

SMPTE STANDARD

for Digital Television Recording — 1/2-in Type D-15 High-Definition Compressed Video Data Format



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1 Scope

This standard specifies the content, format, and recording method of the data blocks containing compressed video data, AES3 audio data, and associated data which form the helical records on 12.65-mm (0.5-in) tape. In addition, this standard specifies the content, format, and recording method of the longitudinal record containing tracking information for the scanning head associated with the helical records, and also the longitudinal cue audio, and time and control code.

One video channel of high definition compressed video data and eight independent AES3 audio data channels are recorded in the digital format. Each of these channels is designed to be capable of independent editing.

The HD video compressed data are derived from the following HD video signals:

- 1080 line / 59.94 Hz field frequency interlace system (1080/59.94i)
- 720 line / 59.94 Hz frame frequency progressive system (720/59.94p)
- 1080 line / 50 Hz field frequency interlace system (1080/50i)
- 1080 line / 25 Hz frame frequency progressive system (1080/25p)
- 1080 line / 24 Hz frame frequency progressive system (1080/24p)
- 1080 line / 23.98 Hz frame frequency progressive system (1080/23.98p)

Through out the text of this standard, the expression “AES3 audio data” may be abbreviated to “audio data” and represents digitized audio and data in AES-3 format. The tape format also supports a recording of AES-3 data payload streams with some limitation (see 6.3.3 d).

Figures 1 and 2 show block diagrams of typical recording and playback circuits. The compression part in the dotted line rectangle in figure 1 refers to SMPTE 342M.

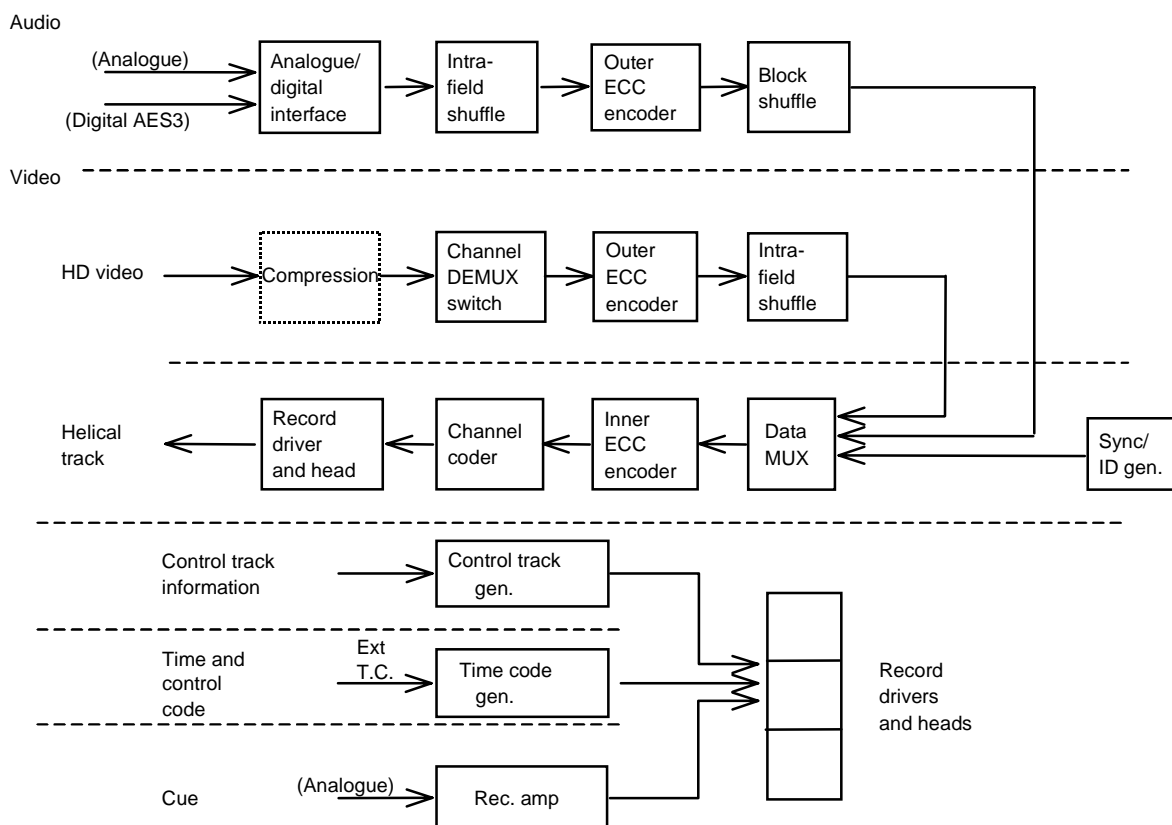


Figure 1 – Record block diagram

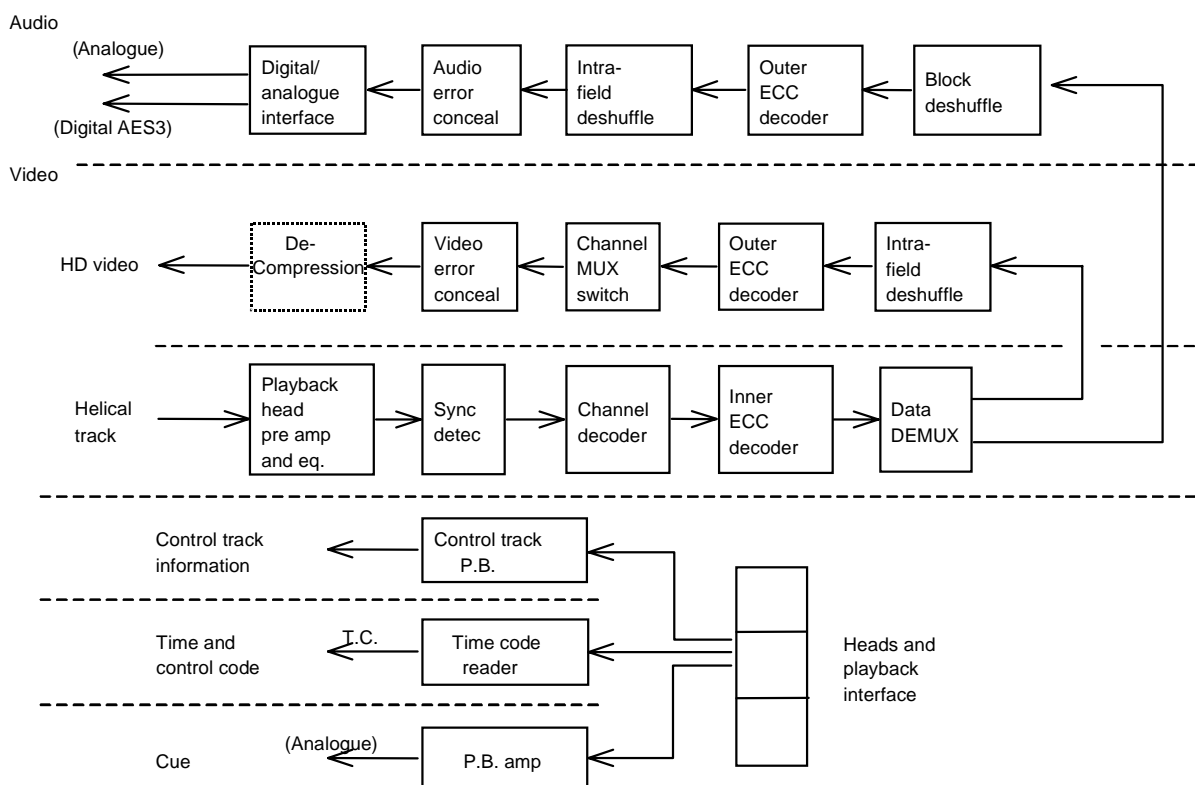


Figure 2 – Playback block diagram (including decompression)

2 Normative references

The following standards contain provisions, which through reference in this text constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this Standard are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

ANSI/SMPTE 299M-1997 24-Bit Digital Audio Format of HDTV Bit-Serial Interface

SMPTE 12M-1999, Television, Audio and Film — Time and Control Code

SMPTE 342M-2004, Television — HD-D5 Compressed Video 1080i and 720p Systems — Encoding Process and Data Format

SMPTE RP 155-1997, Audio levels for Digital Audio Records on Digital Television Tape Recorders

AES3-1992 (R1997), Serial Transmission Format for two Channel Linearly Represented Digital Audio Data

3 Environment and test conditions

3.1 Environment

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

- Temperature 20 °C ± 1 °C
- Relative humidity (50 ± 2) %
- Barometric pressure from 86 kPa to 106 kPa
- Tape conditioning not less than 24 h
- Center tape tension 0.31 N ± 0.05 N (see annex A)

4 Magnetic tape

4.1 Base

The base material shall be polyester or equivalent.

4.2 Width

The tape width shall be 12.650 mm ± 0.008 mm. The tape, covered with glass, is measured without tension at a minimum of five different positions along the tape using a calibrated comparator having an accuracy of 0.001 mm (1 µm). The tape width is defined as the average of the five readings.

4.3 Width fluctuation

Tape width fluctuation shall not exceed 5 µm peak to peak. Measurement of tape width fluctuation shall be taken over a tape length of 900 mm. The value of tape width fluctuation shall be evaluated by measuring the tape width at 10 points, each separated by a distance of 100 mm.

4.4 Tape thickness

Two types of tape thickness shall be permitted by this standard. The first tape thickness shall be 10.2 µm to 11.0 µm (referred to as 11 µm); the second tape thickness shall be 13.0 µm to 14.0 µm (referred to as 14 µm).

4.5 Transmissivity

Transmissivity shall be less than 5%, measured over the range of wavelengths 800 nm to 900 nm.

4.6 Offset yield strength

The offset yield strength shall be greater than 9 N for 11-µm tape and 10 N for 14-µm tape. The force required to produce 0.2 % elongation of a 1000 mm test sample with a pull rate of a 10 mm per minute shall be used to confirm the offset yield strength. The line beginning at 0.2 % elongation parallel to the initial tangential slope is drawn and then read at the point of intersection of the line and the stress-strain curve.

4.7 Magnetic coating

The magnetic layer of the tape shall consist of a coating of metal particles or equivalent.

4.8 Coating coercivity

The coating coercivity shall be a class 1800 (144000 A/m) with an applied field of 400000 A/m (5000 Oe) as measured by a 50-Hz or 60-Hz B-H meter or vibrating sample magnetometer (VSM).

4.9 Particle orientation

The metal particles shall be longitudinally oriented.

5 Helical recordings

5.1 Tape speed

The tape speed shall be 167.228 mm/s for the 1080/59.94i and 720/59.94p systems, 139.496 mm/s for the 1080/50i and 1080/25p system, 133.782 mm/s for the 1080/24p and 1080/23.98p system respectively. The tolerance shall be $\pm 0.2\%$.

5.2 Record location and dimensions

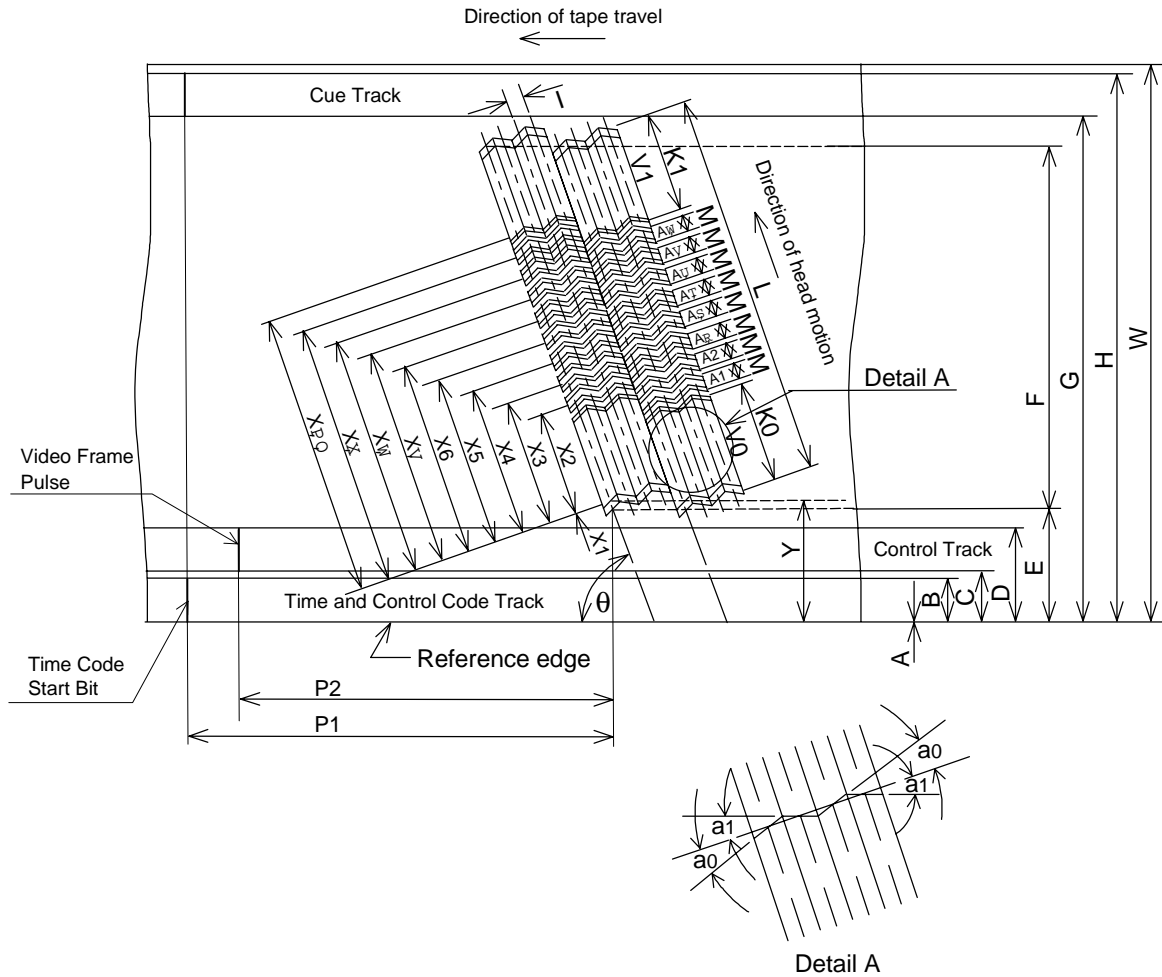
5.2.1 The format requires full track width erasure for continuous recording and flying erasure for insert editing.

5.2.2 Record location and dimensions for continuous recording shall be as specified in figures 3 and 4 and table 1. In recording, sector locations on each helical track shall be contained within the tolerances specified in figure 3 and table 1.

