hour)	See Figure 53
D168	7~0	VITC UB data (frame)	See Figure 53
D169	7~0	VITC UB data (second)	See Figure 53
D170	7~0	VITC UB data (minute)	See Figure 53
D171	7~0	VITC UB data (hour)	See Figure 53
D172	7~0	Checksum	Bit inverted least significant byte of the sum of bytes D164 to D171
D173	7~0	1st ancillary data line number	See Table 17
D174	7~0	2nd ancillary data line number	See Table 17
D175	7~0	3rd ancillary data line number	See Table 17
D176 to D225	7~0	Reserved	Fixed value ‘0’

The auxiliary data bytes D1 to D64 shall take the values of the quantizer matrix used when quantizing the luminance or green-component DCT coefficients of each macro block. The bytes shall be in the order defined by the MPEG-4 studio profile for ‘intra_quantizer_matrix’.

The auxiliary data bytes in D65 to D128 shall take the values of the quantizer matrix used when quantizing the chrominance, blue- or red-component DCT coefficients of each macro block. The bytes shall be in the order defined by the MPEG-4 studio profile for ‘chroma_intra_quantizer_matrix’.

The double-rate and frame-rate bits in D129 shall be derived from MPEG-4 studio profile ‘frame_rate_code’ parameter as indicated in Table 16.

Table 16 – Frame-rate flags

Description	frame_rate_code	Double-rate flag	Frame rate	Rate code
1920 × 1080 23,98 Hz	0001	0	10	00000
1920 × 1080 24,00 Hz	0010	0	10	00001
1920 × 1080 25,00 Hz	0011	0	01	00011
1920 × 1080 29,97 Hz	0100	0	00	00100
1280 × 720 50,00 Hz	0110	0	01	01001
1280 × 720 59,94 Hz	0111	0	00	01010

The format for each VITC data word shall be the same as defined in SMPTE RP 188. The least significant bit of each 4-bit VITC data word shall be aligned to bit 0 or bit 4 of the auxiliary data byte. Appropriate flag information defined by SMPTE 12M shall be inserted into the corresponding VITC time code data positions of Figure 53.

LSB MSB

	0 1 2 3	4 5 6 7
D164	LSB VITC TC data (units of frames) MSB	LSB VITC TC data (tens of frames + flag) MSB
D165	LSB VITC TC data (units of seconds) MSB	LSB VITC TC data (tens of seconds + flag) MSB
D166	LSB VITC TC data (units of minutes) MSB	LSB VITC TC data (tens of minutes + flag) MSB
D167	LSB VITC TC data (units of hours) MSB	LSB VITC TC data (tens of hours + flag) MSB
D168	LSB VITC UB data (binary group 1) MSB	LSB VITC UB data (binary group 2) MSB
D169	LSB VITC UB data (binary group 3) MSB	LSB VITC UB data (binary group 4) MSB
D170	LSB VITC UB data (binary group 5) MSB	LSB VITC UB data (binary group 6) MSB
D171	LSB VITC UB data (binary group 7) MSB	LSB VITC UB data (binary group 8) MSB

Figure 53 – Auxiliary data time code

The ancillary data line numbers in bytes D173 to D175 shall be derived from the source line numbers as shown in Table 17. The three bytes shall be filled so that the lowest number appears in byte D173 and the highest number appears in byte D175.

Table 17 – Ancillary data line numbers for 1920 × 1080 sources

1920 x 1080 sources		1280 x 720 sources	
Source line number in 1st field or segmented frame	Source line number in 2nd field or segmented frame	Source line number in frame	Ancillary data line number in auxiliary basic block
9	572	9	9
10	573	10	10
11	574	11	11
12	575	12	12
13	576	13	13
14	577	14	14
15	578	15	15
16	579	16	16
17	580	17	17
18	581	18	18
19	582	19	19
20	583	20	20
Not allowed	Not allowed	21	21
Not allowed	Not allowed	22	22
Not allowed	Not allowed	23	23
Not allowed	Not allowed	24	24
Not allowed	Not allowed	25	25

8.5.4 Compressed data basic block packing

Each macro block unit shall be packed into 204 compressed data basic blocks. Each macro block in the macro block unit shall pack macro block header data (as defined in 8.5.4.1), ancillary data (as defined in 8.5.4.2) and compressed picture data. The DC coefficients for DCT encoded macro blocks shall be transcoded as defined in 8.5.4.3. The code words shall be interleaved as defined in 8.5.4.4 and packed into the basic blocks of the macro block unit as defined in 8.5.4.5.

8.5.4.1 Macro block header data packing

The header data for each encoded macro block shall be packed into the basic block with the macro block unit and basic block number corresponding to the macro block unit and macro block number of the block.

The sequence of bits to be packed for each macro block shall be as defined in Table 18. The first bit shall be packed into bit 6 of the first payload byte, D0. The header comprises 34 bits for macro blocks encoded in DCT mode and 37 bits for macro blocks encoded in DPCM mode.

The Type D-16 parameter 'type_d16_compression_mode' shall be set to the inverse of the MPEG-4 Studio Profile 'compression_mode' parameter.

The Type D-16 parameter 'type_d16_dct_precision' shall be set to the bitwise inverse of the MPEG-4 Studio Profile 'dct_precision' parameter.

The Type D-16 parameter 'type_d16_mb_length' shall be equal to the total number of bits packed for the macro block plus one. This includes the header and ancillary bits and the compressed data bits, taking into account the DC transcoding defined in 8.5.4.3. It does not include the size of the four BID bytes in the basic block.

The values in Table 18 are unsigned decimal integers.

Table 18 – Macro block header syntax

Name	Number of bits	Value
MacroBlockHeader{		
type_d16_ancillary_enable	1	1
type_d16_mb_length	14	Variable
type_d16_ancillary_bits	8	15
type_d16_compression_mode	1	0 or 1
If (type_d16_compression_mode == 0) { // DCT mode		
intra_dc_precision	2	0
quantiser_scale_code	5	1 to 31
q_scale_type	1	0 or 1
type_d16_dct_precision	2	0 to 3
} else { // DPCM mode		
dpcm_scan_order	1	0 or 1
Y/G component rice_parameter	4	1 to 10
C_B/B component rice_parameter	4	1 to 10
C_R/R component rice_parameter	4	1 to 10
}		
}		

8.5.4.2 Ancillary data packing

Following the macro block header data, the next 15 bits shall be taken from the ancillary data stream for the relevant coded sequence, as defined in 8.3.5

The first 15 bits of the ancillary data stream shall be packed into basic block number '0' of the first macro block unit in the coded sequence, and subsequent bursts of 15 bits shall be packed into each successive basic block. When all the available bits of the ancillary data stream are packed for the field, subsequent basic blocks shall pad the ancillary data with zero bits as required. There shall be no sharing of ancillary data between coded sequences.

NOTE Including the unused payload bit (byte D0 bit 7), the DCT format macro blocks have 50 header and ancillary bits and the DPCM format macro blocks have 53 header and ancillary bits.

8.5.4.3 DCT block DC transcoding

The encoded differential DC values in each DCT mode macro block are decoded to their original quantized values. New DC differential values shall then be calculated as defined in this section. The new values are then VLC coded as defined by MPEG-4 studio profile.

8.5.4.3.1 4:2:2 YC_BC_R DCT blocks

For 4:2:2 YC_BC_R macro blocks the new DC differentials for each component shall be recalculated in the order defined for the MPEG-4 studio profile. The initial predictor value shall be zero for each component.

The block order for the new DC differential calculation is shown in Figure 54 for information.

Y Component:

0	1
2	3

Differential DC block order = 0, 1, 2, 3

C_B Component:

4
6

Differential DC block order = 4, 6

C_R Component:

5
7

Differential DC block order = 5, 7

Figure 54 – 4:2:2 YC_BC_R differential DC block order

The new differential DC values shall then be VLC coded as defined by ISO/IEC 14496-2, with the exception that the 'marker_bit' indicated in the MPEG-4 studio profile "StudioBlock" syntax shall not be included.

8.5.4.3.2 4:4:4 RGB DCT blocks

For 4:4:4 RGB macro blocks the new DC differentials for each component shall be recalculated in the block order defined by Figure 55 using the MPEG-4 studio profile DCT block numbers. The initial predictor value shall be zero for each component.

The block order for the new DC differential calculation is different to that defined by the MPEG-4 studio profile for the red and blue components.

G Component:

0	1
2	3

Differential DC block order = 0, 1, 2, 3

B Component:

4	8
6	10

Differential DC block order = 4, 8, 6, 10

R Component:

5	9
7	11

Differential DC block order = 5, 9, 7, 11

Figure 55 – 4:4:4 RGB differential DC block order

The new differential DC values shall then be VLC-coded as defined by ISO/IEC 14496-2, with the exception that the ‘marker_bit’ indicated in the MPEG-4 studio profile “StudioBlock” syntax shall not be included.

8.5.4.4 Code interleave

After the encoding steps defined in the previous subclauses each macro block comprises a number of code words which are interleaved into a continuous sequence of bits as defined in one of the four following subclauses.

8.5.4.4.1 4:2:2 YC_BC_R DCT code interleave

For each 4:2:2 YC_BC_R macro block encoded in DCT mode, each of the 8 DCT blocks comprises one DC code word and between 1 and 63 AC code words.

The code words shall be interleaved by taking one code word from each DCT block in sequence, as defined in Figure 56, and concatenating its bits from the most significant to the least significant to create a continuous sequence of bits for the macro block which is then packed as defined in 8.5.4.5.

Figure 56 defines the component type and the MPEG-4 studio profile DCT block number in the interleave sequence.

Code interleave order →

Y,0	Y,1	Y,2	Y,3	C_B,4	C_R,5	C_B,6	C_R,7

Figure 56 – 4:2:2 DCT code interleave

The first interleaved code word for each DCT block shall be the DC code word, followed by the AC code words. When all the AC code words in a DCT block have been included in the macro block stream, that block shall be excluded from the next iteration of the interleave sequence.

Figure 57 shows an example of the interleaving for a 4:2:2 YC_BC_R format macro block encoded in DCT mode with the interleaving starting at the top left and proceeding from top to bottom then from left to right.

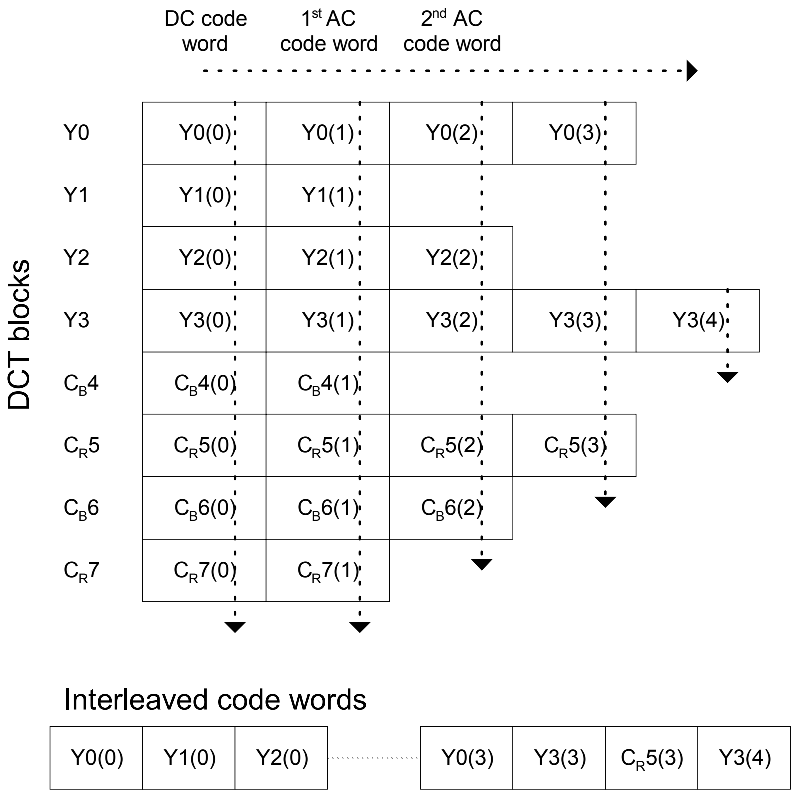


Figure 57 – 4:2:2 YC_BC_R DCT macro block interleaving example

8.5.4.4.2 4:4:4 RGB DCT code interleave

For each 4:4:4 RGB format macro block encoded in DCT mode, each of the 12 DCT blocks comprises 1 DC code word and between 1 and 63 AC code words.

The code words shall be interleaved by taking one code word from each DCT block in sequence, as defined in Figure 58, and concatenating its bits from the most significant to the least significant to create a continuous sequence of bits for the macro block which is then packed as defined in 8.5.4.5.

Figure 58 defines the component type and the MPEG-4 studio profile DCT block number in the interleave sequence.

Code interleave order

G,0	G,1	G,2	G,3	B,4	B,8	B,6	B,10	R,5	R,9	R,7	R,11

Figure 58 – 4:4:4 DCT code interleave

The first interleaved code word for each DCT block shall be the DC code word, followed by the AC code words. When all the AC code words in a DCT block have been included in the macro block stream, that block shall be excluded from the next iteration of the interleave sequence.

Figure 59 shows an example of the interleaving for a 4:4:4 RGB format macro block encoded in DCT mode with the interleaving starting at the top left and proceeding from top to bottom then from left to right.

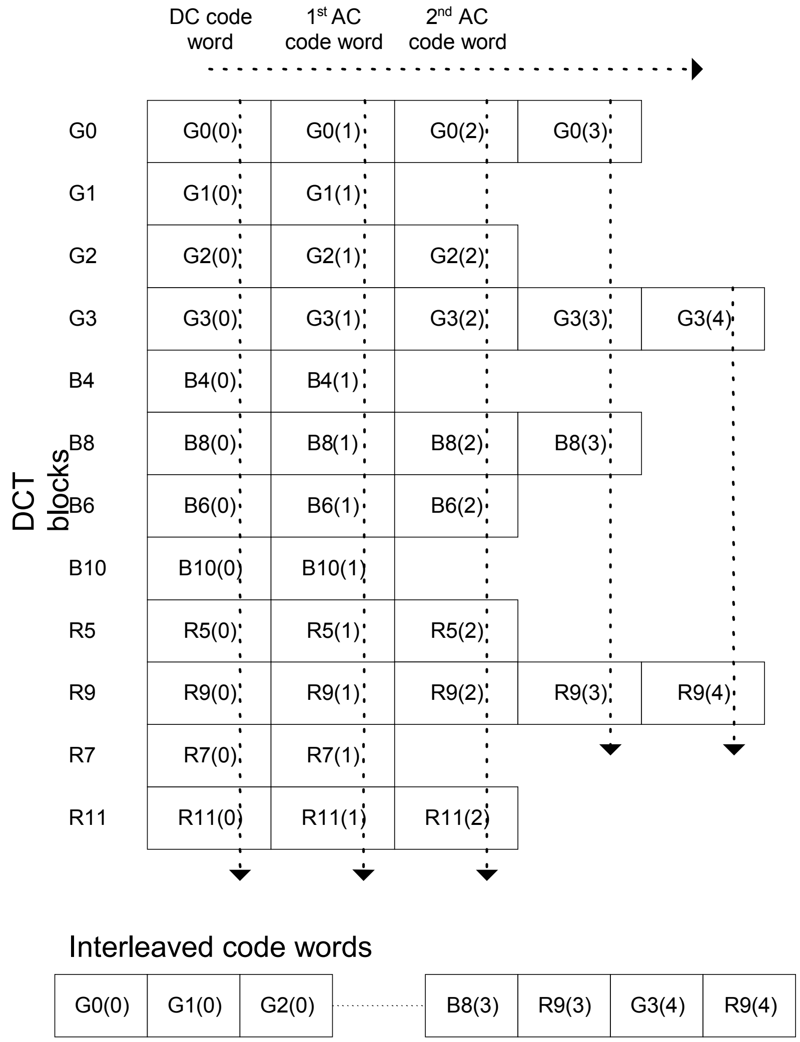


Figure 59 – 4:4:4 RGB DCT macro block interleaving example

8.5.4.4.3 4:2:2 YC_BC_R DPCM code interleave

For each 4:2:2 YC_BC_R format macro block encoded in DPCM mode, each component comprises one 10-bit block mean value followed by either 128 or 256 DPCM residual code words.

The first values interleaved shall be the 3 block mean values, in the order Y, C_B, C_R. The block mean values shall be followed by the code words which shall be interleaved by taking 1 value from each component in sequence, as defined in Figure 60. These values are concatenated from the most significant to the least significant bits to create a continuous sequence of bits for the macro block which is then packed as defined in 8.5.4.5.

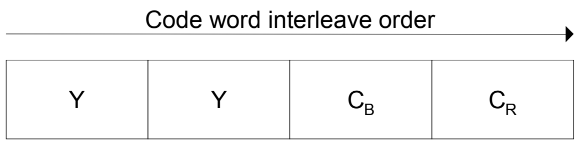


Figure 60 – 4:2:2 YC_BC_R DPCM code word interleave order

Figure 61 shows an example of the interleaving for a 4:2:2 YC_BC_R format macro block encoded in DPCM mode with the interleaving starting at the top left and proceeding from top to bottom then from left to right. The luminance code words are shown in two rows to clarify the interleave process.

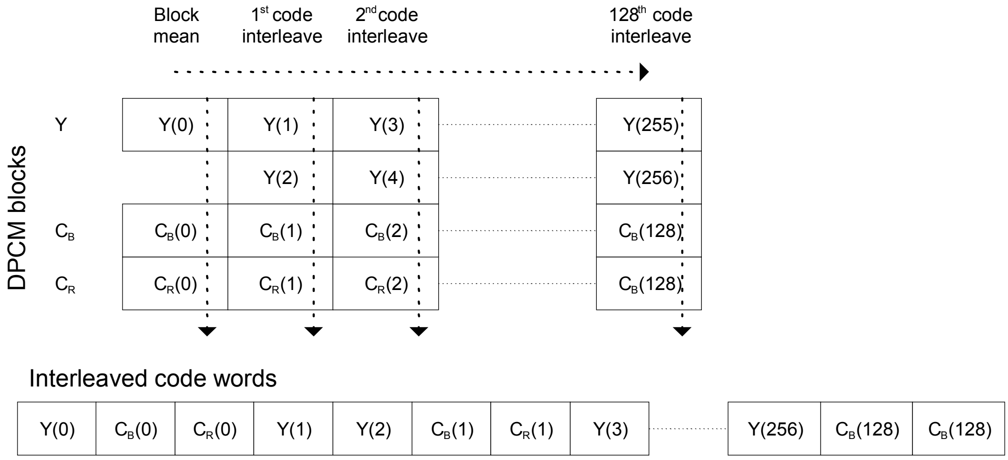


Figure 61 – 4:2:2 YC_BC_R DPCM macro block interleaving example

8.5.4.4.4 4:4:4 RGB DPCM code interleave

For each 4:4:4 RGB macro block encoded in DPCM mode, each component comprises 1 10-bit block mean value followed by 256 DPCM residual code words.

The first values interleaved shall be the 3 block mean values, in the order G, B, R. The block mean values shall be followed by the code words which shall be interleaved by taking 1 value from each component in sequence, as defined in Figure 62. These values are concatenated from the most significant to the least significant bits to create a continuous sequence of bits for the macro block which is then packed as defined in 8.5.4.5.

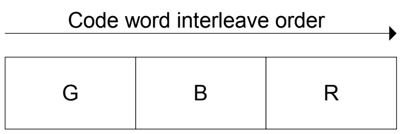


Figure 62 – 4:4:4 RGB DPCM code word interleave order

Figure 63 shows an example of the interleaving for a 4:4:4 RGB format macro block encoded in DPCM mode with the interleaving starting at the top left and proceeding from top to bottom then from left to right. The luminance code words are shown in 2 rows to clarify the interleave process.

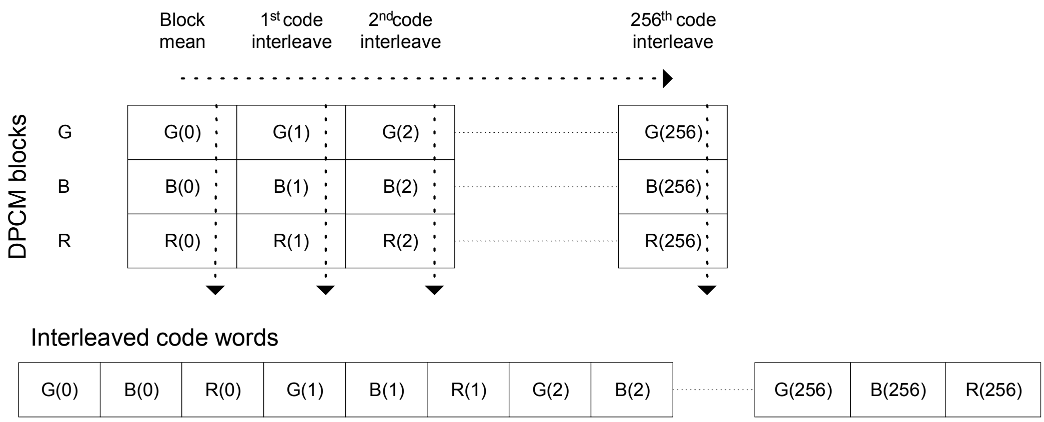


Figure 63 – 4:4:4 RGB DPCM macro block interleaving example

8.5.4.5 Data packing

The compressed and interleaved picture data produced for each macro block in the macro block unit shall be packed to the 204 basic blocks allocated for the macro block unit by a 2-stage packing process defined in this subclause.

The first stage packs data for each macro block to the basic block, with the same macro block unit and basic block numbers, and stores any unpacked data for the next packing stage. The second stage uses any unpacked locations in the 204 basic blocks to pack any data stored in the first stage.

8.5.4.5.1 Stage 1 data packing

The concatenated encoded and interleaved data for each macro block shall be packed into its corresponding basic block immediately after the last ancillary data bit. The macro blocks shall be packed in order from block number '0' in the macro block unit. For each macro block, packing shall continue until either all the macro block data is packed or Bit 0 of the last payload byte of the basic block is reached.

Any remaining unpacked data for the macro block shall be concatenated to form the overflow data for the macro block unit.

In 4:4:4 RGB mode the use of two coding channels means that there are only 2 040 macro block to pack (10 macro block units) for each coded sequence. Each packed basic block is followed by an unused second basic block with the same macro block unit and basic block number. These blocks are differentiated from the packing blocks by setting the basic block count (Bit 0 of BID2) to the value '1'. All payload bytes in these second blocks are set to '0' and shall not be used for packing. The unused basic blocks in 4:4:4 RGB mode are not recorded.

8.5.4.5.2 Stage 2 data packing

When Stage 1 packing is complete, any accumulated overflow data shall then be packed into any unused space in the basic blocks of the macro block unit.

Starting from the lowest numbered basic block in the macro block unit that is not completely filled, the first overflow data bit shall be packed into the first unfilled bit in the payload space. Successive overflow data bits shall then be packed into the unfilled bits in the same basic block until either all the overflow data bits are packed or Bit 0 of the last payload byte of the basic block is reached.

Any remaining unpacked overflow data for the macro block unit shall be packed in the same manner into subsequent basic blocks with unfilled bits within the macro block unit.

Any remaining unfilled basic block bits at the end of Stage 2 packing should be filled with zero.

Any unpacked overflow data bits at the end of Stage 2 packing shall be discarded.

NOTE When packing encoded 1280 x 720 pictures, basic block numbers 180 to 203 can only contain overflow data bits, because there is no corresponding macro block in the macro block unit.

8.5.5 Data packing examples

8.5.5.1 1920 × 1080 example

Figure 64 shows a reduced example of the packing used for 1920 × 1080 macro block units. In the example, a macro block unit of 5 macro blocks is packed into 5 basic blocks. The output from the second stage packing is shown shaded to distinguish it from the first stage packing. In this example, there is one unused output location indicated by ‘x’.

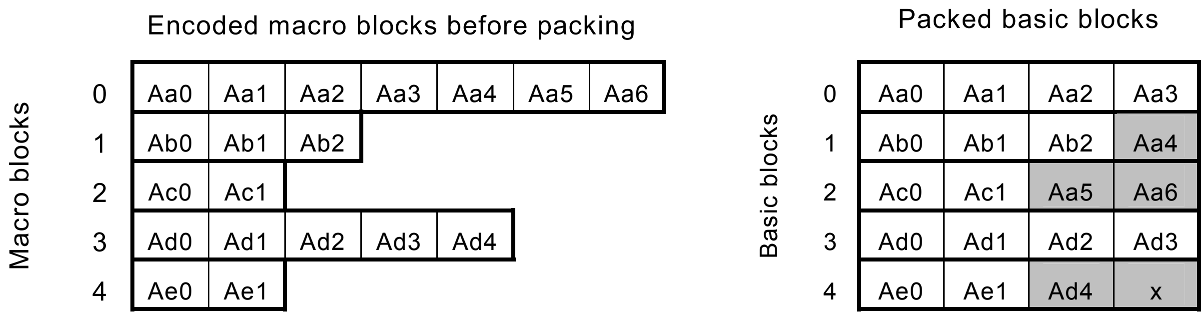


Figure 64 – 1920 × 1080 packing example

8.5.5.2 1280 × 720 example

Figure 65 shows a reduced example of the packing used for 1280 × 720 macro block units. In the example, a macro block unit of 4 macro blocks is packed into 5 basic blocks. The output from the second stage packing is shown shaded to distinguish it from the first-stage packing. In this example, there are no unused output locations in the example.