5.2.3 The reference edge of the tape for record location dimensions specified in this standard shall be the lower edge as shown in figure 3. The magnetic coating, with the direction of tape travel as shown in figure 3, is on the side facing the observer (measuring techniques are shown in annex B).

5.2.4 As indicated in figure 3, this standard anticipates a zero guard band between recorded tracks, and the record head width should be equivalent to the track pitch of 20 μm . The scanner head configuration should be chosen such that the recorded track widths are contained within the limits of 18 μm to 22 μm .

5.2.5 In insert editing, this standard provides a guard band of 2 μm (nominal) between the previously recorded track and the inserted track at editing points only. A typical track pattern for insert editing is shown in figure C.1 of annex C.



NOTES

- 1 A1 to A8 are audio data sectors.
- 2 V0 and V1 are compressed video data sectors.
- 3 Tape viewed from magnetic coating side.
- 4 Dimensions X1 to X10 are determined by the program reference point as defined in figure 4.

Figure 3 – Location and dimensions* of recorded tracks
 (*See table 1)

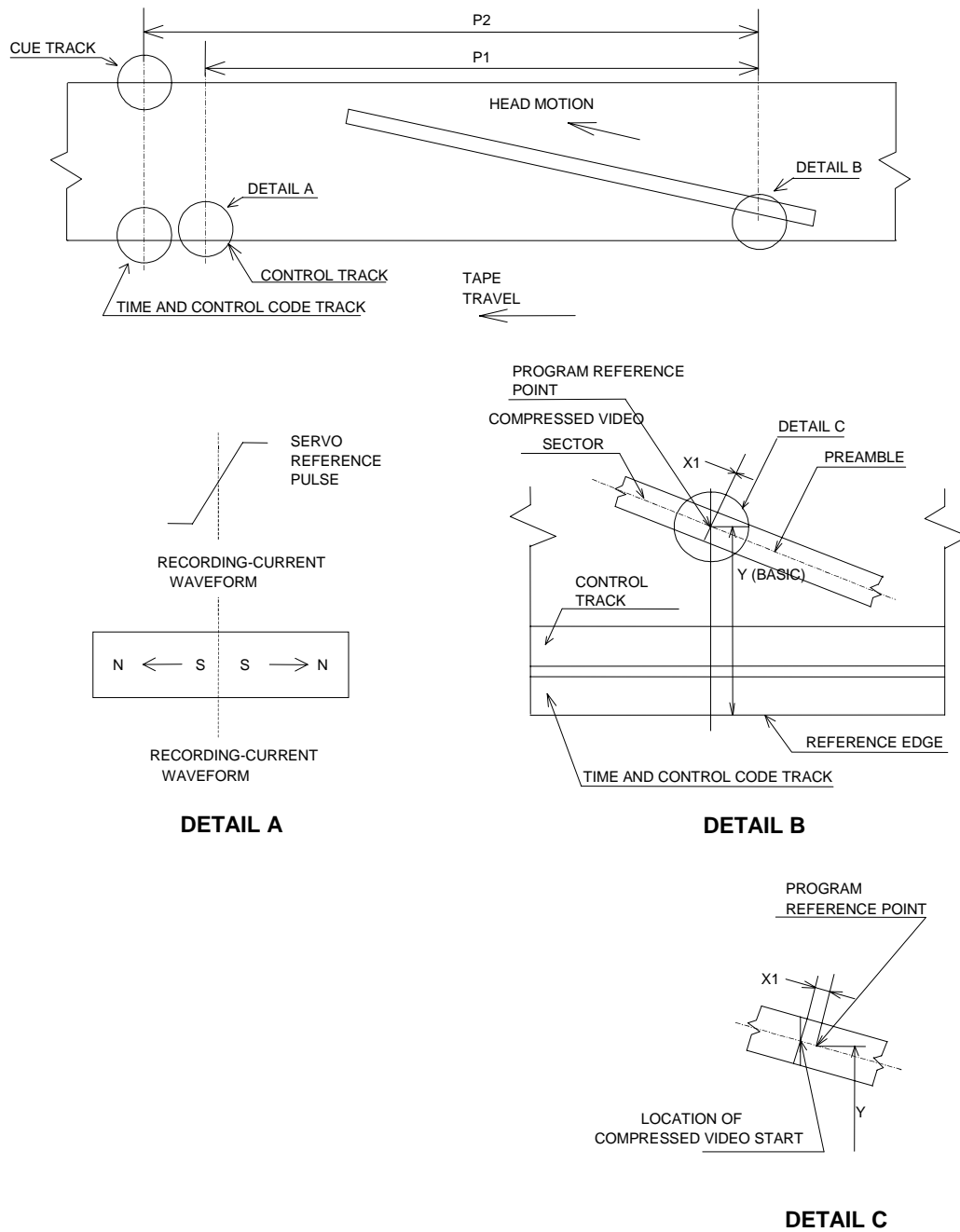


Figure 4 – Location of cue and time and control code track records

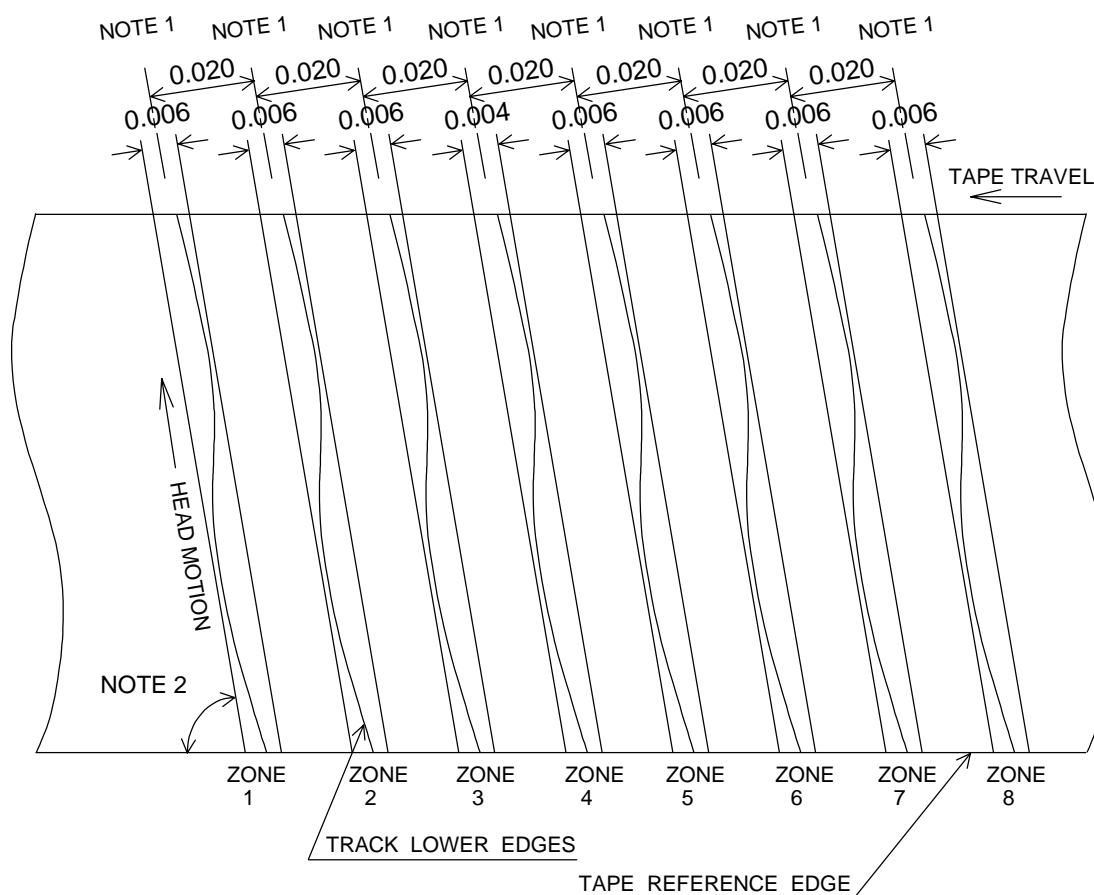
Table 1 – Record location and dimensions

| Dimensions | | 59.94i 50i 25p 23.98p | 24p | Tolerance |
|--|---|--------------------------------|------------|-----------|
| A | Time and control code track lower edge | 0 | 0 | Basic |
| B | Time and control code track upper edge | 0.450 | 0.450 | ± 0.050 |
| C | Control track lower edge | 0.900 | 0.900 | ± 0.050 |
| D | Control track upper edge | 1.300 | 1.300 | ± 0.050 |
| E | Program area lower edge | 1.629 | 1.624 | Derived |
| F | Program area width | 10.020 | 10.030 | Derived |
| G | Cue audio track lower edge | 11.950 | 11.950 | ± 0.050 |
| H | Cue audio track upper edge | 12.550 | 12.550 | ± 0.050 |
| I | Helical track pitch | 0.0200 | 0.0200 | Ref |
| K0 | Compressed video data sector 0 length | 51.624 | 51.676 | Derived |
| K1 | Compressed video data sector 1 length | 51.562 | 51.614 | Derived |
| L | Helical track total length | 116.397 | 116.514 | Derived |
| M | Audio data sector length | 1.273 | 1.275 | Derived |
| P1 | Control track reference pulse to program reference point (see figure 4) | 180.556 | 180.614 | ± 0.050 |
| P2 | Cue/time and control code signal, start of code word, to program reference point (see figure 4) | 183.407 | 183.465 | ± 0.100 |
| X1 | Location of start of compressed video data sector V0 | 0 | 0 | ± 0.050 |
| X2 | Location of start of audio data sector A1 | 51.898 | 51.950 | ± 0.050 |
| X3 | Location of start of audio data sector A2 | 53.507 | 53.561 | ± 0.050 |
| X4 | Location of start of audio data sector A3 | 55.117 | 55.172 | ± 0.050 |
| X5 | Location of start of audio data sector A4 | 56.726 | 56.783 | ± 0.050 |
| X6 | Location of start of audio data sector A5 | 58.335 | 58.394 | ± 0.050 |
| X7 | Location of start of audio data sector A6 | 59.944 | 60.005 | ± 0.050 |
| X8 | Location of start of audio data sector A7 | 61.554 | 61.616 | ± 0.050 |
| X9 | Location of start of audio data sector A8 | 63.163 | 63.227 | ± 0.050 |
| X10 | Location of start of compressed video data sector V1 | 64.772 | 64.837 | ± 0.050 |
| Y | Program reference point | 1.639 | 1.634 | Basic |
| θ | Track angle | 4.9384 ° | 4.9384 ° | Basic |
| a0 | Azimuth angle (track 0) | - 20.038 ° | - 20.038 ° | ± 0.150 ° |
| a1 | Azimuth angle (track 1) | 19.962 ° | 19.962 ° | ± 0.150 ° |
| <p>NOTES</p> <p>1 Measurements shall be made under the conditions specified in 3.1. The measurements shall be corrected to account for actual tape speed (see figures B.1 and B.2 of Annex B).</p> <p>2 All dimensions in millimeters.</p> | | | | |

5.3 Helical track record tolerance zones

The lower edges of any eight consecutive tracks starting at the first track in each compressed video data frame shall be contained within the pattern of the eight tolerance zones established in figure 5. Each zone is defined by two parallel lines, which are inclined with respect to the tape reference edge at an angle of 4.9384° (basic).

The centerlines of all zones shall be spaced apart 0.0200 mm (basic). The width of zones 1 to 3 and 5 to 8 shall be 0.006 mm (basic). The width of zone 4 shall be 0.004 mm (basic). These zones are established to contain track angle errors, track straightness errors, and vertical head offset tolerance (measuring technique is shown in annex B).



NOTES

- 1 Tolerance zone centerlines.
- 2 4.9384°
- 3 All dimensions in millimeters.

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

5.4 Relative positions of recorded information

5.4.1 Relative positions of longitudinal tracks

Audio data, compressed video data, control track, time and control code, and cue track with information intended to be time coincident shall be positioned as shown in figures 3 and 4.

5.4.2 Program area reference point

The program area reference point is determined by the intersection of a line parallel to the reference edge of the tape at a distance Y from the reference edge and the centerline of the first track in each compressed video data field (segment 0, track 0) (see figures 3 and 4 and 6.1). The end of the preamble and start of the compressed video data sector are located at the program area reference point, and the tolerance is dimension X1. The locations are shown in figures 3 and 4; dimensions X1 and Y are in table 1. The relationship between sectors and contents of each sector is specified in clause 6.

5.5 Gap azimuth

5.5.1 Cue track, control track, time code track

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

5.5.2 Helical track

The azimuth of the head gaps used for the helical track shall be inclined at angles a_0 and a_1 as specified in table 1, with respect to a line perpendicular to the helical track. The azimuth of the first track of every field (segment 0, track 0) shall be oriented in the counterclockwise direction with respect to a line perpendicular to the helical track direction when viewed from the side of tape containing the magnetic record.

5.6 Transport and scanner (informative)

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

One possible configuration of the transport uses a scanner with an effective diameter of 76.000 mm. Scanner rotation is in the same direction as tape motion during normal playback mode. Data is recorded by two groups of four heads mounted 180° apart. Figure 6 shows one possible mechanical configuration of the scanner, and table 2 shows the corresponding mechanical parameters. Figures 7 and 8 shows the relationship between the longitudinal heads and the scanner.

Other mechanical configurations are allowable provided the same footprint of recorded information is produced on tape.

Erase heads are illustrated in annex C.

6 Program track data

6.1 Introduction

Each television field is recorded on 12 tracks. This standard describes a recorder that processes data every "field". In the case of progressive scan compressed video data based on the 720/59.94p system, consecutive frames 1 and 2 are mapped into a space corresponding to fields 1 and 2 of an interlace system. In the case of a 1080/23.98p, 1080/24p and 1080/25p system a single frame is mapped into a space corresponding to both fields of an interlace system. (See figure 16). Therefore a recorded "field" of progressive compressed video conveys information contained in a whole frame of the progressive video source.

The helical tracks contain digital data from the compressed video channel compressed video data sector, recorded in that order. An edit gap between sectors accommodates timing errors during editing. Figure 9 shows the arrangement of the sectors on helical track. Figure 12 shows the arrangement of compressed video data and audio data sectors on the tape.

Each frame of time code shows a frame number that corresponds to each compressed video frame in an interlace system, and to a pair of two consecutive compressed video frames in progressive 720 system. Therefore the time codes of these equivalent periods of time in the interlaced 59.94i and progressive 59.94p systems are the same.

INFORMATIVE NOTE – SMPTE 12M does not provide for differentiation between the two identical time codes assigned to two consecutive frames in the 720 system.