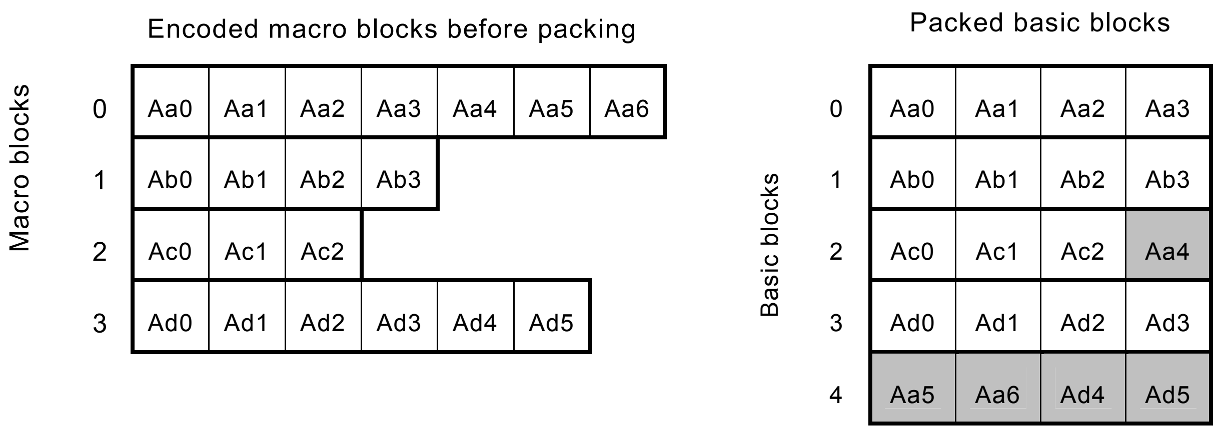


Figure 65 – 1280 × 720 packing example

8.6 Audio input format and data packing

8.6.1 General

The Type D-16 tape format shall facilitate the recording capability of 12 channels of digital audio data, which correspond to 6 pairs of AES3 audio data at 24 bits per sample resolution. Each channel shall be independently editable by channel-independent allocation of audio recording sectors on the tape. The encoding process for recording is common to all audio channels except for the recorded positions and the audio sync block identification patterns (ID_0/ID_1). The format also provides the capability of recording non-audio data in some applications.

8.6.1.1 Sampling clock

The sample clock frequency of the AES3 audio data shall be 48 K Hz and synchronized to the record unit rate.

8.6.2 Audio sample segmentation and packing

The Type D-16 tape format records 2002 audio words of 24 bits per word for each record unit period. Similar to video, each audio record unit consists of 2 audio segments.

AES3 audio data corresponding to each audio segment shall be packed into a block of 1 001 audio words. The AES3 audio data packing shall start from word W0 until it reaches the last word determined by the record unit rate. If the packed data size is less than 1 001 words, then the remainder of the block shall be filled with zero data. Table 19 shows the cases of packed data and stuffing for each record unit rate.

Table 19 – Packing size for each record unit rate

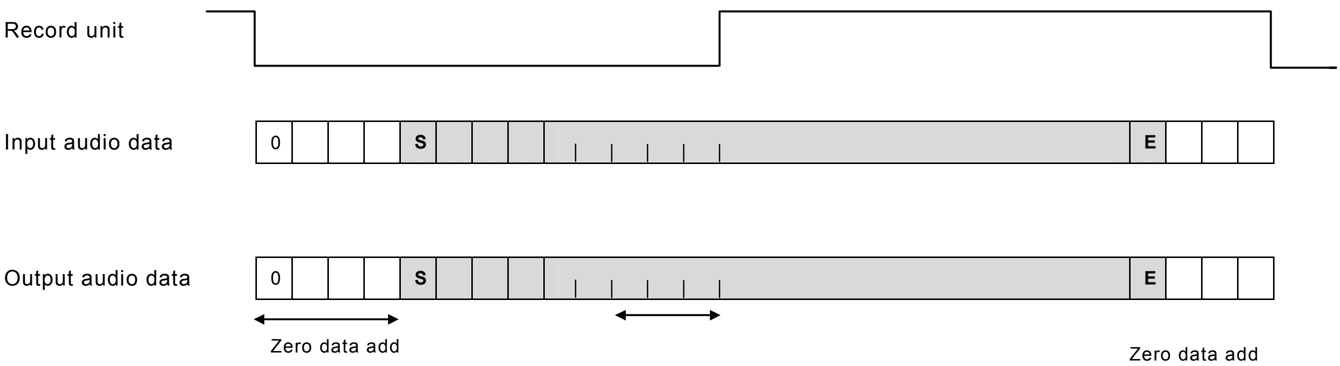
Record unit rate	Valid sample	Stuffing (zero data)	Remarks
23,98 Hz	W0 to W1000	None	
24 Hz	W0 to W999	W1000	
25 Hz	W0 to W959	W960 to W1000	
29,97 Hz	W0 to W799	W800 to W1000	Field 0 of Audio 5 field sequence
29,97 Hz	W0 to W800	W801 to W1000	Field 1 to 4 of Audio 5 field sequence

8.6.3 Data recording mode

The data recording mode provides the capability to record 24-bit AES3 audio samples, which are packed beginning at the defined point after the start of the source record unit and finishing at the defined point before the end of source record unit. Figure 66 shows the start and end sample numbers for each record unit in relation to the input reference video.

In the data recording mode for non-audio applications, the rate converter shall be disabled.

Output data shall contain the same number and location of zero data samples as present at the input.



Record Unit Rate	S	E
23,98 Hz	0	2001
24 Hz	0	1999
25 Hz	0	1919
29,97 Hz	0	1599 or 1600

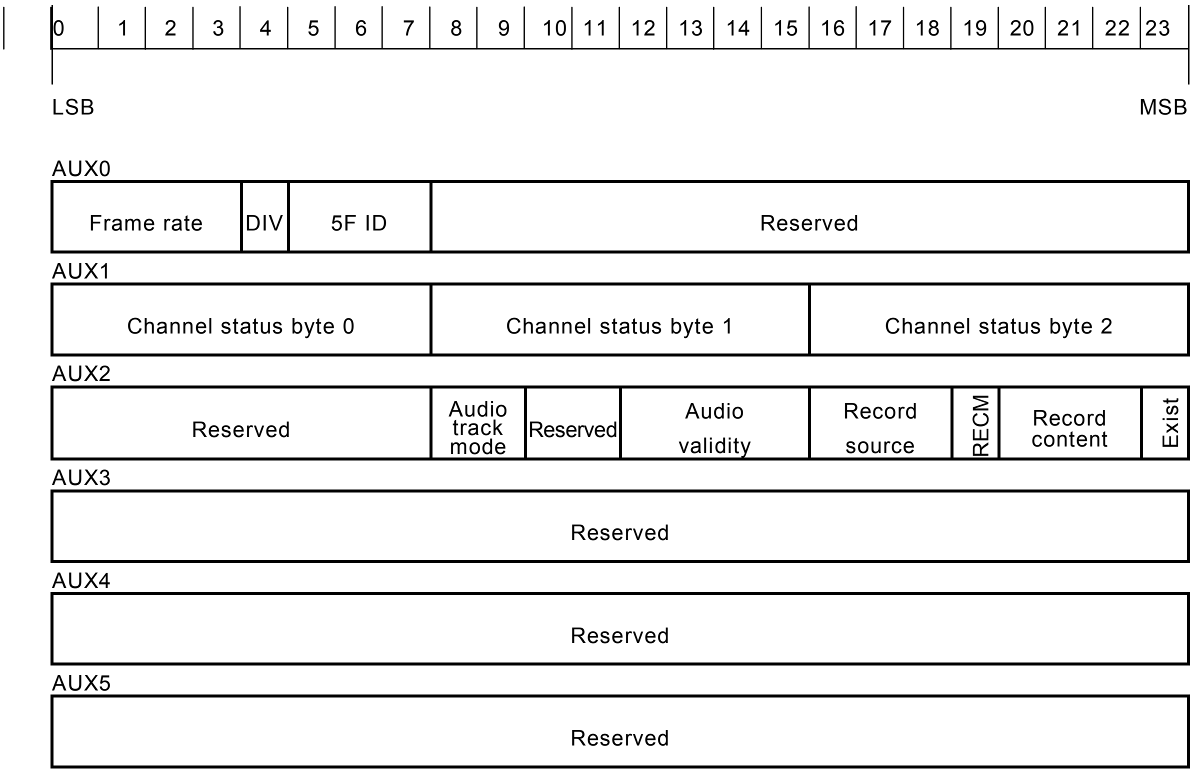
NOTE S: Start sample number of record/playback data; E: End sample number of record/playback data.

Figure 66 – Start and end sample number of data recording mode

8.6.4 Audio auxiliary data words

Six audio auxiliary data words shall be added to the audio data for each channel. These are recorded to allow the playback system to reproduce the full AES3 data format.

The 6 audio auxiliary data words, each of 24 bits, shall be as defined in Figure 67. These 6 words shall be recorded, for each audio channel, as defined in 9.3.1.



AUX 0:	Frame Rate(bit0~3)	‘0000’: 24 Hz ‘0001’: 25 Hz ‘0010’: 30 Hz ‘0011’: 60 Hz Others: reserved
	DIV (bit4)	‘0’:1 ‘1’:1.001
	5F ID (bit5~7)	‘000’: 800 sample Others: 801 sample
	Reserved (bit8~23)	0000h
AUX 1:	Channel status byte 0 (bit0~7)	The channel status specified in AES3
	Channel status byte 1 (bit8~15)	The channel status specified in AES3
	Channel status byte 2 (bit16~23)	The channel status specified in AES3
AUX 2:	Reserved (bit0~7)	00h
	Audio track mode (bit8, 9)	‘00’: Audio ‘01’: Video Others: Reserved
	Reserved (bit10, 11)	‘11’: Reserved
	Audio validity (bit 12~15)	‘1010’: Audio invalid Others: Audio valid
	Record source (bit 16~18)	‘000’: Analog ‘001’: AES/EBU ‘010’: HD SDI Others: Reserved
	RECM (bit19)	‘0’: Initial recording ‘1’: Edit recording
	Record content (bit 20~22)	‘000’: PCM ‘001’: Data Others: Reserved
	Exist (bit23)	‘0’: Data existing ‘1’: No data
AUX 3~AUX 5:	Reserved	000000h

Figure 67 – Audio auxiliary data words

9 Helical track signal parameters and magnetization

This clause defines how the compressed picture data stream and 12 AES3 audio data streams are mapped to the helical track records.

9.1 Introduction

Figure 30 hows the recorder block diagram, identifying the basic schematic signal processing blocks used to map the Type D-16 picture compression data and 12 channels of AES3 audio data to create the helical track data records.

Figure 31 shows the playback block diagram, identifying the basic schematic signal processing blocks used to map the helical track records to the Type D-16 compressed picture data and 12 channels of AES3 audio data. Figure 31 also includes type D-16 decoder/deshuffling blocks.

Subclause 9.2 defines the video outer correction and shuffling blocks.

Subclause 9.3 defines the audio outer correction and shuffling blocks.

Subclause 9.4 defines the sync block structure, identification and track layout.

Subclause 9.5 defines the channel coding.

Subclause 9.6 defines the magnetization.

9.1.1 Labelling convention

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

A suffix "h" indicates a hexadecimal value.

9.2 Video data outer correction and shuffling

The input to the video outer correction comprises the sequence of packed basic blocks defined in 8.5. This sequence forms an array that provides the input to the video outer correction function.

9.2.1 Video outer correction

The parameters for the video outer error correction code (ECC) are defined in this subclause.

The outer ECC shall be of the Reed-Solomon (RS) type having 12 check bytes placed at the end of each group of 114 video data bytes.

Details of the RS code common to all outer ECC blocks shall be as follows:

- Galois field: GF(256)
- Field generator polynomial: $X^8 + X^4 + X^3 + X^2 + 1$,

  where X^i are place-keeping variables in GF(2), the binary field. Note that the ‘+’ sign indicates modulo binary addition.
- The code generator polynomial (GF(256)) is defined as:

$$G(X) = (X + \alpha^0)(X + \alpha^1)(X + \alpha^2)(X + \alpha^3)(X + \alpha^4)(X + \alpha^5)(X + \alpha^6)(X + \alpha^7)(X + \alpha^8)(X + \alpha^9)(X + \alpha^{10})(X + \alpha^{11})$$

where α is given by 02h in GF(256). Note that the '+' sign for this and the following equations indicates modulo 256 addition.