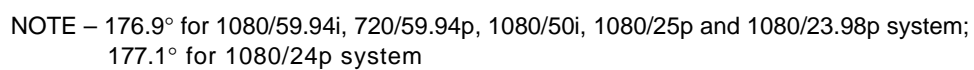
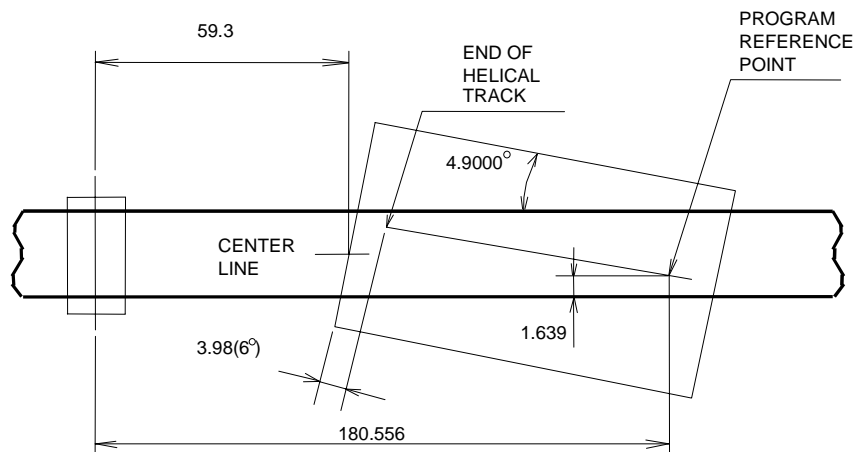
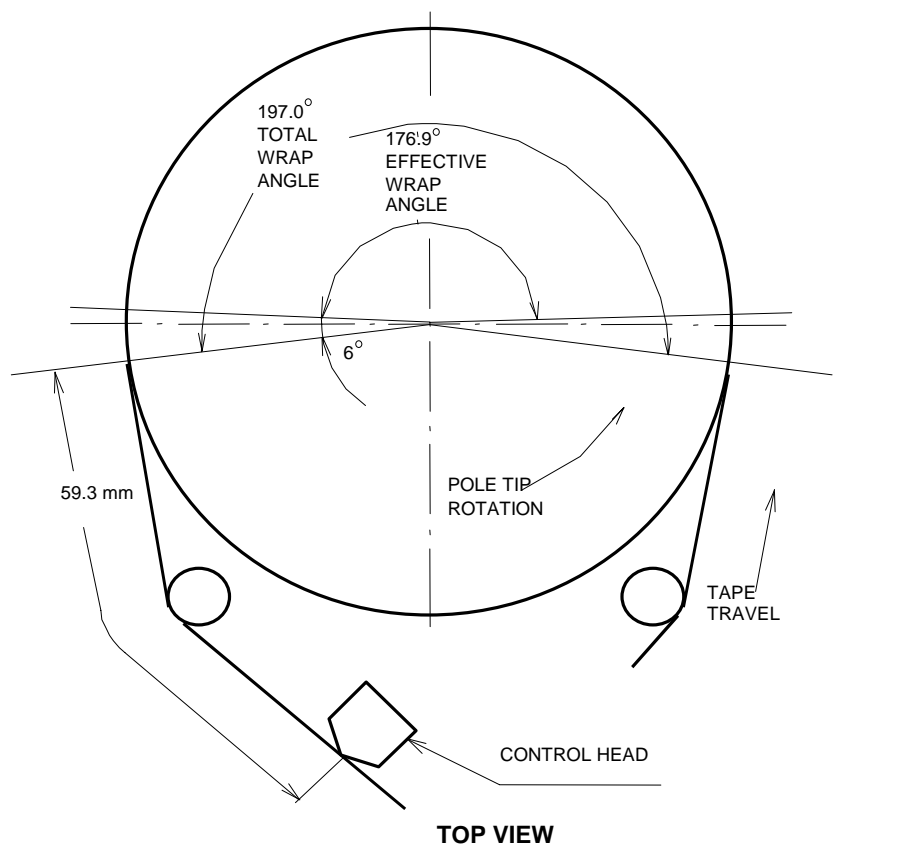


Figure 6 – A possible scanner configuration

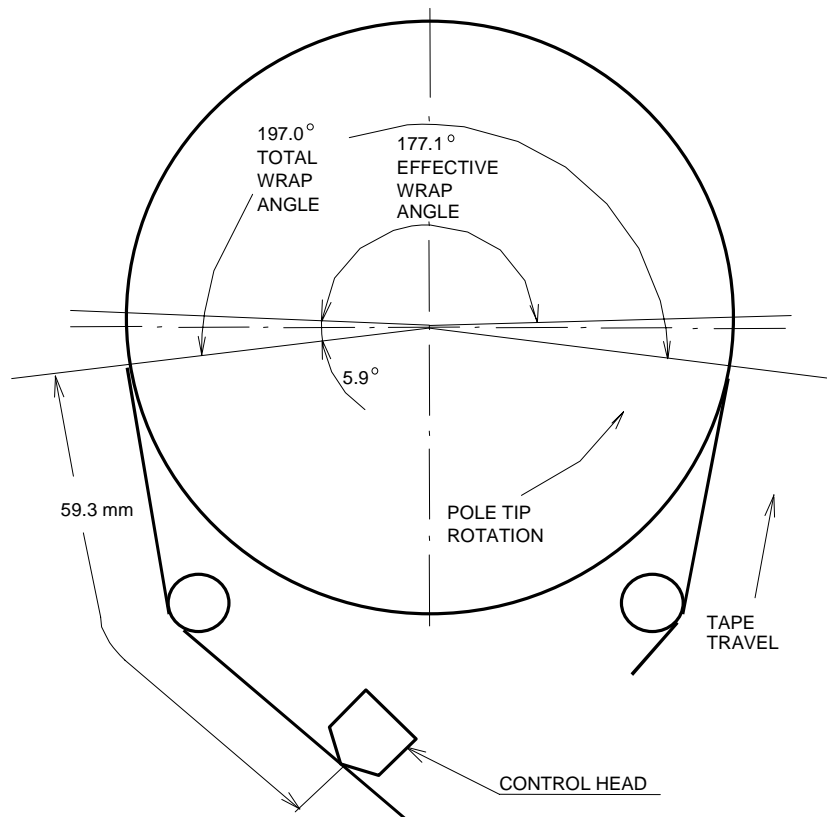
Table 2 – Parameters for a possible scanner design

| Parameters | 1080/59.94i 720/59.94p system | 1080/50i 1080/25p system | 1080/24p system | 1080/23.98p system |
|--|---|---|---|---|
| Scanner rotation speed (rps) | 90/1.001 | 75 | 72 | 72/1.001 |
| Number of tracks per rotation | 8 | 8 | 8 | 8 |
| Drum diameter (mm) | 76.000 | 76.000 | 76.000 | 76.000 |
| Center span tension (N) | 0.31 | 0.31 | 0.31 | 0.31 |
| Helix angle (degrees) | 4.9000 | 4.9000 | 4.9000 | 4.9000 |
| Effective wrap angle (degrees) | 176.9 | 176.9 | 177.1 | 176.9 |
| Scanner circumferential speed (m/s) | 21.5 | 17.9 | 17.2 | 17.2 |
| H1,H5 over wrap head entrance (degrees) | 14.1 | 14.1 | 14.0 | 14.1 |
| H1,H5 over wrap head exit (degrees) | 6 | 6 | 5.9 | 6 |
| Angular relationship (degrees) H1 – H4: H2 – H4: H3 – H4: H5 – H8: H6 – H8: H7 – H8: H4 – H8: | 13.570 9.047 4.523 13.570 9.047 4.523 180.000 | 13.570 9.047 4.523 13.570 9.047 4.523 180.000 | 13.570 9.047 4.523 13.570 9.047 4.523 180.000 | 13.570 9.047 4.523 13.570 9.047 4.523 180.000 |
| Vertical displacement (mm) H1 – H4: H2 – H4: H3 – H4: H5 – H8: H6 – H8: H7 – H8: | 0.054 0.036 0.018 0.054 0.036 0.018 | 0.054 0.036 0.018 0.054 0.036 0.018 | 0.054 0.036 0.018 0.054 0.036 0.018 | 0.054 0.036 0.018 0.054 0.036 0.018 |
| Maximum tip projection (μm) Note: Head projection from a drum surface | 42.0 | 42.0 | 42.0 | 42.0 |
| Record head track width (μm) Note: Track edit points are excepted | 20 | 20 | 20 | 20 |

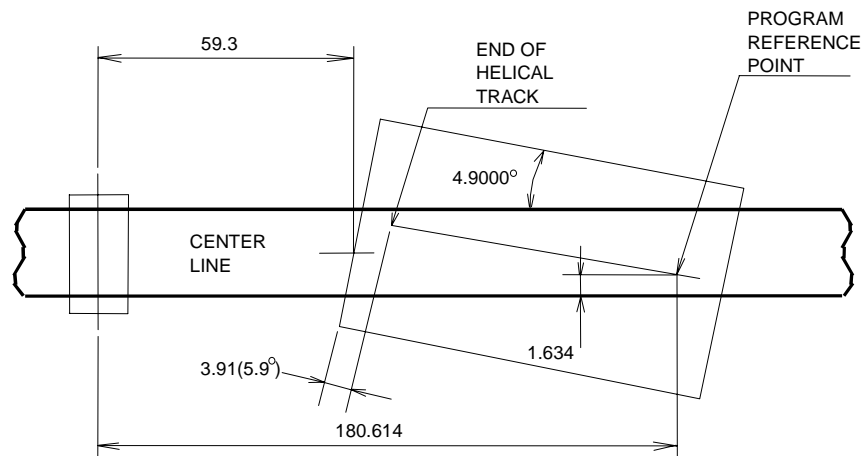


NOTE - Unwrapped, viewed magnetic coating side.

Figure 7 – A possible longitudinal head location and tape wrap (1080/59.94i, 720/59.94p, 1080/50i, 1080/25p and 1080/23.98p systems)

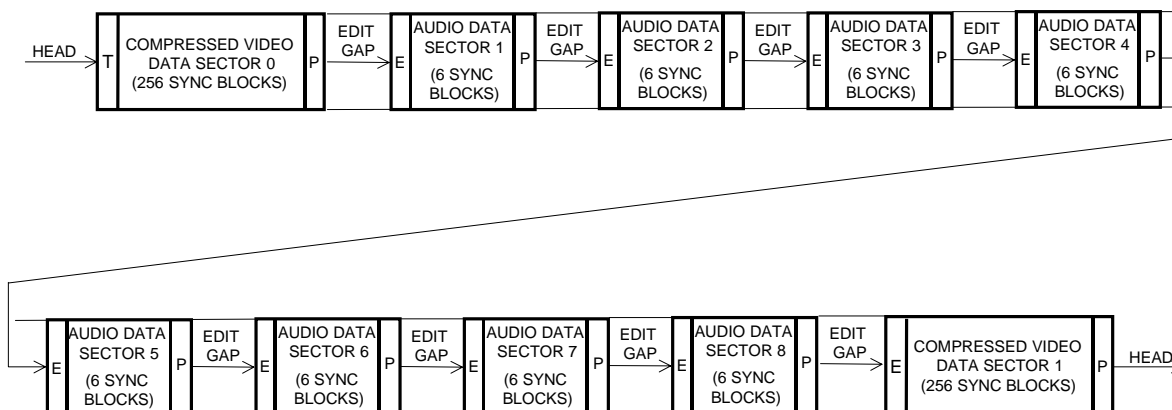


TOP VIEW



NOTE - Unwrapped, viewed magnetic coating side.

Figure 8 – A possible longitudinal head location and tape wrap (1080/24p system)



NOTES

- 1 T = Track preamble (58 bytes).
- 2 E = In-track preamble (28 bytes).
- 3 P = Postamble (4 bytes).
- 4 Sync block: 97 bytes.
- 5 Edit gap: 162 bytes nominal.

Figure 9 – Sector arrangement on helical track

6.2 Labeling convention

The least significant bit is written on the left and first is the recorded to tape.

The lowest numbered byte is shown at the left/top and is the first encountered in the input data stream. Byte values are expressed in hexadecimal notation unless otherwise noted. An h subscript indicates a hexadecimal value.

6.3 Sector details

Each sector (audio data or compressed video data) is divided into the following elements:

- Preamble containing clock run-up sequence, sync pattern, identification pattern and fill pattern;
- Sync blocks containing sync pattern and identification pattern, followed by a fixed length data block with error control;
- Postamble containing sync pattern and identification pattern.

6.3.1 Sync block

The sync block format is common to both audio data and compressed video data sectors. Each sync block contains a sync pattern (2 bytes) and an inner code block. Each inner block contains an identification pattern (2 bytes) and 85 data bytes of compressed video data, audio data, or outer check bytes followed by 8 inner check bytes.

The inner code block contains the two bytes of the identification pattern together with 85 data bytes. Figure 10 shows the sync block format.

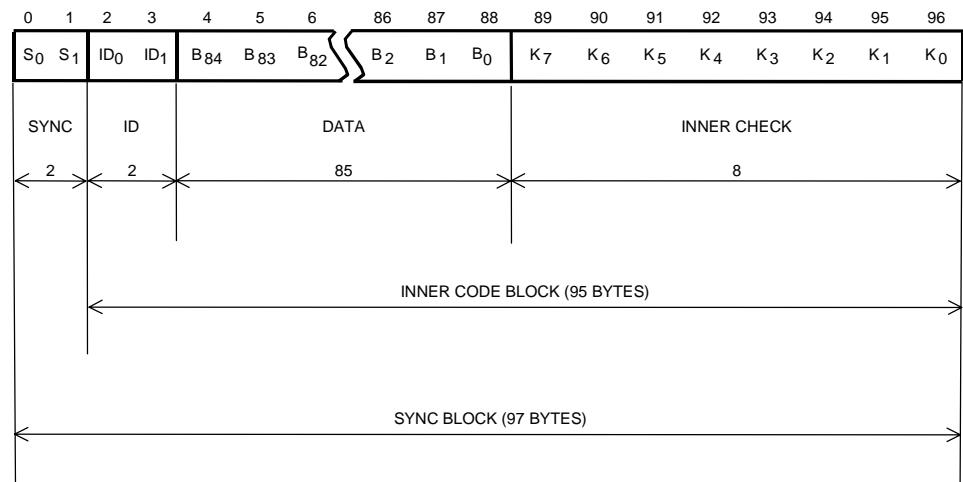


Figure 10 – Sync block format

6.3.2 Sync pattern

- a) Length: 16 bits (2 bytes).
- b) Pattern: 97F1 (in hexadecimal notation).

| | | LSB | | | | | | MSB | |
|--------|---|-----|---|---|---|---|---|-----|---|
| Byte 0 | - | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 |
| Byte 1 | - | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |

- c) Protection: None.
- d) Randomization: None.

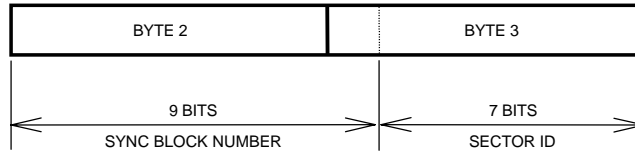
6.3.3 Identification Pattern

As illustrated in figure 11, the first two bytes of each inner block are used for identification of sync block, segment (group of helical tracks scanned simultaneously), helical track number, television field, and sector (portion of a track). While a progressive scan signal format contains only frames, each progressive frame is split into two fields as is indicated in figure 16.. Bits 1 to 6 of the second byte (byte 3 of sync block) of the identification pattern identify the track. Bit 7 of the second byte (byte 3) identifies a sector on the helical track (see figure 12).

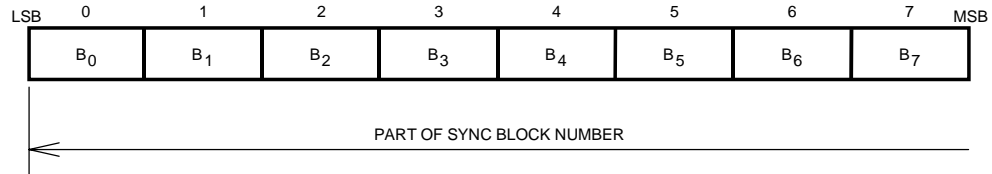
- a) Length: 16 bits (2 bytes).
- b) Arrangement: The sync block number (byte 2 and the bit 0 of byte 3) follows a coded sequence along the track. Figure 13 shows the sequence of the sync block numbers.

The sector ID (bits 1-7 of byte 3) identifies a particular sector.

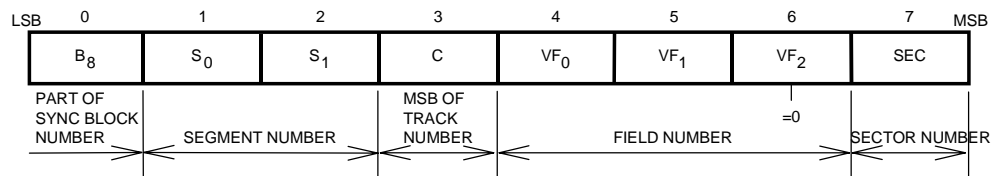
The segment number is modulo 3. For the 1080/59.94i and 720/59.94p system, the field number for compressed video data sectors is modulo 4 ($VF_2 = 0$ in byte 3). The field number for audio data sectors is modulo 4 (for AF_0 and AF_1 in byte 3) and AF_2 (in byte 3) is used for the identification of the five field sequences. For the 1080/50i, 1080/25p, 1080/24p and 1080/23.98p systems, the field number for compressed video data sectors is modulo 8 and the field number for audio data sectors is modulo 4 ($AF_2 = 0$).

ARRANGEMENT**SYNC BLOCK NUMBER**

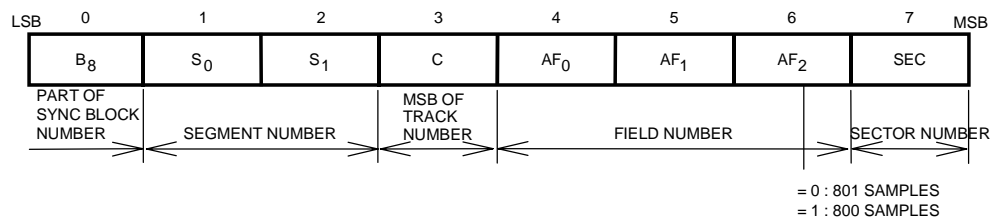
BYTE 2

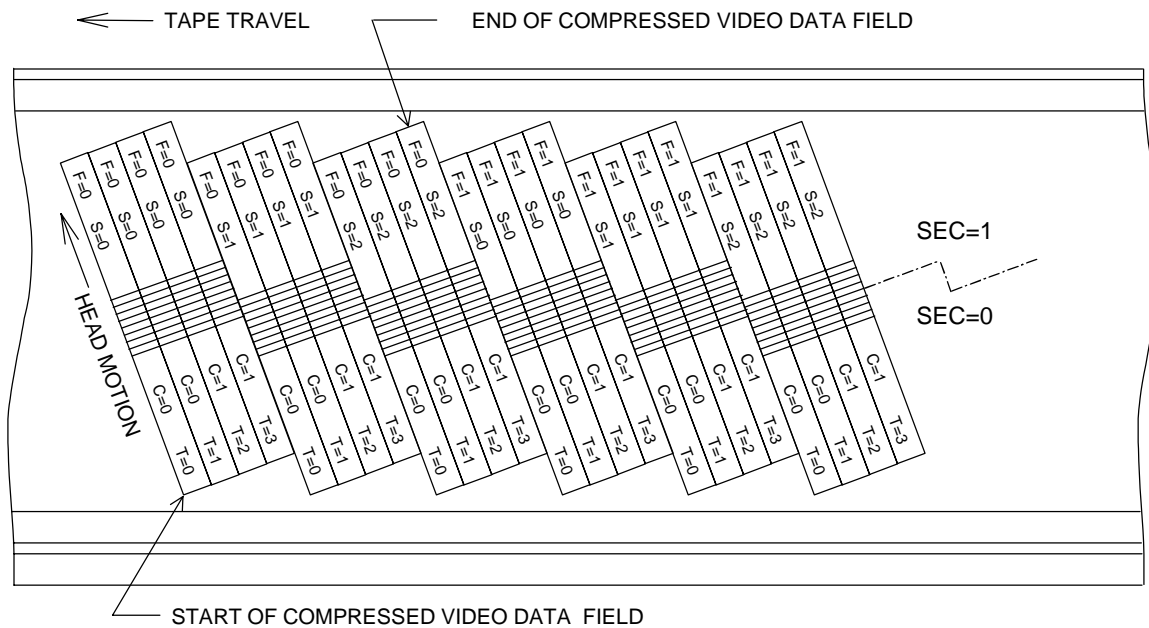
**SECTOR ID FOR VIDEO SYNC BLOCKS**

BYTE 3

**SECTOR ID FOR AUDIO SYNC BLOCKS**

BYTE 3

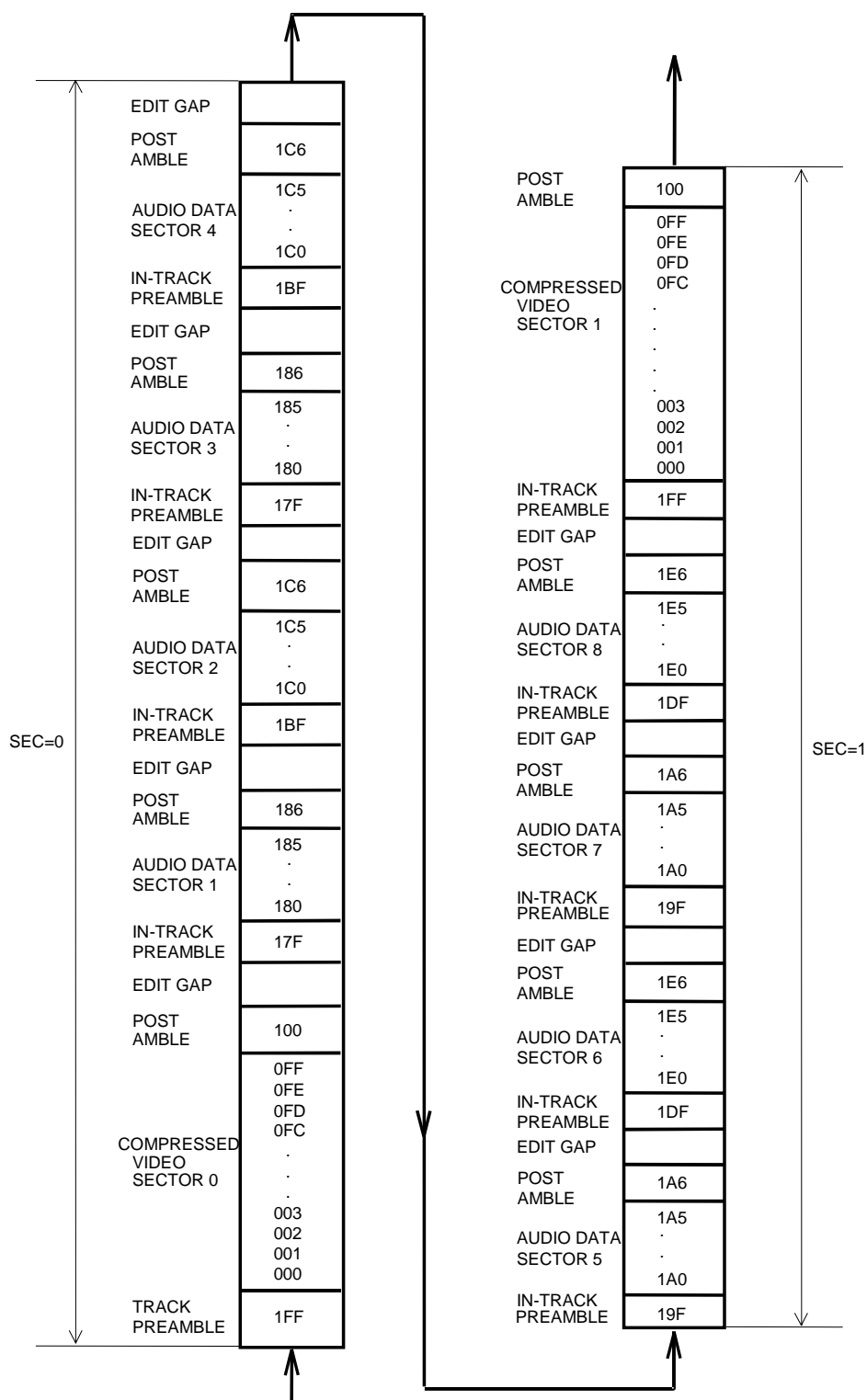
**Figure 11 – Sync block identification format**



NOTES

- 1 F = field number (0, 1, 2, 3).
- 2 S = segment number (0, 1, 2).
- 3 SEC = sector number; C = MSB of track number (0, 1).
- 4 T = track number (0, 1, 2, 3). LSB of track number is identified by the azimuth angle.
- 5 Audio data sectors are not shown.

Figure 12 – Track, segment and field numbers



NOTE – Sync block number shows in hexadecimal notation.

Figure 13 – Sync block number

c) Compressed video data field identification: The field address VF_0 , VF_1 , VF_2 (bits 4, 5, and 6 of the byte 3) for compressed video sync blocks shall identify the field sequence as shown below:

1080/59.94i and 720/59.94p systems:

| | VF_0 | VF_1 | VF_2 |
|-----------------|--------|--------|--------|
| Field 1 / Frame | 0 | 0 | 0 |
| Field 2 / Frame | 1 | 0 | 0 |
| Field 1 / Frame | 0 | 1 | 0 |
| Field 2 / Frame | 1 | 1 | 0 |

1080/50i, 1080/25p, 1080/24p and 1080/23.98p systems:

| | VF_0 | VF_1 | VF_2 |
|-----------------|--------|--------|--------|
| Field 1 / Frame | 0 | 0 | 0 |
| Field 2 / Frame | 1 | 0 | 0 |
| Field 1 / Frame | 0 | 1 | 0 |
| Field 2 / Frame | 1 | 1 | 0 |
| Field 1 / Frame | 0 | 0 | 1 |
| Field 2 / Frame | 1 | 0 | 1 |
| Field 1 / Frame | 0 | 1 | 1 |
| Field 2 / Frame | 1 | 1 | 1 |

d) Audio data field identification: The field address AF_0 and AF_1 of the audio data sync block (bits 4 and 5 of byte 3) shall identify a four-field sequence as shown below. When audio data sectors are edited, the four-field sequence shall be maintained.

| Field/Frame | AF_0 | AF_1 |
|-------------|--------|--------|
| m | 0 | 0 |
| m+1 | 1 | 0 |
| m+2 | 0 | 1 |
| m+3 | 1 | 1 |

For 1080/59.94i and 720/59.94p systems, the field address AF_2 of the audio data sync block (bit 6 of byte 3) shall identify a five-field sequence for the number of audio data samples in the current field as shown below. When audio data sectors are edited, the five-field sequence shall be maintained (see 10.3.6 d)).

For 1080/50i, 1080/25p, 1080/24p and 1080/23.98p systems, the field address AF_2 of the audio data sync block (bit 6 of byte 3) shall be set always to 0.

| | 1080/59.94i 720/59.94p | | 1080/50i 1080/25p | | 1080/24p ¹⁾ 1080/23.98p | |
|-------------|---------------------------|------------------------------------|----------------------|------------------------------------|---------------------------------------|------------------------------------|
| Field/frame | AF_2 | Number of audio data samples | AF_2 | Number of audio data samples | AF_2 | Number of audio data samples |
| n | 0 | 801 | 0 | 960 | 0 | 1001 |
| n+1 | 0 | 801 | 0 | 960 | 0 | 1001 |
| n+2 | 0 | 801 | 0 | 960 | 0 | 1001 |
| n+3 | 0 | 801 | 0 | 960 | 0 | 1001 |
| n+4 | 1 | 800 | 0 | 960 | 0 | 1001 |

¹⁾ The format supports recording of AES3 audio and data payload stream for all frame rates with the exception of the 1080/24p. The 1000 samples of the AES3 audio data payload for the 1080/24p frame rate is made common to the 1080/23.98p by use of a sample rate converter (see figure 15). However use of the sample rate converter in the 1080/24p mode limits the AES streams only to AES3 audio.

e) Protection: The identification pattern is protected by an inner code block.

f) Randomization: The identification pattern is randomized before being channel coded. The randomizing is equivalent to performing the exclusive-OR operation between the serial data stream and serial stream generated by the polynomial function

$$x^8 + x^4 + x^3 + x^2 + 1 \text{ (in GF(2))}$$

The first term is the most significant and the first to enter the division computation. The polynomial generator noted above is preset to 15_h at the first byte of the identification pattern and continues to cycle until the end of the sync block.

6.3.4 Data field

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

a) Length: 1 inner code block. The inner code block contains 95 bytes consisting of two identification pattern bytes, 85 data bytes (outer ECC check bytes are considered data), plus 8 inner ECC check bytes.

b) Arrangement: See figure 10.

c) Interleaving: None

d) Protection: Inner ECC code

Type: Reed-Solomon.

Galois Field: GF(256).