The check characters are defined as:

P_{11}, P_{10}, P_9, P_8, P_7, P_6, P_5, P_4, P_3, P_2, P_1, P_0 in $P_{11}X^{11} + P_{10}X^{10} + P_9X^9 + P_8X^8 + P_7X^7 + P_6X^6 + P_5X^5 + P_4X^4 + P_3X^3 + P_2X^2 + P_1X^1 + P_0$

obtained as the remainder after dividing the polynomial $X^{24}D(X)$ by G(x), where Pi are bit-inverted words of PVi shown in figure 68, and D(X) is the polynomial given by:

$$D(X) = D_{113}X^{113} + D_{112}X^{112} + D_{111}X^{111} + D_{110}X^{110} + \ldots + D_2X^2 + D_1X^1 + D_0$$

The polynomial full code is defined as:

$$D_{113}X^{125} + D_{112}X^{124} + D_{111}X^{123} + \ldots + D_1X^{13} + D_0X^{12} + P_{11}X^{11} + P_{10}X^{10} + P_9X^9 +$$

$$P_4X^4 + P_3X^3 + P_2X^2 + P_1X^1 + P_0 \equiv 0 \pmod{G(X)}$$

There are 36 outer ECC blocks per segment where each outer ECC block comprises 114 video data sync blocks which shall be organized as shown in Figure 68. The horizontal axis is aligned with the basic block data and the vertical axis is aligned with the outer error correction code.

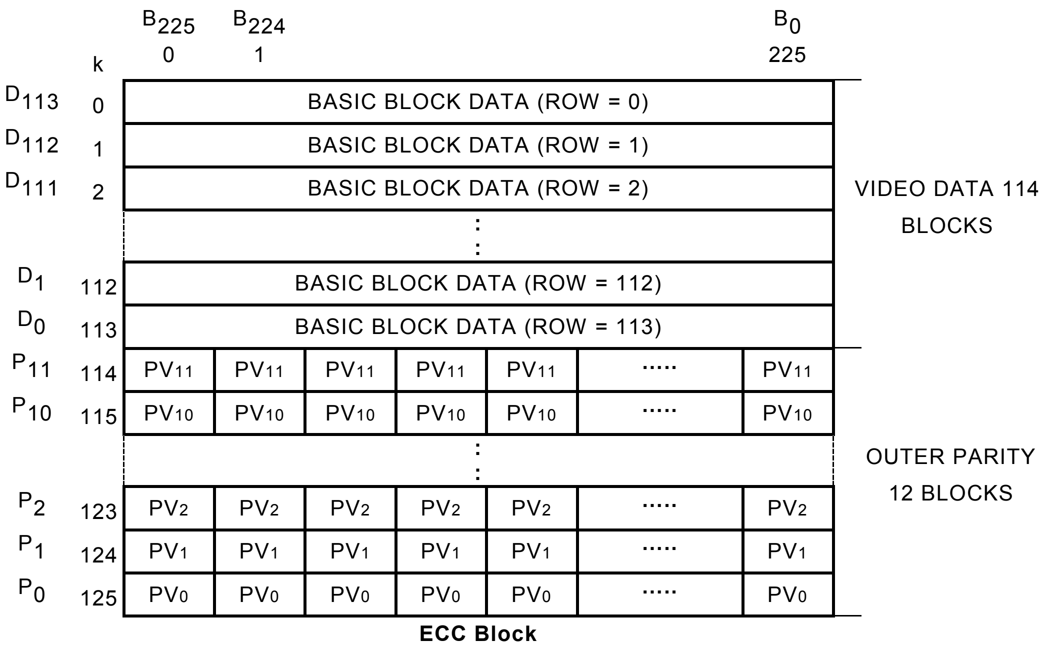


Figure 68 – Video data blocking

The algorithm for determining the OUTER_NUM and ROW with respect to the SYNC_SEQ, UL and TRACK_NUM is defined as follows:

OUTER_NUM = ((SYNC_SEQ + UL×189 + (TRACK_NUM % 4) × 9

+ (TRACK_NUM / 4) × 12) / 2) % 18 + ((SYNC_SEQ + UL + TRACK_NUM) % 2) × 18

ROW = SYNC_SEQ / 9 + UL × 21 + (TRACK_NUM / 4) × 42

NOTE SYNC_SEQ, UL and TRACK_NUM are defined in 9.4.2.4

9.2.2 Video shuffling output

The output of the outer error correction is shuffled by reading the data out of the array in Figure 68 in horizontal scanning order.

9.3 Audio data outer correction and shuffling

9.3.1 AES3 data shuffling

The intra-segment shuffling scheme of audio and auxiliary data per audio channel is depicted in Figure 69 in conjunction with a formation of outer error correction blocks. Two separate outer error correction blocks shall be used to separate odd and even audio samples for protection from potential tape damage. Each outer error correction block shall contain 504 (63 × 8) words of 24 bits.

Eight outer error correction bytes shall be formed from 8 bytes of data placed in the vertical direction of the array in Figure 69. In the horizontal direction of the array, 63 words of 24-bit data shall be placed as a row each representing an audio sample or auxiliary data. Each row of 189 (63 × 3) bytes of data forms an audio inner data block.

Six auxiliary data words of 24-bit length shall be allocated in 2 outer error correction blocks. The auxiliary data word “AUX0” shall be placed in 2 blocks for additional protection.

1001 24-bit WORDS per segment

ROW NUMBER "Rn"

Audio outer ECC block "N"

		0	1	2	---	60	61	62	Pack number
D7	R0	AUX0	10	26	---	954	970	986	Audio data 8 blocks
D6	R1	AUX1	12	28	---	956	972	988	
D5	R2	AUX2	14	30	---	958	974	990	
D4	R3	0	16	32	---	960	976	992	
D3	R4	2	18	34	---	962	978	994	
D2	R5	4	20	36	---	964	980	996	
D1	R6	6	22	38	---	966	982	998	
D0	R7	8	24	40	---	968	984	1000	
P7	R8	PV_0 PV_0 PV_0	PV_0 PV_0 PV_0	PV_0 PV_0 PV_0	---	PV_0 PV_0 PV_0	PV_0 PV_0 PV_0	PV_0 PV_0 PV_0	Outer parity 8 blocks
P6	R9	PV_1 PV_1 PV_1	PV_1 PV_1 PV_1	PV_1 PV_1 PV_1	---	PV_1 PV_1 PV_1	PV_1 PV_1 PV_1	PV_1 PV_1 PV_1	
P5	R10	PV_2 PV_2 PV_2	PV_2 PV_2 PV_2	PV_2 PV_2 PV_2	---	PV_2 PV_2 PV_2	PV_2 PV_2 PV_2	PV_2 PV_2 PV_2	
P4	R11	PV_3 PV_3 PV_3	PV_3 PV_3 PV_3	PV_3 PV_3 PV_3	---	PV_3 PV_3 PV_3	PV_3 PV_3 PV_3	PV_3 PV_3 PV_3	
P3	R12	PV_4 PV_4 PV_4	PV_4 PV_4 PV_4	PV_4 PV_4 PV_4	---	PV_4 PV_4 PV_4	PV_4 PV_4 PV_4	PV_4 PV_4 PV_4	
P2	R13	PV_5 PV_5 PV_5	PV_5 PV_5 PV_5	PV_5 PV_5 PV_5	---	PV_5 PV_5 PV_5	PV_5 PV_5 PV_5	PV_5 PV_5 PV_5	
P1	R14	PV_6 PV_6 PV_6	PV_6 PV_6 PV_6	PV_6 PV_6 PV_6	---	PV_6 PV_6 PV_6	PV_6 PV_6 PV_6	PV_6 PV_6 PV_6	
P0	R15	PV_7 PV_7 PV_7	PV_7 PV_7 PV_7	PV_7 PV_7 PV_7	---	PV_7 PV_7 PV_7	PV_7 PV_7 PV_7	PV_7 PV_7 PV_7	

ROW NUMBER "Rn"

Audio outer ECC block "N+12"

		0	1	2	---	60	61	62	Pack number
D7	R0	AUX3	11	27	---	955	971	987	
D6	R1	AUX4	13	29	---	957	973	989	
D5	R2	AUX5	15	31	---	959	975	991	
D4	R3	1	17	33	---	961	977	993	
D3	R4	3	19	35	---	963	979	995	
D2	R5	5	21	37	---	965	981	997	
D1	R6	7	23	39	---	967	983	999	Audio data 8 blocks
D0	R7	9	25	41	---	969	985	AUX0	
P7	R8	PV_0 PV_0 PV_0	PV_0 PV_0 PV_0	PV_0 PV_0 PV_0	---	PV_0 PV_0 PV_0	PV_0 PV_0 PV_0	PV_0 PV_0 PV_0	
P6	R9	PV_1 PV_1 PV_1	PV_1 PV_1 PV_1	PV_1 PV_1 PV_1	---	PV_1 PV_1 PV_1	PV_1 PV_1 PV_1	PV_1 PV_1 PV_1	
P5	R10	PV_2 PV_2 PV_2	PV_2 PV_2 PV_2	PV_2 PV_2 PV_2	---	PV_2 PV_2 PV_2	PV_2 PV_2 PV_2	PV_2 PV_2 PV_2	
P4	R11	PV_3 PV_3 PV_3	PV_3 PV_3 PV_3	PV_3 PV_3 PV_3	---	PV_3 PV_3 PV_3	PV_3 PV_3 PV_3	PV_3 PV_3 PV_3	Outer parity 8 blocks
P3	R12	PV_4 PV_4 PV_4	PV_4 PV_4 PV_4	PV_4 PV_4 PV_4	---	PV_4 PV_4 PV_4	PV_4 PV_4 PV_4	PV_4 PV_4 PV_4	
P2	R13	PV_5 PV_5 PV_5	PV_5 PV_5 PV_5	PV_5 PV_5 PV_5	---	PV_5 PV_5 PV_5	PV_5 PV_5 PV_5	PV_5 PV_5 PV_5	
P1	R14	PV_6 PV_6 PV_6	PV_6 PV_6 PV_6	PV_6 PV_6 PV_6	---	PV_6 PV_6 PV_6	PV_6 PV_6 PV_6	PV_6 PV_6 PV_6	
P0	R15	PV_7 PV_7 PV_7	PV_7 PV_7 PV_7	PV_7 PV_7 PV_7	---	PV_7 PV_7 PV_7	PV_7 PV_7 PV_7	PV_7 PV_7 PV_7	

NOTE 1 Two ECC blocks are assigned to each segment of each audio channel.

NOTE 2 Audio data are aligned with the LSB first order. The left end of each audio data word is LSB.

NOTE 3 Each audio data word is divided vertically to three 8-bit data for outer parity calculation.

NOTE 4 Numeric table entries are audio pack numbers.

NOTE 5 PV_0 to PV_7 are outer check words corresponding to audio data of each column.

Figure 69 – Audio data blocking for each audio channel

9.3.2 Outer ECC

The outer ECC shall be of the Reed-Solomon (RS) type having 8 check bytes placed at the end of each group of 4 AES3 audio data bytes.

Details of the RS code common to all AES3 outer ECC blocks shall be as follows:

- Galois Field: GF(256)
- Field generator polynomial: $X^8 + X^4 + X^3 + X^2 + 1$,

where X^i are place-keeping variables in GF(2), the binary field. Note that the '+' sign indicates modulo binary addition.

- The code generator polynomial (GF(256)) is defined as:

$$G(X) = (X + \alpha^0)(X + \alpha^1)(X + \alpha^2)(X + \alpha^3)(X + \alpha^4)(X + \alpha^5)(X + \alpha^6)(X + \alpha^7)$$

where α is given by 02 h in GF(256). Note that the '+' sign for this and the following equations indicates modulo 256 addition.

The check characters are defined as:

$P_7, P_6, P_5, P_4, P_3, P_2, P_1, P_0$ in

$$P_7X^7 + P_6X^6 + P_5X^5 + P_4X^4 + P_3X^3 + P_2X^2 + P_1X^1 + P_0$$

obtained as the remainder after dividing the polynomial: $X^{12}D(X)$ by G(x), where Pi are bit-inverted words of PVi shown in figure 69, and D(X) is the polynomial given by:

$$D(X) = D_7X^7 + D_6X^6 + D_5X^5 + D_4X^4 + D_3X^3 + D_2X^2 + D_1X^1 + D_0$$

The polynomial full code is defined as:

$$D_7X^{15}+ D_6X^{14}+ D_5X^{13}+ D_4X^{12}+ D_3X^{11}+ D_2X^{10} + D_1X^9+ D_0X^8 + P_7X^7 + P_6X^6 + P_5X^5 + P_4X^4 + P_3X^3 + P_2X^2 + P_1X^1 + P_0 \equiv 0 \pmod{G(X)}$$

9.3.2.1 Sync block shuffling

After calculation of the outer ECC, each row shown in Figure 69 makes up the data portion of an audio data sync block as shown in Figure 75. The 32 rows of the outer ECC blocks represent every audio and auxiliary data within a period of one segment. The 32 rows shall be mapped to 12 tracks on the tape as illustrated in figure 70.