Field generator polynomial: $x^8 + x^4 + x^3 + x^2 + 1$,

where x^i are place keeping variables in GF(2), the binary field.

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

Code generator polynomial in GF(256) is:

$$G(x) = (x+1)(x+a)(x+a^2)(x+a^3)(x+a^4)(x+a^5)(x+a^6)(x+a^7),$$

where a is given by 02_h in GF(256).

Check characters : $K_7, K_6, K_5, K_4, K_3, K_2, K_1, K_0$ in $K_7x^7 + K_6x^6 + K_5x^5 + K_4x^4 + K_3x^3 + K_2x^2 + K_1x + K_0$ obtained as the remainder after dividing $x^8D(x)$ by $G(x)$, where

$$D(x) = ID_0x^{86} + ID_1x^{85} + B_{84}x^{84} + \dots + B_2x^2 + B_1x + B_0.$$

Polynomial of full code :

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

e) Randomization: All data and error correction check characters are randomized before being channel coded. The randomization is equivalent to randomization as defined in 6.3.3 e).

6.3.5 Sector preamble

All sectors are preceded by a preamble consisting of a clock run-up sequence, sync pattern (2 bytes), identification pattern (2 bytes), and fill pattern (4 bytes). The clock run-up sequence varies in length depending on the sector. The remaining elements of the preamble have the same format for all sectors. When a sector is edited, the appropriate preamble, including run-up sequence, shall be recorded.

6.3.5.1 Track preamble (T)

The track preamble precedes the first sector of every track. The total length of track preamble is 58 bytes and contains 50 bytes of run-up pattern "2C_h" which is followed by two bytes of sync pattern, two bytes of identification pattern, and four bytes of fill pattern "00_h".

| LSB | | | | MSB | | | |
|-----|---|---|---|-----|---|---|---|
| 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 |

- a) Arrangement: See figure 14 (a).
- b) Total length: 58 bytes.
- c) Run-up pattern: 2C_h.
- d) Sync pattern: See 6.3.2.
- e) Identification pattern: See 6.3.3.
- f) Fill pattern: 00_h.
- g) Protection: None.
- h) Randomization: Only the identification pattern and fill pattern are randomized before being channel coded. The randomization is equivalent to randomization as defined in 6.3.3 e).

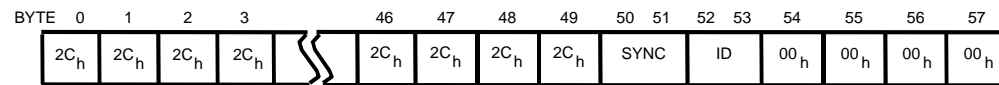
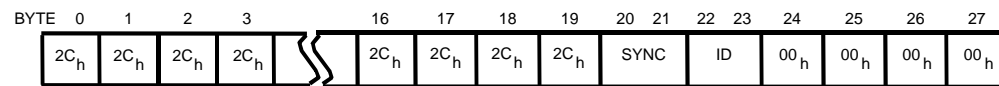
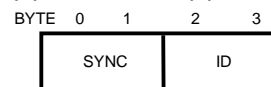
6.3.5.2 In-track preamble (E)

An in-track preamble precedes every sector except the first sector of a track. The total length is 28 bytes long and contains 20 bytes of run-up pattern "2C_h" followed by two bytes of sync pattern, two bytes of identification pattern, and four bytes of fill pattern "00_h".

- a) Arrangement: See figure 14 (b).
- b) Total length: 28 bytes.
- c) Run-up pattern: 2C_h.

| LSB | | | | MSB | | | |
|-----|---|---|---|-----|---|---|---|
| 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 |

- d) Sync pattern: See 6.3.2.
- e) Identification pattern: See 6.3.3.
- f) Fill pattern: 00_h.

(a) TRACK PREAMBLE (T)**(b) IN-TRACK PREAMBLE (E)****(c) POSTAMBLE (P)****Figure 14 – Sector preamble and postamble**

g) Protection: None.

h) Randomization: Only the identification pattern and fill pattern are randomized before being channel coded. The randomization is equivalent to randomization as defined in 6.3.3 f).

6.3.6 Sector postamble (P)

All sectors are followed by a postamble. The total length is four bytes and contains two bytes of sync pattern and two bytes of identification pattern.

a) Arrangement: See figure 14 (c).

b) Total length: 4 bytes.

c) Sync pattern: See 6.3.2.

d) Identification pattern: See 6.3.3.

e) Protection: None.

f) Randomization: Only the identification pattern is randomized before being channel coded. The randomization is equivalent to randomization as defined in 6.3.3 f).

6.4 Edit gaps

The spaces between individual sectors of a track, exclusive of preamble and postamble, are nominally 162 bytes long.

The edit gap is used to accommodate timing errors during editing. In an original recording, the edit gap shall contain the pattern $2C_h$. During an edit, the edit gap may be partially overwritten with $2C_h$ code provided that the preamble and/or postamble of the adjacent unedited track sectors are not overwritten.

a) Protection: None.

b) Randomization: None.

6.5 Channel code

The channel code shall be an 8-14 modulation code which is defined by the following code rules.

NOTES

1 DSV is an abbreviation for digital sum variation and indicates the integral value which is counted from the beginning of the 8-14 modulated wave form, taking high level as 1 and low level as -1.

2 CDS is an abbreviation for code word digital sum and indicates the DSV of one symbol modulation code.

3 8-bit data entries in tables 3 and 4 are in hexadecimal notation.

Selecting the current 14-bit code, the following steps shall be taken:

1) Select a 14-bit code satisfying the following conditions of (A) and (B) from tables 3 and 4:

a) The number of consecutive identical bits at the joint portion with the preceding 14-bit code is two to seven.

b) The absolute value of the DSV at the end of the code (called end DSV hereafter) is equal to or less than two.

2) When two or more 14-bit codes are selected at step (1), choose a 14-bit code that gives the smallest absolute value of the end DSV.

3) When two or more 14-bit codes are still chosen in step (2), select a 14-bit code by calculating the DSV for each bit of the code (called bit DSV hereafter), determining the bit DSV the absolute value of which is minimum for each code, and choosing the code with the bit DSV whose minimum absolute value is smallest.

4) When two or more 14-bit codes are further found in step (3), select a 14-bit code by finding the maximum absolute value of the bit DSV of each code, and choosing a code with the bit DSV whose maximum absolute value is equal to or less than six.

5) When two or more codes are still found in step (4), select a 14-bit code satisfying the condition that the number of consecutive identical bits at the joint portion with the preceding 14-bit code is equal to or less than six.

6) When any codes selected in step (4) do not satisfy step (5), or two or more modulation codes satisfy step (5), select a 14-bit code satisfying the condition that the number of consecutive identical bits in that code is equal to or less than six.

7) When any codes selected in step (4) do not satisfy step (5) and step (6), or when any codes selected in step (5) do not satisfy step (6), or when two or more codes are further found in step (6), the following two steps shall be taken:

a) When the end DSV of the code is -2, select a code of higher priority (corresponding to a smaller number in table 5) according to table 5. Likewise, when the end DSV of the code is

+2, select a code of higher priority (corresponding to smaller number in table 6) according to table 6.

b) When two or more codes belonging to the equal highest priority are found in step (a), select all of them temporarily. When the end DSV is zero, select a code satisfying the last six bits except when 111111 or 000000 are in the code.

8) When any codes selected in step (4) do not satisfy steps (5), (6), and (7), or when any codes selected in step (5) do not satisfy step (6) and step (7), or when any codes selected in step (6) do not satisfy step (7), or when two or more codes are further found in step (7), select a code with the bit DSV whose maximum absolute value is smallest.

9) When two or more codes are still found in step (8), select a 14-bit code with the bit DSV whose minimum absolute value appears earliest in the bit string of the code.

10) When two or more codes are further found in step (9), select a 14-bit code whose bit will be reversed earliest after the joint portion with the preceding code.

Table 3 – 8-14 modulation (CDS≥0)

| Class | 8-bit data | Modulation codes beginning with "0" | CDS | Class | 8-bit data | Modulation codes beginning with "1" | CDS |
|-------|------------|-------------------------------------|-----|-------|------------|-------------------------------------|-----|
| 1(A) | 00 | 01111110000001 | 0 | 1(B) | 00 | 10000001111110 | 0 |
| | 01 | 011111100110000 | 0 | | 01 | 10000011001111 | 0 |
| | 02 | 011111100011000 | 0 | | 02 | 10000011100111 | 0 |
| | 03 | 011111100001100 | 0 | | 03 | 10000011110011 | 0 |
| | 04 | 011111100000110 | 0 | | 04 | 10000011111001 | 0 |
| | 05 | 011111100000011 | 0 | | 05 | 10000011111100 | 0 |
| | 06 | 011110011110000 | 0 | | 06 | 10000110001111 | 0 |
| | 07 | 011110011000001 | 0 | | 07 | 10000110011110 | 0 |
| | 08 | 011110001110000 | 0 | | 08 | 10000111000111 | 0 |
| | 09 | 011110001100001 | 0 | | 09 | 10000111001110 | 0 |
| | 0A | 011110000111000 | 0 | | 0A | 10000111100011 | 0 |
| | 0B | 011110000110010 | 0 | | 0B | 10000111100110 | 0 |
| | 0C | 011110000011100 | 0 | | 0C | 10000111110001 | 0 |
| | 0D | 011110000000111 | 0 | | 0D | 10000111111000 | 0 |
| | 0E | 011100111110000 | 0 | | 0E | 10001100001111 | 0 |
| | 0F | 011100111100001 | 0 | | 0F | 10001100011110 | 0 |
| | 10 | 011100110011100 | 0 | | 10 | 10001100110011 | 0 |
| | 11 | 011100110001100 | 0 | | 11 | 10001100111001 | 0 |
| | 12 | 011100110000110 | 0 | | 12 | 10001100111100 | 0 |
| | 13 | 011100011110000 | 0 | | 13 | 10001110000111 | 0 |
| | 14 | 011100011100001 | 0 | | 14 | 10001110001110 | 0 |
| | 15 | 011100011001100 | 0 | | 15 | 10001110011001 | 0 |
| | 16 | 011100011000110 | 0 | | 16 | 10001110011100 | 0 |
| | 17 | 011100001111000 | 0 | | 17 | 10001111000011 | 0 |
| | 18 | 011100001110010 | 0 | | 18 | 10001111000110 | 0 |
| | 19 | 011100001100110 | 0 | | 19 | 10001111001100 | 0 |
| | 1A | 011100000111100 | 0 | | 1A | 10001111100001 | 0 |
| | 1B | 011100000011110 | 0 | | 1B | 10001111110000 | 0 |
| | 1C | 011001111110000 | 0 | | 1C | 10011000001111 | 0 |
| | 1D | 011001111000010 | 0 | | 1D | 10011000011110 | 0 |
| | 1E | 011001110011100 | 0 | | 1E | 10011000110011 | 0 |
| | 1F | 011001110001100 | 0 | | 1F | 10011000111001 | 0 |
| | 20 | 011001110000110 | 0 | | 20 | 10011000111100 | 0 |
| | 21 | 011001100111000 | 0 | | 21 | 10011001100011 | 0 |
| | 22 | 011001100110010 | 0 | | 22 | 10011001100110 | 0 |
| | 23 | 011001100011100 | 0 | | 23 | 10011001110001 | 0 |
| | 24 | 011001100001110 | 0 | | 24 | 10011001111000 | 0 |
| | 25 | 011000111110000 | 0 | | 25 | 10011100000111 | 0 |
| | 26 | 011000111100001 | 0 | | 26 | 10011100001110 | 0 |
| | 27 | 011000111001100 | 0 | | 27 | 10011100011001 | 0 |
| | 28 | 011000111000110 | 0 | | 28 | 10011100011100 | 0 |
| | 29 | 011000110011100 | 0 | | 29 | 10011100110001 | 0 |
| | 2A | 011000110001110 | 0 | | 2A | 10011100111000 | 0 |
| | 2B | 011000011111000 | 0 | | 2B | 10011110000011 | 0 |
| | 2C | 011000011110010 | 0 | | 2C | 10011110000110 | 0 |
| | 2D | 011000011100110 | 0 | | 2D | 10011110001100 | 0 |
| | 2E | 011000011001110 | 0 | | 2E | 10011110011000 | 0 |
| | 2F | 011000001111100 | 0 | | 2F | 10011111000001 | 0 |
| | 30 | 011000000111110 | 0 | | 30 | 10011111100000 | 0 |
| | 31 | 011111110011000 | 4 | | 31 | 10000011111110 | 2 |
| | 32 | 011111110001100 | 4 | | 32 | 10000110011111 | 2 |
| | 33 | 011111110000110 | 4 | | 33 | 10000111001111 | 2 |
| | 34 | 011111110011100 | 4 | | 34 | 10000111100111 | 2 |
| | 35 | 011111110011001 | 4 | | 35 | 10000111110011 | 2 |
| | 36 | 011111110001110 | 4 | | 36 | 10000111111001 | 2 |
| | 37 | 011111110000111 | 4 | | 37 | 10000111111100 | 2 |
| | 38 | 011111100111100 | 4 | | 38 | 10001100011111 | 2 |

(continued)

Table 3 – 8-14 modulation (CDS≥0) (continued)

| Class | 8-bit data | Modulation codes beginning with "0" | CDS | Class | 8-bit data | Modulation codes beginning with "1" | CDS |
|-------|------------|-------------------------------------|-----|-------|------------|-------------------------------------|-----|
| 1(A) | 39 | 01111100111001 | 4 | 1(B) | 39 | 100011001111110 | 2 |
| | 3A | 01111100110011 | 4 | | 3A | 10001110001111 | 2 |
| | 3B | 01111100011110 | 4 | | 3B | 10001110011110 | 2 |
| | 3C | 01111100001111 | 4 | | 3C | 10001111000111 | 2 |
| | 3D | 01111001111100 | 4 | | 3D | 10001111001110 | 2 |
| | 3E | 01111001111001 | 4 | | 3E | 10001111100011 | 2 |
| | 3F | 01111001110011 | 4 | | 3F | 10001111100110 | 2 |
| | 40 | 01111001100111 | 4 | | 40 | 10001111110001 | 2 |
| | 41 | 01111000111110 | 4 | | 41 | 10001111111000 | 2 |
| | 42 | 01111000011111 | 4 | | 42 | 10011000011111 | 2 |
| | 43 | 01110011111100 | 4 | | 43 | 10011000111110 | 2 |
| | 44 | 01110011111001 | 4 | | 44 | 10011001100111 | 2 |
| | 45 | 01110011110011 | 4 | | 45 | 10011001110011 | 2 |
| | 46 | 01110011100111 | 4 | | 46 | 10011001111001 | 2 |
| | 47 | 01110011001111 | 4 | | 47 | 10011001111100 | 2 |
| | 48 | 01110001111110 | 4 | | 48 | 10011000011111 | 2 |
| | 49 | 01110000111111 | 4 | | 49 | 10011100011110 | 2 |
| | 4A | 01100111111100 | 4 | | 4A | 10011100110011 | 2 |
| | 4B | 01100111111001 | 4 | | 4B | 10011100111001 | 2 |
| | 4C | 01100111110011 | 4 | | 4C | 10011100111100 | 2 |
| | 4D | 01100111100111 | 4 | | 4D | 10011110000111 | 2 |
| | 4E | 01100111001111 | 4 | | 4E | 10011110001110 | 2 |
| | 4F | 01100110011111 | 4 | | 4F | 10011110011001 | 2 |
| | 50 | 01100011111110 | 4 | | 50 | 10011110011100 | 2 |
| | 51 | 0111111000001 | 2 | | 51 | 10011111000011 | 2 |
| | 52 | 01111110011000 | 2 | | 52 | 10011111000110 | 2 |
| | 53 | 01111110001100 | 2 | | 53 | 10011111001100 | 2 |
| | 54 | 01111110000110 | 2 | | 54 | 10011111100001 | 2 |
| | 55 | 01111110000011 | 2 | | 55 | 10011111110000 | 2 |
| | 56 | 01111100111000 | 2 | | 56 | 10001111001111 | 4 |
| | 57 | 01111100110001 | 2 | | 57 | 10001111100111 | 4 |
| | 58 | 01111100011100 | 2 | | 58 | 10001111110011 | 4 |
| | 59 | 01111100011001 | 2 | | 59 | 10011001111110 | 4 |
| | 5A | 01111100001110 | 2 | | 5A | 10011100111110 | 4 |
| | 5B | 01111100000111 | 2 | | 5B | 10011110001111 | 4 |
| | 5C | 01111001111000 | 2 | | 5C | 10011110011110 | 4 |
| | 5D | 01111001110001 | 2 | | 5D | 10011111000111 | 4 |
| | 5E | 01111001100110 | 2 | | 5E | 10011111001110 | 4 |
| | 5F | 01111001100011 | 2 | | 5F | 10011111100011 | 4 |
| | 60 | 01111000111100 | 2 | | 60 | 10011111100110 | 4 |
| | 61 | 01111000111001 | 2 | 2(B) | 61 | 11000111100111 | 4 |
| | 62 | 01111000110011 | 2 | | 62 | 11000111110011 | 4 |
| | 63 | 01111000011110 | 2 | | 63 | 11000000111111 | 2 |
| | 64 | 01111000001111 | 2 | | 64 | 11000001111110 | 2 |
| | 65 | 01110011111000 | 2 | | 65 | 11000011001111 | 2 |
| | 66 | 01110011110001 | 2 | | 66 | 11000011100111 | 2 |
| | 67 | 01110011100110 | 2 | | 67 | 11000011110011 | 2 |
| | 68 | 01110011100011 | 2 | | 68 | 11000011111001 | 2 |
| | 69 | 01110011001110 | 2 | | 69 | 11000011111100 | 2 |
| | 6A | 01110011000111 | 2 | | 6A | 11000110001111 | 2 |
| | 6B | 01110001111100 | 2 | | 6B | 11000110011110 | 2 |
| | 6C | 01110001111001 | 2 | | 6C | 11000111000111 | 2 |
| | 6D | 01110001110011 | 2 | | 6D | 11000111001110 | 2 |
| | 6E | 01110001100111 | 2 | | 6E | 11000111100011 | 2 |
| | 6F | 01110000111110 | 2 | | 6F | 11000111100110 | 2 |
| | 70 | 01110000011111 | 2 | | 70 | 11000111110001 | 2 |

(continued)

Table 3 – 8-14 modulation (CDS≥0) (continued)

| Class | 8-bit data | Modulation codes beginning with "0" | CDS | Class | 8-bit data | Modulation codes beginning with "1" | CDS |
|-------|------------|-------------------------------------|-----|-------|------------|-------------------------------------|-----|
| 1(A) | 71 | 01100111111000 | 2 | | 71 | 11000111111000 | 2 |
| | 72 | 01100111110001 | 2 | | 72 | 11001100001111 | 2 |
| | 73 | 01100111100110 | 2 | | 73 | 11001100011110 | 2 |
| | 74 | 01100111100011 | 2 | | 74 | 11001100110011 | 2 |
| | 75 | 01100111001110 | 2 | | 75 | 11001100111001 | 2 |
| | 76 | 01100111000111 | 2 | | 76 | 11001100111100 | 2 |
| | 77 | 01100110011110 | 2 | | 77 | 11001110000111 | 2 |
| | 78 | 01100110001111 | 2 | | 78 | 11001110001110 | 2 |
| | 79 | 01100011111100 | 2 | | 79 | 11001110011001 | 2 |
| | 7A | 01100011111001 | 2 | | 7A | 11001110011100 | 2 |
| | 7B | 01100011110011 | 2 | | 7B | 11001111000011 | 2 |
| | 7C | 01100011100111 | 2 | | 7C | 11001111000110 | 2 |
| | 7D | 01100011001111 | 2 | | 7D | 11001111001100 | 2 |
| | 7E | 01100001111110 | 2 | | 7E | 11001111100001 | 2 |
| | 7F | 01100000111111 | 2 | | 7F | 11001111110000 | 2 |
| 2(A) | 80 | 00111111100000 | 0 | 2(B) | 80 | 11000000011111 | 0 |
| | 81 | 00111111000001 | 0 | | 81 | 11000000111110 | 0 |
| | 82 | 00111110011000 | 0 | | 82 | 11000001100111 | 0 |
| | 83 | 00111110001100 | 0 | | 83 | 11000001110011 | 0 |
| | 84 | 00111110000110 | 0 | | 84 | 11000001111001 | 0 |
| | 85 | 00111110000011 | 0 | | 85 | 11000001111100 | 0 |
| | 86 | 001111100111000 | 0 | | 86 | 11000011000111 | 0 |
| | 87 | 001111100110001 | 0 | | 87 | 11000011001110 | 0 |
| | 88 | 001111100011100 | 0 | | 88 | 11000011100011 | 0 |
| | 89 | 001111100011001 | 0 | | 89 | 11000011100110 | 0 |
| | 8A | 001111100001110 | 0 | | 8A | 11000011110001 | 0 |
| | 8B | 001111100000111 | 0 | | 8B | 11000011111000 | 0 |
| | 8C | 001111001111000 | 0 | | 8C | 11000110000111 | 0 |
| | 8D | 001111001110001 | 0 | | 8D | 11000110001110 | 0 |
| | 8E | 001111001100110 | 0 | | 8E | 11000110011001 | 0 |
| | 8F | 001111001100011 | 0 | | 8F | 11000110011100 | 0 |
| | 90 | 001111000111100 | 0 | | 90 | 11000111000011 | 0 |
| | 91 | 001111000111001 | 0 | | 91 | 11000111000110 | 0 |
| | 92 | 001111000110011 | 0 | | 92 | 11000111001100 | 0 |
| | 93 | 001111000011110 | 0 | | 93 | 11000111100001 | 0 |
| | 94 | 001111000001111 | 0 | | 94 | 11000111110000 | 0 |
| | 95 | 001100111111000 | 0 | | 95 | 11001100000111 | 0 |
| | 96 | 00110011110001 | 0 | | 96 | 11001100001110 | 0 |
| | 97 | 00110011100110 | 0 | | 97 | 11001100011001 | 0 |
| | 98 | 00110011100011 | 0 | | 98 | 11001100011100 | 0 |
| | 99 | 00110011001110 | 0 | | 99 | 11001100110001 | 0 |
| | 9A | 00110011000111 | 0 | | 9A | 11001100111000 | 0 |
| | 9B | 00110001111100 | 0 | | 9B | 11001110000011 | 0 |
| | 9C | 00110001111001 | 0 | | 9C | 11001110000110 | 0 |
| | 9D | 00110001110011 | 0 | | 9D | 11001110001100 | 0 |
| | 9E | 00110001100111 | 0 | | 9E | 11001110011000 | 0 |
| | 9F | 00110000111110 | 0 | | 9F | 11001111000001 | 0 |
| | A0 | 00110000011111 | 0 | | A0 | 11001111100000 | 0 |
| | A1 | 00111111100001 | 2 | | A1 | 11001100111110 | 4 |
| | A2 | 00111111001100 | 2 | | A2 | 11001110011110 | 4 |
| | A3 | 00111111000110 | 2 | | A3 | 11001111000111 | 4 |
| | A4 | 00111111000011 | 2 | | A4 | 11001111001110 | 4 |
| | A5 | 00111110011100 | 2 | | A5 | 11001111100011 | 4 |
| | A6 | 00111110011001 | 2 | | A6 | 11001111100110 | 4 |

(continued)

Table 3 – 8-14 modulation (CDS≥0) (continued)

| Class | 8-bit data | Modulation codes beginning with "0" | CDS | Class | 8-bit data | Modulation codes beginning with "1" | CDS |
|-------|------------|-------------------------------------|-----|-------|------------|-------------------------------------|-----|
| 2(A) | A7 | 00111110001110 | 2 | 3(B) | A7 | 11100001111110 | 4 |
| | A8 | 00111110000111 | 2 | | A8 | 11100011100111 | 4 |
| | A9 | 001111100111100 | 2 | | A9 | 11100011110011 | 4 |
| | AA | 001111100111001 | 2 | | AA | 11100011111100 | 4 |
| | AB | 001111100110011 | 2 | | AB | 11100110011110 | 4 |
| | AC | 001111100011110 | 2 | | AC | 11100111000111 | 4 |
| | AD | 001111100001111 | 2 | | AD | 11100111001110 | 4 |
| | AE | 001110011111100 | 2 | | AE | 11100111100011 | 4 |
| | AF | 00111001111001 | 2 | | AF | 11100111100110 | 4 |
| | B0 | 00111001110011 | 2 | | B0 | 11100111111000 | 4 |
| | B1 | 00111001100111 | 2 | | B1 | 11100000011111 | 2 |
| | B2 | 00111000111110 | 2 | | B2 | 11100000111110 | 2 |
| | B3 | 00111000011111 | 2 | | B3 | 11100001100111 | 2 |
| | B4 | 00110011111100 | 2 | | B4 | 11100001110011 | 2 |
| | B5 | 00110011111001 | 2 | | B5 | 11100001111001 | 2 |
| | B6 | 00110011110011 | 2 | | B6 | 11100001111100 | 2 |
| | B7 | 00110011100111 | 2 | | B7 | 11100011000111 | 2 |
| | B8 | 00110011001111 | 2 | | B8 | 11100011001110 | 2 |
| | B9 | 00110001111110 | 2 | | B9 | 11100011100011 | 2 |
| | BA | 00110000111111 | 2 | | BA | 11100011100110 | 2 |
| | BB | 00111111100110 | 4 | | BB | 11100011110001 | 2 |
| | BC | 00111111100011 | 4 | | BC | 11100011111000 | 2 |
| | BD | 00111111001110 | 4 | | BD | 11100110000111 | 2 |
| | BE | 00111111000111 | 4 | | BE | 11100110001110 | 2 |
| | BF | 00111111001110 | 4 | | BF | 11100110011001 | 2 |
| | C0 | 00111110001111 | 4 | | C0 | 11100110011100 | 2 |
| | C1 | 00111110011110 | 4 | | C1 | 11100111000011 | 2 |
| | C2 | 00111110001111 | 4 | | C2 | 11100111000110 | 2 |
| | C3 | 00111001111110 | 4 | | C3 | 11100111001100 | 2 |
| | C4 | 00111000111111 | 4 | | C4 | 11100111100001 | 2 |
| | C5 | 00110011111110 | 4 | | C5 | 11100111110000 | 2 |
| 3(A) | C6 | 00011111110000 | 0 | 4(B) | C6 | 11100000001111 | 0 |
| | C7 | 000111111100001 | 0 | | C7 | 11100000001110 | 0 |
| | C8 | 000111111001100 | 0 | | C8 | 11100000110011 | 0 |
| | C9 | 000111111000110 | 0 | | C9 | 11100000111001 | 0 |
| | CA | 000111111000011 | 0 | | CA | 11100000111100 | 0 |
| | CB | 000111110011100 | 0 | | CB | 11100001100011 | 0 |
| | CC | 000111110011001 | 0 | | CC | 11100001100110 | 0 |
| | CD | 000111110001110 | 0 | | CD | 11100001110001 | 0 |
| | CE | 000111110000111 | 0 | | CE | 11100001111000 | 0 |
| | CF | 000111001111100 | 0 | | CF | 11100011000011 | 0 |
| | D0 | 00011100111001 | 0 | | D0 | 11100011000110 | 0 |
| | D1 | 00011100110011 | 0 | | D1 | 11100011001100 | 0 |
| | D2 | 00011100011110 | 0 | | D2 | 11100011100001 | 0 |
| | D3 | 00011100001111 | 0 | | D3 | 11100011110000 | 0 |
| | D4 | 000110011111100 | 0 | | D4 | 11100110000011 | 0 |
| | D5 | 00011001111001 | 0 | | D5 | 11100110000110 | 0 |
| | D6 | 00011001110011 | 0 | | D6 | 11100110001100 | 0 |
| | D7 | 00011001100111 | 0 | | D7 | 11100110011000 | 0 |
| | D8 | 00011000111110 | 0 | | D8 | 11100111000001 | 0 |
| | D9 | 00011000011111 | 0 | | D9 | 11100111100000 | 0 |
| | DA | 00011111110001 | 2 | | DA | 11110001111100 | 4 |
| | DB | 00011111110010 | 2 | | DB | 11110011111000 | 4 |
| | DC | 000111111100011 | 2 | | DC | 11110000001111 | 2 |
| | DD | 000111111001110 | 2 | | DD | 11110000011110 | 2 |

(continued)