In Figure 70, the horizontal direction shows number of tracks. In Figure 70, 4 tracks are grouped together for the purpose of explanation. In the vertical direction there are 8 blocks. Each block represents an audio sector on tape and consists of 4 audio sync blocks. Figure 70 identifies the audio channels from A1 to A12. Figure 70 also shows the detailed mapping of 1 audio channel outer ECC block as described in Figure 69. Two offset blocks shall be used for 1 channel audio recording. The actual mapping is shown as matrix (X,Y), where X indicates the audio outer ECC block number "N" in Figure 69 and Y indicates the row number "Rn" in Figure 69.

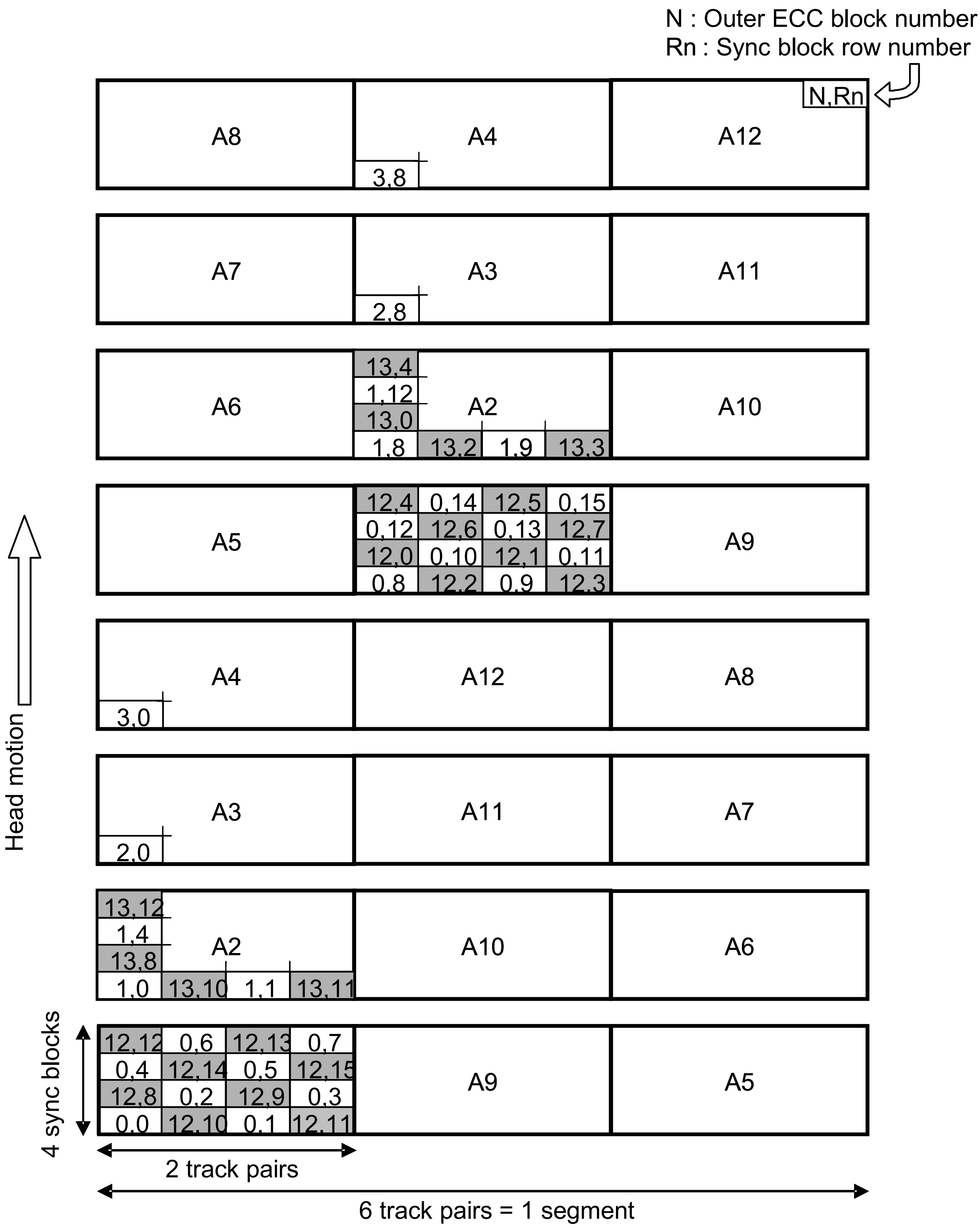


Figure 70 – Audio sync block alignments on helical tracks

9.4 Helical track data parameters

Each record unit of Type D-16 compressed picture data is recorded onto 12 helical track pairs together with the associated AES3 audio data and tracking data.

Each helical track is subdivided into 2 sectors for video data, 8 sectors for AES3 audio data and 1 sector space for servo tracking data with edit guard bands between each sector.

The layout of the sectors and guard bands is shown in Figure 71.

Each audio and video sector shall be divided into the following components:

a) a preamble containing a clock run-up sequence;

b) a sequence of sync blocks each containing a sync pattern, an identification pattern, a fixed length data block and terminated with an error control block;

c) a post-amble containing a sync pattern and an identification pattern.

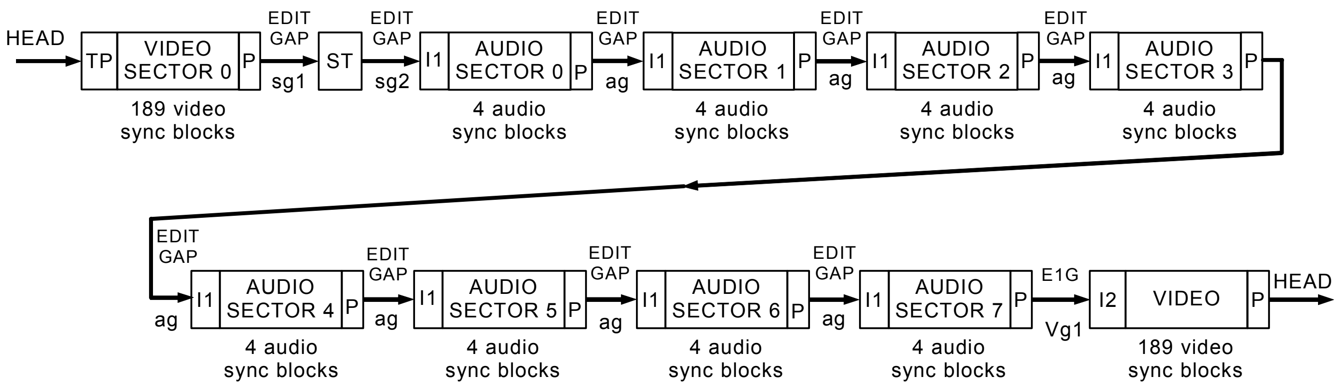
The servo tracking sector is defined in 9.4.6 and occurs only on the 6 tracks with the same azimuth alignment as illustrated in Figure 72.

9.4.1 Primary data components on the 12 helical track pairs

Figure 71 shows the general arrangement of preambles, post-ambles, sync blocks, edit gaps and the tracking data blocks (where applicable) as a group for each of the 12 helical track pairs.

NOTE The 'ST' block is only present on the 6 helical tracks identified in Figure 73.

Figure 72 shows the specific data arrangement and data sizes.



NOTES

1. TP: Track preamble (246 bytes)
2. I1: In-track preamble1 (104 bytes)
3. I2: In-track preamble2 (123 bytes)
4. P: Postamble (4 bytes)
5. vg1: P + Edit gap + I2 (246 bytes)
6. ag: P + Edit gap + I1 (209 bytes)
7. sg1: P + Edit gap (246 bytes)
8. sg2: Edit gap + I1 (640 bytes)
9. Video sync block: 226 bytes
10. Audio sync block: 209 bytes
11. ST: Servo tracking data (590 bytes)

Figure 71 – General sector arrangement on helical track

Segment (LSB)	Track pair	Track azimuth																								
0	0	+	TP	Vd0	sg			A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	vg1	Vd1	P
0	0	-	TP	Vd0	sg1	ST1	sg2	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	vg1	Vd1	P
0	1	+	TP	Vd0	sg1	ST2	sg2	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	vg1	Vd1	P
0	1	-	TP	Vd0	sg			A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	vg1	Vd1	P
0	2	+	TP	Vd0	sg			A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	vg1	Vd1	P
0	2	-	TP	Vd0	sg			A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	vg1	Vd1	P
0	3	+	TP	Vd0	sg1	ST2	sg2	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	vg1	Vd1	P
0	3	-	TP	Vd0	sg1	ST1	sg2	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	vg1	Vd1	P
0	4	+	TP	Vd0	sg			A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	vg1	Vd1	P
0	4	-	TP	Vd0	sg1	ST1	sg2	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	vg1	Vd1	P
0	5	+	TP	Vd0	sg1	ST2	sg2	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	vg1	Vd1	P
0	5	-	TP	Vd0	sg			A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	vg1	Vd1	P
1	0	+	TP	Vd0	sg			A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	vg1	Vd1	P
1	0	-	TP	Vd0	sg			A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	vg1	Vd1	P
1	1	+	TP	Vd0	sg1	ST2	sg2	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	vg1	Vd1	P
1	1	-	TP	Vd0	sg1	ST1	sg2	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	vg1	Vd1	P
1	2	+	TP	Vd0	sg			A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	vg1	Vd1	P
1	2	-	TP	Vd0	sg1	ST1	sg2	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	vg1	Vd1	P
1	3	+	TP	Vd0	sg1	ST2	sg2	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	vg1	Vd1	P
1	3	-	TP	Vd0	sg			A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	vg1	Vd1	P
1	4	+	TP	Vd0	sg			A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	vg1	Vd1	P
1	4	-	TP	Vd0	sg			A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	vg1	Vd1	P
1	5	+	TP	Vd0	sg1	ST2	sg2	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	vg1	Vd1	P
1	5	-	TP	Vd0	sg1	ST1	sg2	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	A	ag	vg1	Vd1	P

NOTES

Vd0:	Video sector 0	189 video sync blocks
Vd1:	Video sector 1	189 video sync blocks
A:	Audio sector	4 Audio sync blocks
ST1:	Servo tracking data (80T)	590 bytes
ST2:	Servo tracking data (8T)	590 bytes
vg1:	Post-amble + Edit gap + Preamble	246 bytes
ag:	Post-amble + Edit gap + Preamble	209 bytes
sg:	Post-amble + Edit gap + Preamble	1476 bytes
sg1:	Post-amble + Edit gap	246 bytes
sg2:	Post-amble + Edit gap + Preamble	640 bytes
TP:	Track preamble	246 bytes
P:	Post-amble	4 bytes
	T is a period of Nyquist frequency recording (Refer to 9.4.6)	

Figure 72 – Sector and segment arrangement on helical track

9.4.2 Track segmentation

Each segment data of video and AES3 audio with servo tracking data shall be recorded in consecutive 6 track pairs (12 tracks). The 6 track pairs form a track segment and a cyclic repetition number of 0, 1, 2 and 3 shall be assigned to each segment.

The segment number sequence shall be continuous in a continuous sequence of record units.

The starting value of the segment sequence at an initial recording shall be either of 0 or 2.

Figure 73 shows the outline of the track segment structure and component parts of the ID_1 assignment defined in 9.4.2.4.

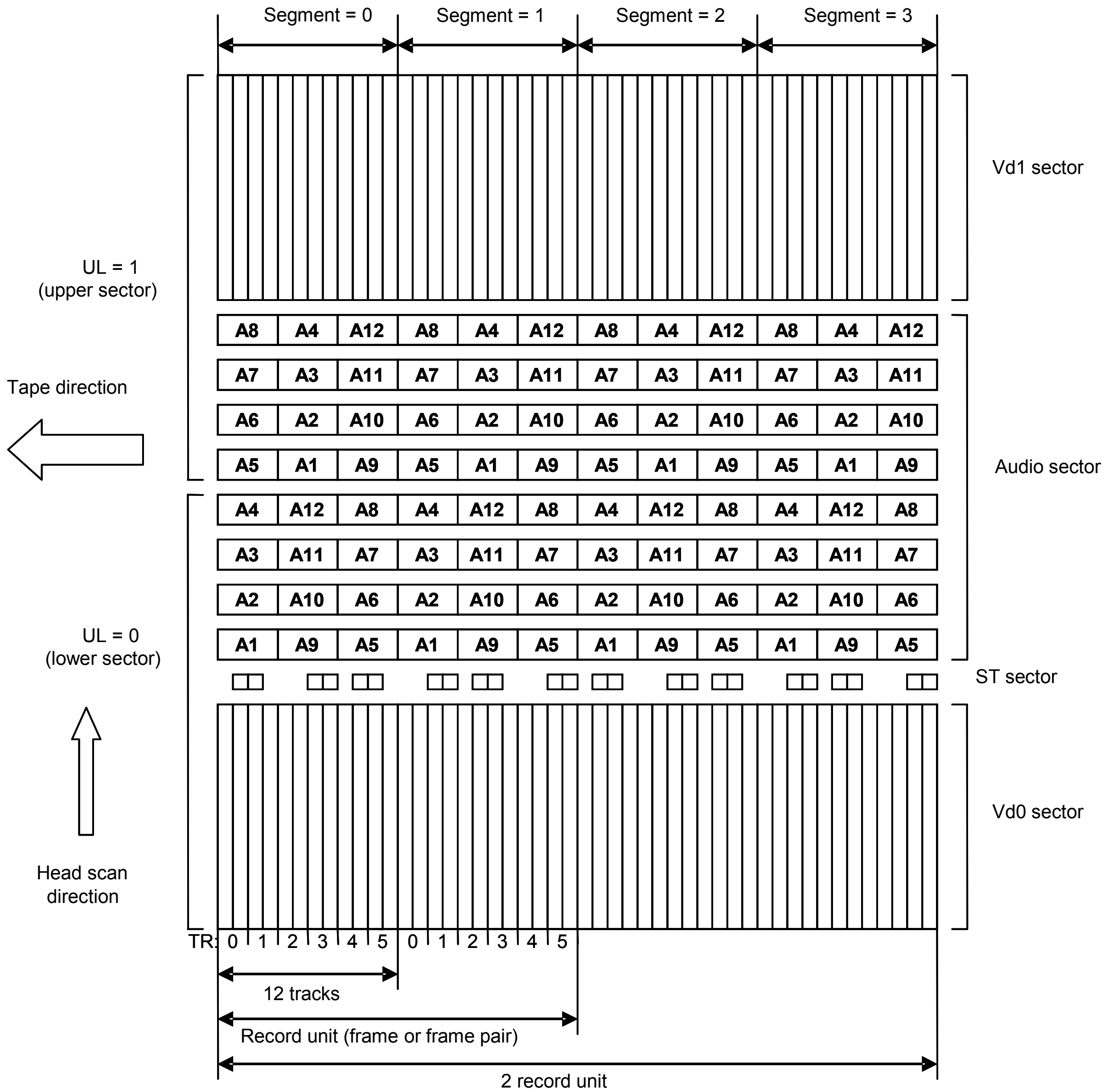


Figure 73 – Record unit, segment, channel and track pair counts

9.4.2.1 Video sync blocks

The Type D-16 picture compression format provides compressed picture basic blocks and auxiliary basic blocks which shall be mapped into video sync blocks.

The payload included in each basic block of Type D-16 picture compression shall be mapped into bytes 4 to 229 of a video sync block as illustrated in Figure 74. The value of byte 2 (ID_0) is modified according to the algorithm specified in 9.4.2.4.

For each track, the auxiliary basic blocks and the compressed picture basic blocks shall be mapped into the video sync blocks numbered according to the algorithm specified in 9.4.2.3.

Every video sync block shall contain a sync identification pattern of 2 bytes, 226 bytes of data, and an inner check code of 16 bytes.

Figure 74 shows the sync block format for, respectively, video sync blocks.

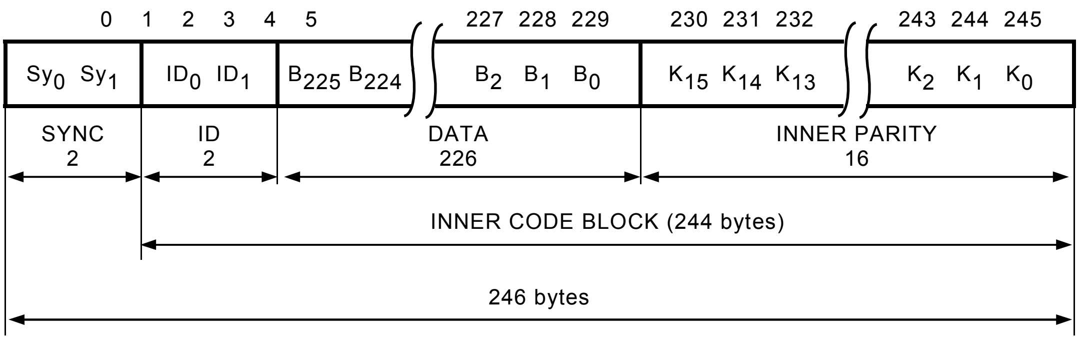


Figure 74 – Video sync block format

9.4.2.2 Audio sync blocks

The rows of 189 byte data from Figure 69 shall form the inner code block of an audio sync block (bytes 4 to 192) as illustrated in Figure 75.

Every audio sync block shall contain a sync identification pattern of 2 bytes, 189 bytes of data, and an inner check code of 16 bytes.

Figure 75 shows the sync block format for audio sync blocks.

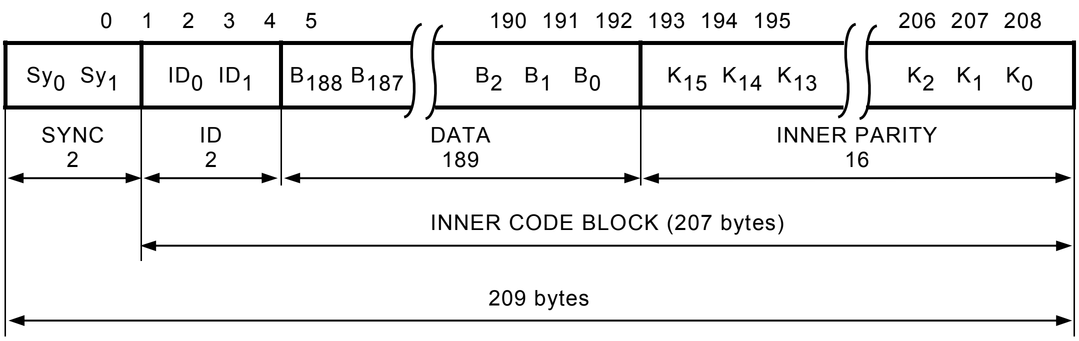


Figure 75 – Audio sync block format

9.4.2.3 Sync pattern

The length of the sync pattern shall be 2 bytes. The byte values shall be 76h and B4h leading to the bit sequence as shown below.

Byte 0 (Sy0)

	0	1	2	3	4	5	6	7	
LSB	0	1	1	0	1	1	1	0	MSB

Byte 1 (Sy1)

	0	1	2	3	4	5	6	7	
LSB	0	0	1	0	1	1	0	1	MSB

9.4.2.4 Sync block identification pattern

The length of the sync block identification (ID) pattern shall be 2 bytes.

NOTE The ID pattern for video sync blocks is initialized to be the same as the BID pattern for basic blocks defined in 8.5.2. However, the value of the first byte of the BID is modified by the algorithm defined in this subclause.

The first byte of the ID (ID_0) shall be used to uniquely identify every sync block within each Vd0 sector or Vd1 sector. The second byte of the ID (ID_1) shall be used to identify the sector position, track pair and segment numbers. Figure 76 shows the pattern of the sync block identification.

SYNC BLOCK NUMBER (ID_0)

Byte 2

LSB 0	1	2	3	4	5	6	7 MSB
B_0	B_1	B_2	B_3	B_4	B_5	B_6	B_7
SYNC BLOCK NUMBER (ID_0)							

SECTOR ID SYNC BLOCKS (ID_1)

Byte 3

LSB 0	1	2	3	4	5	6	7 MSB
UL	TR_0	TR_1	TR_2	SG_0	SG_1	SG_2	SG_3
UPPER/ LOWER	TRACK PAIR NUMBER			SEGMENT NUMBER			

Figure 76 – Sync block identification bytes

The first sync block ID byte (ID_0) is a coded sequence, which follows the syntax of the ID_0 defined below. The last ID_0 code of each sector shall be reserved for post-amble identification.

The sync sequence number is used as a parameter to derive the ID_0 value and signifies the order of a sync block in a sector.

Figure 77 and Table 20 show the assignment of the sync sequence number in a helical track.

Syntax of the ID_1 algorithm for video sync blocks(MBU_NUM<80_h)

MBU_NUM: Macro Block Unit number in BID_0 of compressed picture basic blocks
BB_NUM: Basic Block number in BID_1 of compressed picture basic blocks
UL: Upper or lower sector identifier, 1 means Upper sector
SYNC_SEQ: Sync sequence number
TRACK_NUM: track pair number.

UL = ((MBU_NUM×204+BB_NUM) %2 + ((MBU_NUM×204+BB_NUM)/8) ×2) %2

SYNC_SEQ = ((MBU_NUM×204+BB_NUM) %2
+((MBU_NUM×204+BB_NUM)/8) ×2) %188

TRACK_NUM = ((MBU_NUM×204+BB_NUM) /2) %4
+((MBU_NUM×204+BB_NUM)/376) ×4

Syntax of the ID_1 algorithm for video AUX sync blocks(MBU_NUM=80_h)

UL = BB_NUM%2

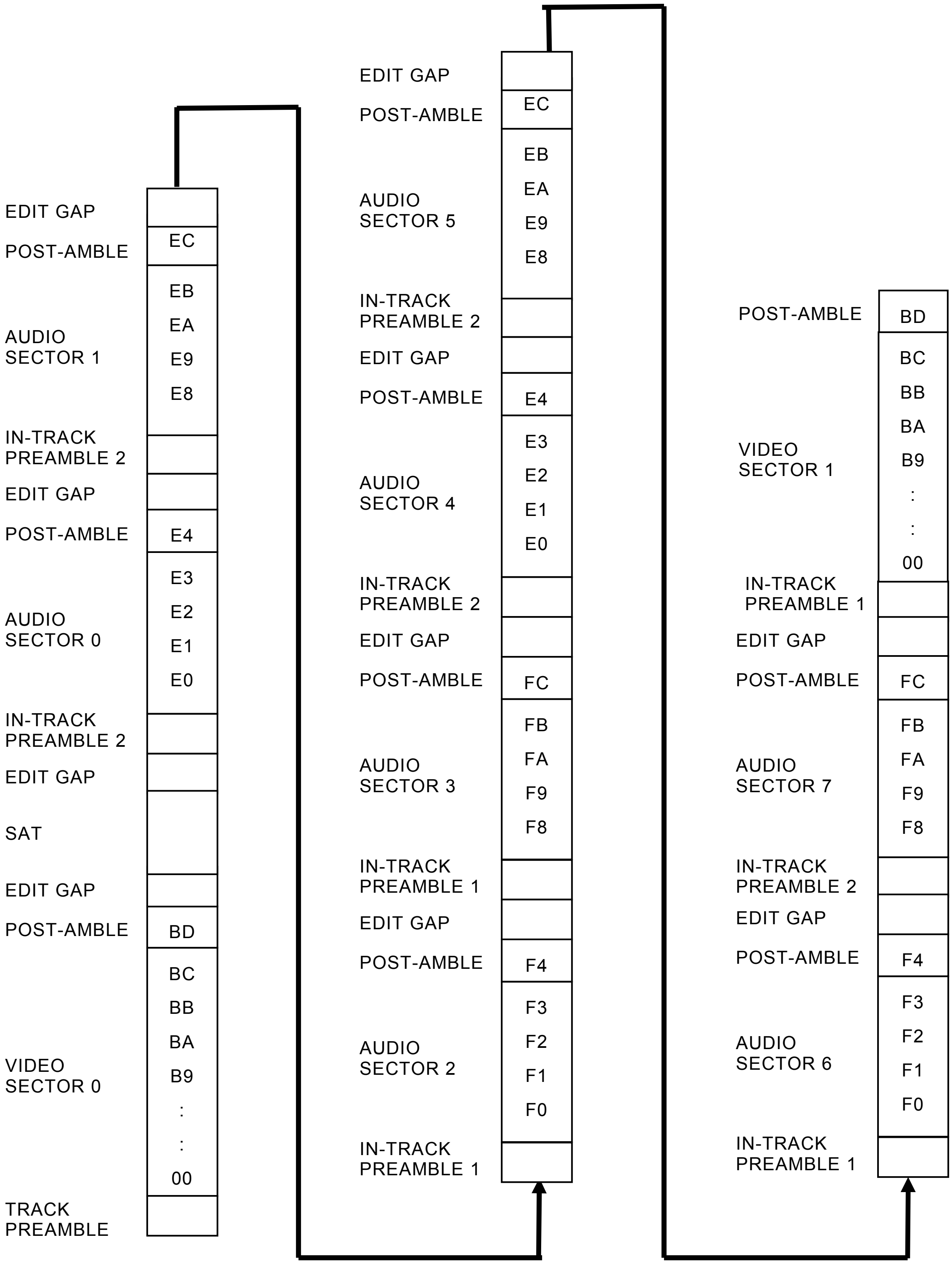
SYNC_SEQ = ((BB_NUM+1) /2) ×188

TRACK_NUM = BB_NUM /2

Syntax of the ID_0 generation algorithm for sync blocks

```
{       ID0 = 80h;
        for (I = 0; I < SYNC_SEQ; i++)
        {
                k = ID0 % 2;
                for (j = 2; j < 5; j++)
                {
                        k += ((ID0 >> j) % 2);
                }
        ID0= ID0 >> 1+ (k % 2) × 80h;
        }
}
```

Where ">> n" represents n-bit right shift to the left operand.