Table 3 – 8-14 modulation (CDS \geq 0) (concluded)

| Class | 8-bit data | Modulation codes beginning with "0" | CDS | Class | 8-bit data | Modulation codes beginning with "1" | CDS |
|-------|------------|-------------------------------------|-----|-------|------------|-------------------------------------|-----|
| 3(A) | DE | 00011111000111 | 2 | 4(B) | DE | 11110000110011 | 2 |
| | DF | 00011110011110 | 2 | | DF | 11110000111001 | 2 |
| | E0 | 00011110001111 | 2 | | E0 | 11110000111100 | 2 |
| | E1 | 00011100111110 | 2 | | E1 | 11110001100011 | 2 |
| | E2 | 00011100011111 | 2 | | E2 | 11110001100110 | 2 |
| | E3 | 00011001111110 | 2 | | E3 | 11110001110001 | 2 |
| | E4 | 00011000111111 | 2 | | E4 | 11110001111000 | 2 |
| | E5 | 00011111110011 | 4 | | E5 | 11110011000011 | 2 |
| | E6 | 00011111001111 | 4 | | E6 | 11110011000110 | 2 |
| | E7 | 00011111001111 | 4 | | E7 | 11110011001100 | 2 |
| 4(A) | E8 | 00011110011111 | 4 | | E8 | 11110011100001 | 2 |
| | E9 | 00011100111111 | 4 | | E9 | 11110011110000 | 2 |
| | EA | 00001111111000 | 0 | 5(B) | EA | 11110000000111 | 0 |
| | EB | 00001111110001 | 0 | | EB | 11110000001110 | 0 |
| | EC | 00001111100110 | 0 | | EC | 11110000011001 | 0 |
| | ED | 00001111100011 | 0 | | ED | 11110000011100 | 0 |
| | EE | 00001110011110 | 0 | | EE | 11110000110001 | 0 |
| | EF | 00001111000111 | 0 | | EF | 11110000111000 | 0 |
| | F0 | 00001110011110 | 0 | | F0 | 11110001100001 | 0 |
| | F1 | 00001110001111 | 0 | | F1 | 11110001110000 | 0 |
| | F2 | 00001100111110 | 0 | | F2 | 11110011000001 | 0 |
| | F3 | 00001100011111 | 0 | | F3 | 11110011100000 | 0 |
| | F4 | 00001111111001 | 2 | | F4 | 11111000000111 | 2 |
| | F5 | 00001111110011 | 2 | | F5 | 11111000001110 | 2 |
| | F6 | 00001111100111 | 2 | | F6 | 11111000011001 | 2 |
| | F7 | 00001111001111 | 2 | | F7 | 11111000011100 | 2 |
| | F8 | 00001110011111 | 2 | | F8 | 11111000110001 | 2 |
| 5(A) | F9 | 00001100111111 | 2 | | F9 | 11111000111000 | 2 |
| | FA | 00000111111100 | 0 | | FA | 11111001100001 | 2 |
| | FB | 00000111111001 | 0 | | FB | 11111001110000 | 2 |
| | FC | 00000111110011 | 0 | | FC | 11111000001100 | 0 |
| | FD | 00000111100111 | 0 | | FD | 11111000011000 | 0 |
| | FE | 00000111001111 | 0 | | FE | 11111000110000 | 0 |
| | FF | 00000110011111 | 0 | | FF | 11111001100000 | 0 |

Table 4 – 8-14 modulation (CDS≤0)

| Class | 8-bit data | Modulation codes beginning with "0" | CDS | Class | 8-bit data | Modulation codes beginning with "1" | CDS |
|-------|------------|-------------------------------------|-----|-------|------------|-------------------------------------|-----|
| 1(C) | 00 | 01111110000001 | 0 | 1(D) | 00 | 10000001111110 | 0 |
| | 01 | 01111100110000 | 0 | | 01 | 10000011001111 | 0 |
| | 02 | 01111100011000 | 0 | | 02 | 10000011100111 | 0 |
| | 03 | 01111100001100 | 0 | | 03 | 10000011110011 | 0 |
| | 04 | 01111100000110 | 0 | | 04 | 10000011111001 | 0 |
| | 05 | 01111100000011 | 0 | | 05 | 10000011111100 | 0 |
| | 06 | 01111001110000 | 0 | | 06 | 10000110001111 | 0 |
| | 07 | 01111001100001 | 0 | | 07 | 10000110011110 | 0 |
| | 08 | 01111000111000 | 0 | | 08 | 10000111000111 | 0 |
| | 09 | 01111000110001 | 0 | | 09 | 10000111001110 | 0 |
| | 0A | 01111000011100 | 0 | | 0A | 10000111100011 | 0 |
| | 0B | 01111000011001 | 0 | | 0B | 10000111100110 | 0 |
| | 0C | 01111000001110 | 0 | | 0C | 10000111110001 | 0 |
| | 0D | 01111000000111 | 0 | | 0D | 10000111111000 | 0 |
| | 0E | 01110011110000 | 0 | | 0E | 10001100001111 | 0 |
| | 0F | 01110011100001 | 0 | | 0F | 10001100011110 | 0 |
| | 10 | 01110011001100 | 0 | | 10 | 10001100110011 | 0 |
| | 11 | 01110011000110 | 0 | | 11 | 10001100111001 | 0 |
| | 12 | 01110011000011 | 0 | | 12 | 10001100111100 | 0 |
| | 13 | 01110001111000 | 0 | | 13 | 10001110000111 | 0 |
| | 14 | 01110001110001 | 0 | | 14 | 10001110001110 | 0 |
| | 15 | 01110001100110 | 0 | | 15 | 10001110011001 | 0 |
| | 16 | 01110001100011 | 0 | | 16 | 10001110011100 | 0 |
| | 17 | 01110000111100 | 0 | | 17 | 10001111000011 | 0 |
| | 18 | 01110000111001 | 0 | | 18 | 10001111000110 | 0 |
| | 19 | 01110000110011 | 0 | | 19 | 10001111001100 | 0 |
| | 1A | 01110000011110 | 0 | | 1A | 10001111100001 | 0 |
| | 1B | 01110000001111 | 0 | | 1B | 10001111110000 | 0 |
| | 1C | 01100111110000 | 0 | | 1C | 10011000001111 | 0 |
| | 1D | 01100111100001 | 0 | | 1D | 10011000011110 | 0 |
| | 1E | 01100111001100 | 0 | | 1E | 10011000110011 | 0 |
| | 1F | 01100111000110 | 0 | | 1F | 10011000111001 | 0 |
| | 20 | 01100111000011 | 0 | | 20 | 10011000111100 | 0 |
| | 21 | 01100110011100 | 0 | | 21 | 10011001100011 | 0 |
| | 22 | 01100110011001 | 0 | | 22 | 10011001100110 | 0 |
| | 23 | 01100110001110 | 0 | | 23 | 10011001110001 | 0 |
| | 24 | 01100110000111 | 0 | | 24 | 10011001111000 | 0 |
| | 25 | 01100011111000 | 0 | | 25 | 10011100000111 | 0 |
| | 26 | 01100011110001 | 0 | | 26 | 10011100001110 | 0 |
| | 27 | 01100011100110 | 0 | | 27 | 10011100011001 | 0 |
| | 28 | 01100011100011 | 0 | | 28 | 10011100011100 | 0 |
| | 29 | 01100011001110 | 0 | | 29 | 10011100110001 | 0 |
| | 2A | 01100011000111 | 0 | | 2A | 10011100111000 | 0 |
| | 2B | 01100001111100 | 0 | | 2B | 10011110000011 | 0 |
| | 2C | 01100001111001 | 0 | | 2C | 10011110000110 | 0 |
| | 2D | 01100001110011 | 0 | | 2D | 10011110001100 | 0 |
| | 2E | 01100001100111 | 0 | | 2E | 10011110011000 | 0 |
| | 2F | 01100000111110 | 0 | | 2F | 10011111000001 | 0 |
| | 30 | 01100000011111 | 0 | | 30 | 10011111100000 | 0 |
| | 31 | 01111100000001 | -2 | | 31 | 10000000110011 | -4 |
| | 32 | 01111001100000 | -2 | | 32 | 10000000111001 | -4 |
| | 33 | 01111000110000 | -2 | | 33 | 10000000111100 | -4 |
| | 34 | 01111000011000 | -2 | | 34 | 10000001100011 | -4 |
| | 35 | 01111000001100 | -2 | | 35 | 10000001100110 | -4 |
| | 36 | 01111000000110 | -2 | | 36 | 10000001110001 | -4 |
| | 37 | 01111000000011 | -2 | | 37 | 10000001111000 | -4 |
| | 38 | 01110011100000 | -2 | | 38 | 10000011000011 | -4 |

(continued)

Table 4 – 8-14 modulation (CDS≤0) (continued)

| Class | 8-bit data | Modulation codes beginning with "0" | CDS | Class | 8-bit data | Modulation codes beginning with "1" | CDS |
|-------|------------|-------------------------------------|-----|-------|------------|-------------------------------------|-----|
| 1(C) | 39 | 01110011000001 | -2 | 1(D) | 39 | 10000011000110 | -4 |
| | 3A | 01110001110000 | -2 | | 3A | 10000011001100 | -4 |
| | 3B | 01110001100001 | -2 | | 3B | 10000011100001 | -4 |
| | 3C | 01110000111000 | -2 | | 3C | 10000011110000 | -4 |
| | 3D | 01110000110001 | -2 | | 3D | 10000110000011 | -4 |
| | 3E | 01110000011100 | -2 | | 3E | 10000110000110 | -4 |
| | 3F | 01110000011001 | -2 | | 3F | 10000110001100 | -4 |
| | 40 | 01110000001110 | -2 | | 40 | 10000110011000 | -4 |
| | 41 | 01110000000111 | -2 | | 41 | 10000111000001 | -4 |
| | 42 | 01100111100000 | -2 | | 42 | 10000111100000 | -4 |
| | 43 | 01100111000001 | -2 | | 43 | 10001100000011 | -4 |
| | 44 | 01100110011000 | -2 | | 44 | 10001100000110 | -4 |
| | 45 | 01100110001100 | -2 | | 45 | 10001100001100 | -4 |
| | 46 | 01100110000110 | -2 | | 46 | 10001100011000 | -4 |
| | 47 | 01100110000011 | -2 | | 47 | 10001100110000 | -4 |
| | 48 | 01100011110000 | -2 | | 48 | 10001110000001 | -4 |
| | 49 | 01100011100001 | -2 | | 49 | 10001111000000 | -4 |
| | 4A | 01100011001100 | -2 | | 4A | 10011000000011 | -4 |
| | 4B | 01100011000110 | -2 | | 4B | 10011000000110 | -4 |
| | 4C | 01100011000011 | -2 | | 4C | 10011000001100 | -4 |
| | 4D | 01100001111000 | -2 | | 4D | 10011000011000 | -4 |
| | 4E | 01100001110001 | -2 | | 4E | 10011000110000 | -4 |
| | 4F | 01100001100110 | -2 | | 4F | 10011001100000 | -4 |
| | 50 | 01100001100011 | -2 | | 50 | 10011100000001 | -4 |
| | 51 | 01100000111100 | -2 | | 51 | 10000000111110 | -2 |
| | 52 | 01100000111001 | -2 | | 52 | 10000001100111 | -2 |
| | 53 | 01100000110011 | -2 | | 53 | 10000001110011 | -2 |
| | 54 | 01100000011110 | -2 | | 54 | 10000001111001 | -2 |
| | 55 | 01100000001111 | -2 | | 55 | 10000001111100 | -2 |
| | 56 | 01110000110000 | -4 | | 56 | 10000011000111 | -2 |
| | 57 | 01110000011000 | -4 | | 57 | 10000011001110 | -2 |
| | 58 | 01110000001100 | -4 | | 58 | 10000011100011 | -2 |
| | 59 | 01100110000001 | -4 | | 59 | 10000011100110 | -2 |
| | 5A | 01100011000001 | -4 | | 5A | 10000011110001 | -2 |
| | 5B | 01100001110000 | -4 | | 5B | 10000011111000 | -2 |
| | 5C | 01100001100001 | -4 | | 5C | 10000110000111 | -2 |
| | 5D | 01100000111000 | -4 | | 5D | 10000110001110 | -2 |
| | 5E | 01100000110001 | -4 | | 5E | 10000110011001 | -2 |
| | 5F | 01100000011100 | -4 | | 5F | 10000110011100 | -2 |
| | 60 | 01100000011001 | -4 | | 60 | 10000111000011 | -2 |
| | 61 | 00111000011000 | -4 | | 61 | 10000111000110 | -2 |
| 2(C) | 62 | 00111000001100 | -4 | | 62 | 10000111001100 | -2 |
| | 63 | 00111111000000 | -2 | | 63 | 10000111100001 | -2 |
| | 64 | 00111110000001 | -2 | | 64 | 10000111110000 | -2 |
| | 65 | 00111100110000 | -2 | | 65 | 10001100000111 | -2 |
| | 66 | 00111100011000 | -2 | | 66 | 10001100001110 | -2 |
| | 67 | 00111100001100 | -2 | | 67 | 10001100011001 | -2 |
| | 68 | 00111100000110 | -2 | | 68 | 10001100011100 | -2 |
| | 69 | 00111100000011 | -2 | | 69 | 10001100110001 | -2 |
| | 6A | 00111001110000 | -2 | | 6A | 10001100111000 | -2 |
| | 6B | 00111001100001 | -2 | | 6B | 10001110000011 | -2 |
| | 6C | 00111000111000 | -2 | | 6C | 10001110000110 | -2 |
| | 6D | 00111000110001 | -2 | | 6D | 10001110001100 | -2 |
| | 6E | 00111000011100 | -2 | | 6E | 10001110011000 | -2 |
| | 6F | 00111000011001 | -2 | | 6F | 10001111000001 | -2 |
| | 70 | 00111000001110 | -2 | | 70 | 10001111100000 | -2 |

(continued)