NOTE The hexadecimal numbers indicate the values of ID_0.

Figure 77 – Sync sequence number

Table 20 – Sync sequence number and UL

Sector	Sync sequence number	ID_1 UL
Video sector V0	00 h to BC h	0
Video sector V1	00 h to BC h	1
Audio sector A0	E0 h to E3 h	0
Audio sector A1	E8 h to EB h	0
Audio sector A2	F0 h to F3 h	0
Audio sector A3	F8 h to F3 h	0
Audio sector A4	E0 h to E3	1
Audio sector A5	E8 h to EB	1
Audio sector A6	F0 h to F3	1
Audio sector A7	F8 h to FB	1

The second sync ID byte (ID_1), as shown in Figure 76, shall be used to define several data fields.

- The UL bit shall be used to distinguish the two data sector arrangements corresponding to upper sector and the lower sector. Table 20 describes the UL value.
- The TR bits (TR0, TR1, TR2) shall be used to identify the track pair number as defined in the table below.

	TR0	TR1	TR2
Track pair 0:	0	0	0
Track pair 1:	1	0	0
Track pair 2:	0	1	0
Track pair 3:	1	1	0
Track pair 4:	0	0	1
Track pair 5:	1	0	1

The SG bits (SG0, SG1, SG2, SG3) shall be used to identify the track segment number as defined in the table below.

The LSB value of the segment number bits in the second sync ID byte (ID_1) shown in Figure 76, shall match the Seg_0 bit of BID_3 defined in Section 8.5.2.

These bits are defined as follows.

	SG0	SG1	SG2	SG3
Segment 0:	0	0	0	0
Segment 1:	1	0	0	0
Segment 2:	0	1	0	0
Segment 3:	1	1	0	0

9.4.2.5 Data scrambling

Data shall be scrambled before generation of inner ECC as shown in Figure 30 by the field generator polynomial:

$X^8 + X^4 + X^3 + X^2 + 1$ Seed: ID_0 Start: B_{225} for video
B_{188} for audio

The first term is the most significant and first to enter the division computation.

NOTE The value of ID_0 for video is loaded into the scrambler at the timing point defined by the location of the B_{225} word as identified in Figure 74. The value of ID_0 for audio is loaded into the scrambler at the timing point defined by the location of the B_{188} word as identified in Figure 75. Thus, the B_{225} or B_{188} word carries the ID_0 value as a seed to preset the field generator polynomial with a unique value for each sync block.

9.4.2.6 Inner ECC calculation

Inner ECC blocks for video sync block are defined as video sync blocks without the 2-byte sync pattern. Each inner ECC block is 244 bytes in length with the last 16 bytes forming the inner ECC.

Inner ECC blocks for audio sync block are defined as audio sync blocks without the 2-byte sync pattern. Each inner ECC block is 207 bytes in length with the last 16 bytes forming the inner ECC.

The data content of inner ECC blocks shall be scrambled before generation of the inner ECC, as defined in 9.4.2.5.

The inner ECC shall be of the Reed-Solomon (RS) type having 16 check words placed at the end of each inner ECC block. Details of the RS code common to all inner ECC blocks shall be as follows:

- Galois field: GF(256)
- Field generator polynomial: $X^8 + X^4 + X^3 + X^2 + 1$,
  where X^i are place-keeping variables in GF(2), the binary field. Note that the '+' sign indicates modulo binary addition.
- The code generator polynomial (GF(256)) is defined as:

  $$G(X) = (X + \alpha^0)(X + \alpha^1)(X + \alpha^2)(X + \alpha^3)(X + \alpha^4)(X + \alpha^5)(X + \alpha^6)(X + \alpha^7)(X + \alpha^8)(X + \alpha^9)(X + \alpha^{10})(X + \alpha^{11})(X + \alpha^{12})(X + \alpha^{13})(X + \alpha^{14})(X + \alpha^{15})$$

  where α is given by 02h in GF(256). Note that the '+' sign for this and the following equations indicates modulo 256 addition.

The RS check characters are defined as

$K_{15}, K_{14}, K_{13}, K_{12}K_{11}, K_{10}, K_9, K_8, K_7, K_6, K_5, K_4, K_3, K_2, K_1, K_0$ in

$$K_{15}X^{15} + K_{14}X^{14} + K_{13}X^{13} + K_{12}\,X^{12} + K_{11}X^{11} + K_{10}X^{10} + K_9X^9 + K_8X^8 + K_7X^7 + K_6X^6 + K_5X^5 + K_4X^4 + K_3X^3 + K_2X^2 + K_1X^1 + K_0$$

obtained as the remainder after dividing the polynomial $X^{16}D(X)$ by G(x), where K_i are bit-inverted words of the ECC words, k_i, shown in figures 74 and 75, and D(X) is the polynomial given by:

a) for video sync blocks:

$D(X) = ID_0X^{227} + ID_1X^{226} + B_{225}X^{225} + B_{224}X^{224} + B_{223}X^{223} + \ldots + B_2X^2 + B_1X^1 + B_0$

b) for audio sync blocks:

$D(X) = ID_0X^{190} + ID_1X^{189} + B_{188}X^{188} + B_{187}X^{187} + \ldots + B_2X^2 + B_1X^1 + B_0$

The polynomial full code is defined as

c) for video sync blocks:

$$ID_0X^{243} + ID_1X^{242} + B_{225}X^{241} + B_{224}X^{240} + \ldots + B_2X^{18} + B_1X^{17} + B_0X^{16} + K_{15}X^{15} + K_{14}X^{14} + \ldots + K_2X^2 + K_1X^1 + K_0 \equiv 0 \pmod{G(X)}$$

d) for audio sync blocks:

$$ID_0X^{206} + ID_1X^{205} + B_{188}X^{204} + B_{187}X^{203} + \ldots + B_2X^{18} + B_1X^{17} + B_0X^{16} + K_{15}X^{15} + K_{14}X^{14} + \ldots + K_2X^2 + K_1X^1 + K_0 \equiv 0 \pmod{G(X)}$$

9.4.3 Sector preamble

All sector preambles shall have bytes with a value of CCh.

The preamble which precedes a second video in a track shall be 123 bytes long.

The preamble that precedes audio sector in a track shall be 104 bytes long.

9.4.3.1 Track preamble

A track preamble (TP) immediately precedes the first video data sector of every track. The length is 246 bytes.

9.4.4 Sector post-amble

All sectors are followed by a post-amble, the length of which shall be 4 bytes. Each post-amble shall consist of a 2-byte sync pattern and a 2-byte identification pattern.

9.4.5 Edit gap

The space between sectors on a track, exclusive of post-amble and preamble, is used to accommodate timing errors during editing. In an original recording, the edit gap shall contain bytes with the value ‘CCh’. The length of the edit gap varies according to the position on the track.

9.4.6 Tracking servo signal

Two kinds of tracking servo signals shall be recorded on the helical tracks. Both signals shall be recorded between the fourth audio and second video sectors on azimuth $\alpha 0$ track as indicated in Figure 27, Table 2 and Figure 71. One signal is a rectangular waveform with an eighth (1/8) of the Nyquist frequency for track 0 of segment 0, 2 and 4. The frequency of this signal is 9,71 M Hz for 29,97 Hz record unit rates, 8,10 M Hz for 25 Hz record unit rates and 7,77 M Hz for 23,98 Hz and 24 Hz record unit rates. The other signal is a rectangular waveform with an eightieth (1/80) of the Nyquist frequency for track 0 of segment 1, 3 and 5. The frequency of this signal is 971 K Hz for 29,97 Hz record unit rates, 810 K Hz for 25 Hz record unit rates and 777 K Hz for 23,98 Hz and 24 Hz record unit rates.

9.5 Channel coding

The channel code shall be scrambled NRZ modulation code.

The LSB of each byte shall be written first to tape.

9.6 Magnetization

9.6.1 Polarity

During the 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.

9.6.2 Record level

The level of the recording current applied to the head of a channel shall be optimized for the best signal-to-noise ratio in reproduction in the range from half the Nyquist frequency to the Nyquist frequency.

9.6.3 Record equalization

The frequency characteristics of the recording current applied to the head shall be such that the Nyquist frequency is emphasized by 3 dB with reference to the response at 1 M Hz (which is a very low frequency compared to the Nyquist frequency).

Annex A
(normative)

Digital interfaces

A.1 Introduction

Figure A.1 represents the relationship between the compression processes and the associated specifications that provides complete Type D-16 specification.

- ‘1’ is the MPEG-4 compression specification described in Clause 8.
- ‘2’ is the VTR specification described in Clause 9.

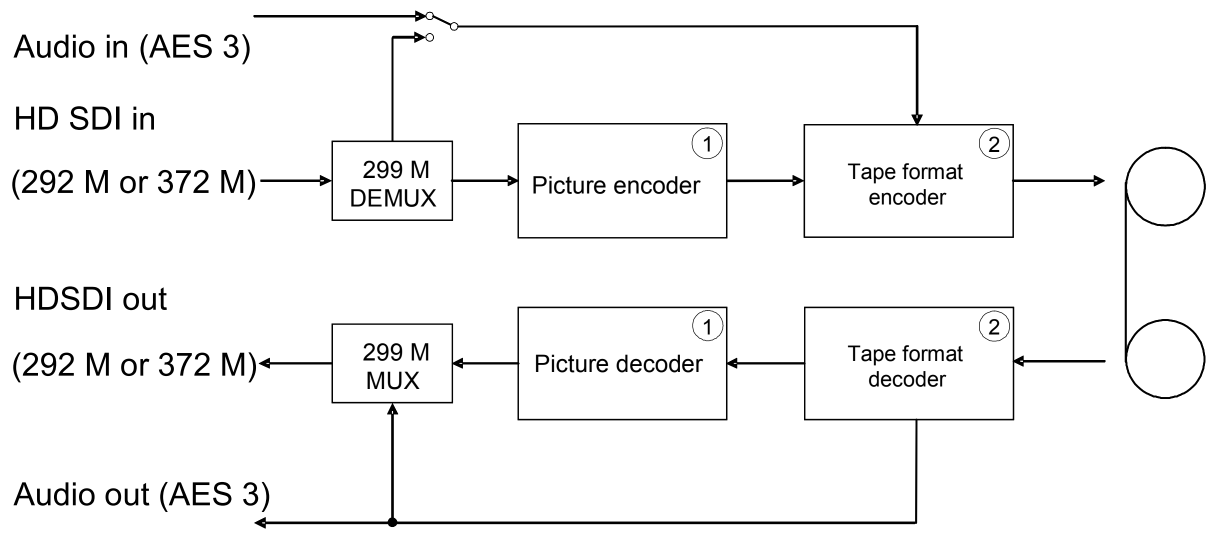


Figure A.1 – System overview

Equipment which provides digital audio, digital video and SDI interfaces to the Type D-16 format recorder shall conform to the following general specifications.

A.2 Video interface

A.2.1 Source coding parameters

Source digital signals using 1920 × 1080 pixels shall comply with the 4:2:2 or 4:4:4 sampling parameters as defined in ITU-R Recommendation BT.709 operating at 74,25 MHz and 74,25/1,001 MHz sampling frequencies.

Source digital signals using 1280 × 720 pixels shall comply with the 4:2:2 sampling parameters as defined in SMPTE 296M.

A.2.2 Digital interface

The 1920 × 1080 high-definition digital video interface or progressive digital video interface with 1280 × 720 pixels, if present, shall conform to the serial digital interface format as defined in SMPTE 292M (for 4:2:2 sampling) or 372M (for 4:4:4 sampling).

Ancillary data, if present in the digital video interface, shall conform to the ancillary data packet and space formatting as defined in SMPTE 291M.

In case of time code information embedded in ancillary data space shall conform to SMPTE RP-188.

A.3 Audio interface

A.3.1 Source coding parameters

The audio sample rate (F_S) shall be 48 K Hz locked to the record unit rate of the input reference signal (F_R) as shown in Table A.1.

Table A.1 – Audio sampling clock ratios

Reference record unit rate (F_R)	Audio lock ratio
29,97 Hz	$F_S = F_R \times 8008/5$
25 Hz	$F_S = F_R \times 1920$
24 Hz	$F_S = F_R \times 2000$
23,98 Hz	$F_S = F_R \times 2002$

A.3.2 Digital interface

The digital audio interface, if present, shall conform to the format for two-channel audio as defined in AES3-1997 and SMPTE 276M.

The digital audio data interface for embedded AES3 audio data, if present, shall conform to SMPTE 299M.

A.3.3 Sample phasing

For all record unit rates, the first sample of AES3 data in a record unit shall be defined to coincide with line 1 ± 6 lines of the input digital video signal.

NOTE Picture compression encoding may introduce delays in the signal encoding path. These delays may need an equivalent audio delay.

Annex B
(informative)

Tape transport and scanner

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

A possible configuration of the transport uses a scanner with an effective diameter of 81,400 mm. Scanner rotation is in the same direction as tape motion during normal playback mode. Data is recorded by two head pairs mounted at 180° from each other. Figure B.1 shows a possible mechanical configuration of the scanner and Table B.1 shows the corresponding mechanical parameters. Figure B.2 shows the relationship between the longitudinal heads and the scanner.

Other mechanical configurations are allowable, providing the same footprint of recorded information is present on tape.

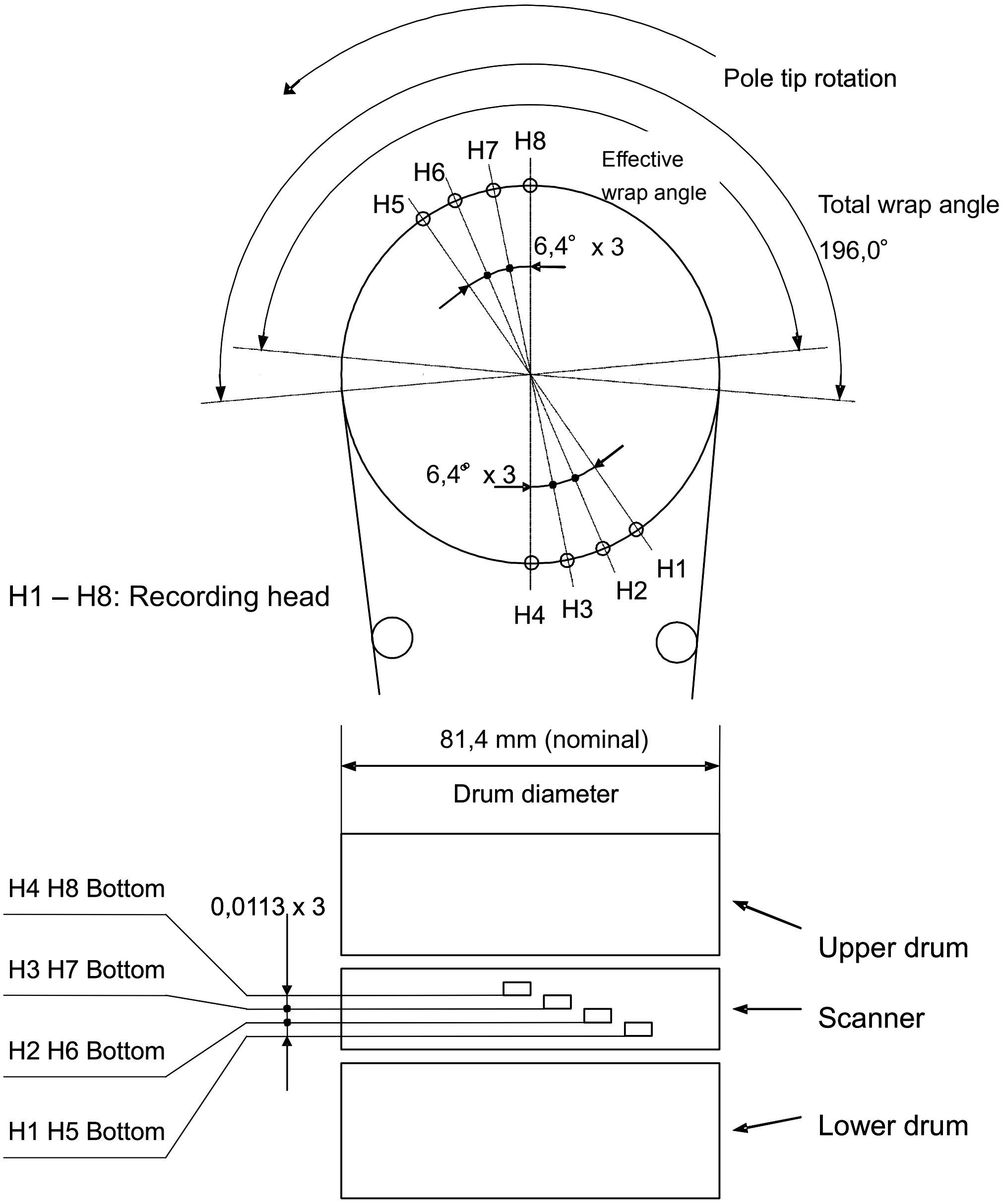
Table B.1 – Parameters for a possible scanner design

Parameters		Value		
		29,97 Hz record unit rate	**25 Hz record unit rate**	**24 (/1,001) Hz record unit rate**
Scanner rotation speed (r.p.s.)		90/1,001	75	72 (/1,001)
Number of tracks per rotation		8	8	8
Drum diameter (mm)		81,4	81,4	81,4
Centre span tension (N)		0,3	0,3	0,3
Helix angle (degrees)		4,607	4,607	4,607
Effective wrap angle (degrees)		171,8	171,8	171,8
Scanner circumferential speed (m/s)		23,0	19,2	18,4
H1, H3 over wrap head entrance (degrees)		21,9	21,9	21,9
H1, H3 over wrap head exit (degrees)		2,3	2,3	2,3
Angular relationship (degrees)	H1 – H2: H2 – H3: H3 – H4:	6,4	6,4	6,4
	H5 – H6: H6 – H7: H7 – H8:	6,4	6,4	6,4
	H1 – H5:	180,0	180,0	180,0
Vertical displacement (mm)	H1 – H2:	0,0113	0,0113	0,0113
	H3 – H4:	0,0166	0,0166	0,0166
Maximum tip projection (µm)		35	35	35
Record head track width (µm)		14	14	14

For the scanner configuration defined above, the recorder data rate and the shortest recorded wavelength are given in Table B.2, provided for reference only.

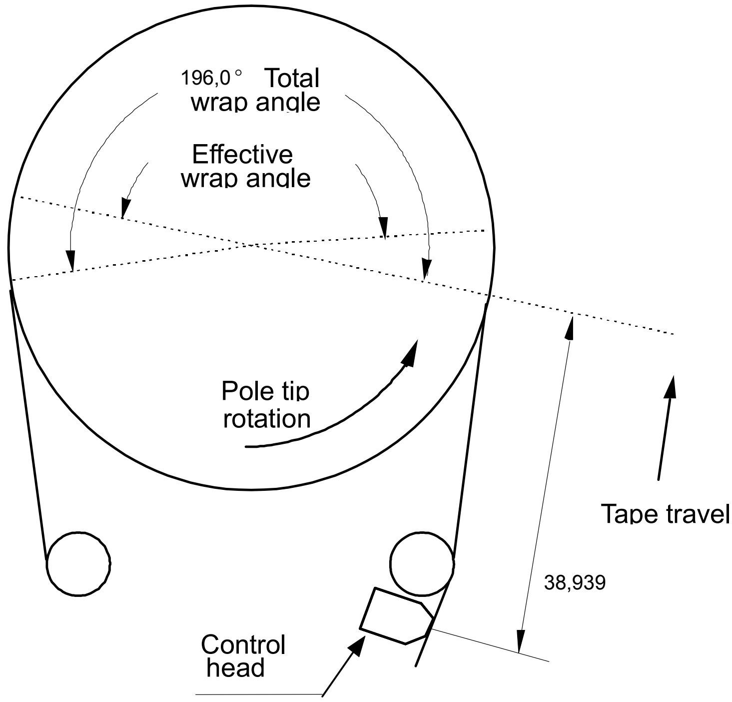
Table B.2 – Data rate and recorded wavelength

Parameter	29,97 Hz record unit rate	25 Hz record unit rate	24(/1,001) Hz record unit rate
Total data rate	593,325 Mbps	494,932 Mbps	475,135 (/1,001) Mbps
Instantaneous channel data rate (maximum rate per channel)	155,41 Mbps	129,64 Mbps	124,45 (/1,001) Mbps
Shortest recorded wavelength	0,294 μm	0,294 μm	0,294 μm

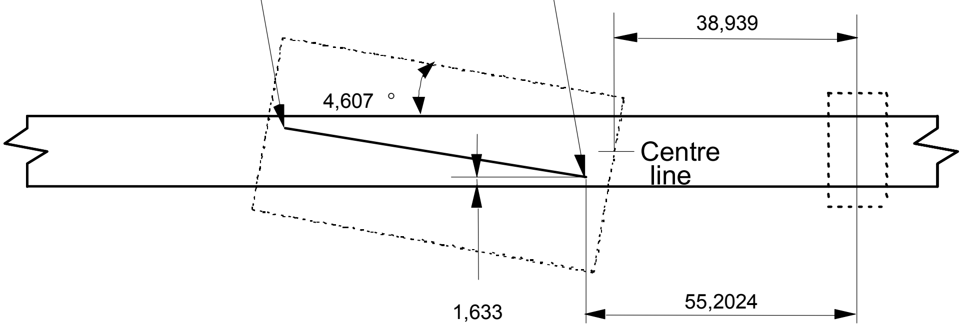


Dimensions in millimetres

Figure B.1 – Possible scanner configuration (29,97 Hz, 25 Hz, 24 Hz and 23,98 Hz record unit rates)



Top view



Dimensions in millimetres

Figure B.2 – Possible longitudinal head location and tape wrap
(29,97 Hz, 25 Hz, 24 Hz and 23,98 Hz record unit rates)

Annex C
(informative)

Compatibility with the other digital formats using Type-L derivative cassettes

The physical format parameters selected for the D-16 digital tape format provide for the possibility of backwards compatibility with other digital formats using format-L derivative cassettes.

A scanning drum diameter of 81,4 mm, and associated lead angle of 4,607°, provides the basis for achieving playback compatibility with other formats.

Automatic detection of a given tape format is provided by the cassette tape format identification holes.

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Thank you for your contribution to the standards-making process.

Nicht frankieren
Ne pas affranchir

Non affrancare
No stamp required

A Prioritaire

RÉPONSE PAYÉE

SUISSE

Customer Service Centre (CSC)
International Electrotechnical Commission
3, rue de Varembé
1211 GENEVA 20
Switzerland

Q1 Please report on **ONE STANDARD** and **ONE STANDARD ONLY**. Enter the exact number of the standard: *(e.g. 60601-1-1)*

....

Q2 Please tell us in what capacity(ies) you bought the standard *(tick all that apply).* I am the/a:

- purchasing agent ❑
- librarian ❑
- researcher ❑
- design engineer ❑
- safety engineer ❑
- testing engineer ❑
- marketing specialist ❑
- other...

Q3 I work for/in/as a: *(tick all that apply)*

- manufacturing ❑
- consultant ❑
- government ❑
- test/certification facility ❑
- public utility ❑
- education ❑
- military ❑
- other...

Q4 This standard will be used for: *(tick all that apply)*

- general reference ❑
- product research ❑
- product design/development ❑
- specifications ❑
- tenders ❑
- quality assessment ❑
- certification ❑
- technical documentation ❑
- thesis ❑
- manufacturing ❑
- other...

Q5 This standard meets my needs: *(tick one)*

- not at all ❑
- nearly ❑
- fairly well ❑
- exactly ❑

Q6 If you ticked NOT AT ALL in Question 5 the reason is: *(tick all that apply)*

- standard is out of date ❑
- standard is incomplete ❑
- standard is too academic ❑
- standard is too superficial ❑
- title is misleading ❑
- I made the wrong choice ❑
- other ....

Q7 Please assess the standard in the following categories, using the numbers:
(1) unacceptable,
(2) below average,
(3) average,
(4) above average,
(5) exceptional,
(6) not applicable

- timeliness ....
- quality of writing....................................
- technical contents.................................
- logic of arrangement of contents ....
- tables, charts, graphs, figures...............
- other ....

Q8 I read/use the: *(tick one)*

- French text only ❑
- English text only ❑
- both English and French texts ❑

Q9 Please share any comment on any aspect of the IEC that you would like us to know:

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