Table 4 – 8-14 modulation (CDS≤0) (continued)

| Class | 8-bit data | Modulation codes beginning with "0" | CDS | Class | 8-bit data | Modulation codes beginning with "1" | CDS |
|-------|------------|-------------------------------------|-----|-------|------------|-------------------------------------|-----|
| 2(C) | 71 | 00111000000111 | -2 | 1(D) | 71 | 10011000000111 | -2 |
| | 72 | 00110011110000 | -2 | | 72 | 10011000001110 | -2 |
| | 73 | 00110011100001 | -2 | | 73 | 10011000011001 | -2 |
| | 74 | 00110011001100 | -2 | | 74 | 10011000011100 | -2 |
| | 75 | 00110011000110 | -2 | | 75 | 10011000110001 | -2 |
| | 76 | 00110011000011 | -2 | | 76 | 10011000111000 | -2 |
| | 77 | 00110001111000 | -2 | | 77 | 10011001100001 | -2 |
| | 78 | 00110001110001 | -2 | | 78 | 10011001110000 | -2 |
| | 79 | 00110001100110 | -2 | | 79 | 10011100000011 | -2 |
| | 7A | 00110001100011 | -2 | | 7A | 10011100000110 | -2 |
| | 7B | 00110000111100 | -2 | | 7B | 10011100001100 | -2 |
| | 7C | 00110000111001 | -2 | | 7C | 10011100011000 | -2 |
| | 7D | 00110000110011 | -2 | | 7D | 10011100110000 | -2 |
| | 7E | 00110000011110 | -2 | | 7E | 10011110000001 | -2 |
| | 7F | 00110000001111 | -2 | | 7F | 10011111000000 | -2 |
| | 80 | 00111111100000 | 0 | 2(D) | 80 | 11000000011111 | 0 |
| | 81 | 00111111000001 | 0 | | 81 | 11000000111110 | 0 |
| | 82 | 00111110011000 | 0 | | 82 | 11000001100111 | 0 |
| | 83 | 00111110001100 | 0 | | 83 | 11000001110011 | 0 |
| | 84 | 00111110000110 | 0 | | 84 | 11000001111001 | 0 |
| | 85 | 00111110000011 | 0 | | 85 | 11000001111100 | 0 |
| | 86 | 00111100111000 | 0 | | 86 | 11000011000111 | 0 |
| | 87 | 00111100110001 | 0 | | 87 | 11000011001110 | 0 |
| | 88 | 00111100011100 | 0 | | 88 | 11000011100011 | 0 |
| | 89 | 00111100011001 | 0 | | 89 | 11000011100110 | 0 |
| | 8A | 00111100001110 | 0 | | 8A | 11000011110001 | 0 |
| | 8B | 00111100000111 | 0 | | 8B | 11000011111000 | 0 |
| | 8C | 00111001111000 | 0 | | 8C | 11000110000111 | 0 |
| | 8D | 00111001110001 | 0 | | 8D | 11000110001110 | 0 |
| | 8E | 00111001100110 | 0 | | 8E | 11000110011001 | 0 |
| | 8F | 00111001100011 | 0 | | 8F | 11000110011100 | 0 |
| | 90 | 00111000111100 | 0 | | 90 | 11000111000011 | 0 |
| | 91 | 00111000111001 | 0 | | 91 | 11000111000110 | 0 |
| | 92 | 00111000110011 | 0 | | 92 | 11000111001100 | 0 |
| | 93 | 00111000011110 | 0 | | 93 | 11000111100001 | 0 |
| | 94 | 00111000001111 | 0 | | 94 | 11000111110000 | 0 |
| | 95 | 00110011111000 | 0 | | 95 | 11001100000111 | 0 |
| | 96 | 00110011110001 | 0 | | 96 | 11001100001110 | 0 |
| | 97 | 00110011100110 | 0 | | 97 | 11001100011001 | 0 |
| | 98 | 00110011100011 | 0 | | 98 | 11001100011100 | 0 |
| | 99 | 00110011001110 | 0 | | 99 | 11001100110001 | 0 |
| | 9A | 00110011000111 | 0 | | 9A | 11001100111000 | 0 |
| | 9B | 00110001111100 | 0 | | 9B | 11001110000011 | 0 |
| | 9C | 00110001111001 | 0 | | 9C | 11001110000110 | 0 |
| | 9D | 00110001110011 | 0 | | 9D | 11001110001100 | 0 |
| | 9E | 00110001100111 | 0 | | 9E | 11001110011000 | 0 |
| | 9F | 00110000111110 | 0 | | 9F | 11001111000001 | 0 |
| | A0 | 00110000011111 | 0 | | A0 | 11001111100000 | 0 |
| | A1 | 00110011000001 | -4 | | A1 | 11000000011110 | -2 |
| | A2 | 00110001100001 | -4 | | A2 | 11000000110011 | -2 |
| | A3 | 00110000111000 | -4 | | A3 | 11000000111001 | -2 |
| | A4 | 00110000110001 | -4 | | A4 | 11000000111100 | -2 |
| | A5 | 00110000011100 | -4 | | A5 | 11000001100011 | -2 |
| | A6 | 00110000011001 | -4 | | A6 | 11000001100110 | -2 |

(continued)

Table 4 – 8-14 modulation (CDS≤0) (continued)

| Class | 8-bit data | Modulation codes beginning with "0" | CDS | Class | 8-bit data | Modulation codes beginning with "1" | CDS |
|-------|------------|-------------------------------------|-----|-------|------------|-------------------------------------|-----|
| 3(C) | A7 | 00011110000001 | -4 | 2(D) | A7 | 11000001110001 | -2 |
| | A8 | 000111100011000 | -4 | | A8 | 11000001111000 | -2 |
| | A9 | 000111100001100 | -4 | | A9 | 11000011000011 | -2 |
| | AA | 000111100000011 | -4 | | AA | 11000011000110 | -2 |
| | AB | 00011001100001 | -4 | | AB | 11000011001100 | -2 |
| | AC | 00011000111000 | -4 | | AC | 11000011100001 | -2 |
| | AD | 00011000110001 | -4 | | AD | 11000011110000 | -2 |
| | AE | 00011000011100 | -4 | | AE | 11000110000011 | -2 |
| | AF | 00011000011001 | -4 | | AF | 11000110000110 | -2 |
| | B0 | 00011000000111 | -4 | | B0 | 11000110001100 | -2 |
| | B1 | 00011111100000 | -2 | | B1 | 11000110011000 | -2 |
| | B2 | 00011111000001 | -2 | | B2 | 11000111000001 | -2 |
| | B3 | 00011110011000 | -2 | | B3 | 11000111100000 | -2 |
| | B4 | 00011110001100 | -2 | | B4 | 11001100000011 | -2 |
| | B5 | 00011110000110 | -2 | | B5 | 11001100000110 | -2 |
| | B6 | 00011110000011 | -2 | | B6 | 11001100001100 | -2 |
| | B7 | 00011100111000 | -2 | | B7 | 11001100011000 | -2 |
| | B8 | 00011100110001 | -2 | | B8 | 11001100110000 | -2 |
| | B9 | 00011100011100 | -2 | | B9 | 11001110000001 | -2 |
| | BA | 00011100011001 | -2 | | BA | 11001111000000 | -2 |
| | BB | 00011100001110 | -2 | | BB | 11000000011001 | -4 |
| | BC | 00011100000111 | -2 | | BC | 11000000011100 | -4 |
| | BD | 00011001111000 | -2 | | BD | 11000000110001 | -4 |
| | BE | 00011001110001 | -2 | | BE | 11000000111000 | -4 |
| | BF | 00011001100110 | -2 | | BF | 11000001100001 | -4 |
| | C0 | 00011001100011 | -2 | | C0 | 11000001110000 | -4 |
| | C1 | 00011000111100 | -2 | | C1 | 11000011000001 | -4 |
| | C2 | 00011000111001 | -2 | | C2 | 11000011100000 | -4 |
| | C3 | 00011000110011 | -2 | | C3 | 11000110000001 | -4 |
| | C4 | 00011000011110 | -2 | | C4 | 11000111000000 | -4 |
| | C5 | 00011000001111 | -2 | | C5 | 11001100000001 | -4 |
| 3(D) | C6 | 00011111110000 | 0 | 3(D) | C6 | 11100000001111 | 0 |
| | C7 | 00011111100001 | 0 | | C7 | 11100000011110 | 0 |
| | C8 | 00011111001100 | 0 | | C8 | 11100000110011 | 0 |
| | C9 | 00011111000110 | 0 | | C9 | 11100000111001 | 0 |
| | CA | 00011111000011 | 0 | | CA | 11100000111100 | 0 |
| | CB | 00011110011100 | 0 | | CB | 11100001100011 | 0 |
| | CC | 00011110011001 | 0 | | CC | 11100001100110 | 0 |
| | CD | 00011110001110 | 0 | | CD | 11100001110001 | 0 |
| | CE | 00011110000111 | 0 | | CE | 11100001111000 | 0 |
| | CF | 00011100111100 | 0 | | CF | 11100011000011 | 0 |
| | D0 | 00011100111001 | 0 | | D0 | 11100011000110 | 0 |
| | D1 | 00011100110011 | 0 | | D1 | 11100011001100 | 0 |
| | D2 | 00011100011110 | 0 | | D2 | 11100011100001 | 0 |
| | D3 | 00011100001111 | 0 | | D3 | 11100011110000 | 0 |
| | D4 | 00011001111100 | 0 | | D4 | 11100110000011 | 0 |
| | D5 | 00011001111001 | 0 | | D5 | 11100110000110 | 0 |
| | D6 | 00011001110011 | 0 | | D6 | 11100110001100 | 0 |
| | D7 | 00011001100111 | 0 | | D7 | 11100110011000 | 0 |
| | D8 | 00011000111110 | 0 | | D8 | 11100111000001 | 0 |
| | D9 | 00011000011111 | 0 | | D9 | 11100111100000 | 0 |
| 4(C) | DA | 00001110000011 | -4 | 4(C) | DA | 11100000001110 | -2 |
| | DB | 00001100000011 | -4 | | DB | 11100000011001 | -2 |
| | DC | 00001111110000 | -2 | | DC | 11100000011100 | -2 |
| | DD | 00001111100001 | -2 | | DD | 11100000110001 | -2 |

(continued)

Table 4 – 8-14 modulation (CDS≤0) (concluded)

| Class | 8-bit data | Modulation codes beginning with "0" | CDS | Class | 8-bit data | Modulation codes beginning with "1" | CDS |
|-------|------------|-------------------------------------|-----|-------|------------|-------------------------------------|-----|
| 4(C) | DE | 00001111001100 | -2 | 3(D) | DE | 11100000111000 | -2 |
| | DF | 00001111000110 | -2 | | DF | 11100001100001 | -2 |
| | E0 | 00001111000011 | -2 | | E0 | 11100001110000 | -2 |
| | E1 | 00001110011100 | -2 | | E1 | 11100011000001 | -2 |
| | E2 | 00001110011001 | -2 | | E2 | 11100011100000 | -2 |
| | E3 | 00001110001110 | -2 | | E3 | 11100110000001 | -2 |
| | E4 | 00001110000111 | -2 | | E4 | 11100111000000 | -2 |
| | E5 | 00001100111100 | -2 | | E5 | 11100000011100 | -4 |
| | E6 | 00001100111001 | -2 | | E6 | 11100000011000 | -4 |
| | E7 | 00001100110011 | -2 | | E7 | 11100000110000 | -4 |
| | E8 | 00001100011110 | -2 | | E8 | 11100001100000 | -4 |
| | E9 | 00001100001111 | -2 | | E9 | 11100011000000 | -4 |
| | EA | 00001111111000 | 0 | 4(D) | EA | 11110000000111 | 0 |
| | EB | 00001111110001 | 0 | | EB | 11110000001110 | 0 |
| | EC | 00001111100110 | 0 | | EC | 11110000011001 | 0 |
| | ED | 00001111100011 | 0 | | ED | 11110000011100 | 0 |
| | EE | 00001111001110 | 0 | | EE | 11110000110001 | 0 |
| | EF | 00001111000111 | 0 | | EF | 11110000111000 | 0 |
| | F0 | 00001110011110 | 0 | | F0 | 11110001100001 | 0 |
| | F1 | 00001110001111 | 0 | | F1 | 11110001110000 | 0 |
| | F2 | 00001100111110 | 0 | | F2 | 11110011000001 | 0 |
| | F3 | 00001100011111 | 0 | | F3 | 11110011100000 | 0 |
| 5(C) | F4 | 00000111111000 | -2 | | F4 | 11110000000110 | -2 |
| | F5 | 00000111110001 | -2 | | F5 | 11110000001100 | -2 |
| | F6 | 00000111100110 | -2 | | F6 | 11110000011000 | -2 |
| | F7 | 00000111100011 | -2 | | F7 | 11110000110000 | -2 |
| | F8 | 00000111001110 | -2 | | F8 | 11110001100000 | -2 |
| | F9 | 00000111000111 | -2 | | F9 | 11110011000000 | -2 |
| | FA | 00000110011110 | -2 | 5(D) | FA | 11111000000011 | 0 |
| | FB | 00000110001111 | -2 | | FB | 11111000000110 | 0 |
| | FC | 00000111110011 | 0 | | FC | 11111000001100 | 0 |
| | FD | 00000111100111 | 0 | | FD | 11111000011000 | 0 |
| | FE | 00000111001111 | 0 | | FE | 11111000110000 | 0 |
| | FF | 00000110011111 | 0 | | FF | 11111001100000 | 0 |

Table 5 – Priority of modulation code selection (end DSV = –2)

| Modulation codes | Priority |
|--|----------|
| x x x x x x x x x x 0 0 1 | 4 |
| x x x x x x x x x x 0 0 1 1 | 1 |
| x x x x x x x x x x 0 0 1 1 1 | 2 |
| x x x x x x x x 0 0 1 1 1 1 | 3 |
| x x x x x x x 0 0 1 1 1 1 1 | 8 |
| x x x x x x x x x x x 1 1 0 | 10 |
| x x x x x x x x x x 1 1 0 0 | 5 |
| x x x x x x x x 1 1 0 0 0 | 6 |
| x x x x x x x 1 1 0 0 0 0 | 7 |
| x x x x x x 1 1 0 0 0 0 0 | 9 |
| x x x x x 1 1 0 0 0 0 0 0 | 11 |
| NOTES 1 "x" is a don't-care bit. (default value is meaningless) 2 This table shall be used in the case where DSV at the end of modulation code is –2 | |

Table 6 – Priority of modulation code selection (end DSV = +2)

| Modulation codes | Priority |
|--|----------|
| x x x x x x x x x x 1 1 0 | 4 |
| x x x x x x x x x x 1 1 0 0 | 1 |
| x x x x x x x x x 1 1 0 0 0 | 2 |
| x x x x x x x x 1 1 0 0 0 0 | 3 |
| x x x x x x x 1 1 0 0 0 0 0 | 8 |
| x x x x x x x x x x x 0 0 1 | 10 |
| x x x x x x x x x x 0 0 1 1 | 5 |
| x x x x x x x x 0 0 1 1 1 | 6 |
| x x x x x x x 0 0 1 1 1 1 | 7 |
| x x x x x x 0 0 1 1 1 1 1 | 9 |
| x x x x x 0 0 1 1 1 1 1 1 | 11 |
| NOTES 1 "x" is a don't-care bit. (default value is meaningless). 2 This table shall be used in the case where DSV at the end of modulation code is +2. | |

The recorded data rate (for the scanner configuration defined in 5.6) and shortest recorded wavelength are given in table 7, provided for reference only.

Table 7 – Data rate and wavelength

| Parameter | 1080/59.94i 720/59.94p system | 1080/50i 1080/25p system | 1080/24p system | 1080/23.98p system |
|---------------------------------|-------------------------------------|--------------------------------|--------------------|-----------------------|
| Total average data rate | 322.97 Mb/s | 269.41 Mb/s | 258.64 Mb/s | 258.38 Mb/s |
| Instantaneous channel data rate | 82.2 Mb/s | 68.5 Mb/s | 65.7 Mb/s | 65.7 Mb/s |
| Shortest recorded wavelength | 0.59 μm | 0.59 μm | 0.59 μm | 0.59 μm |

6.6 Magnetization

6.6.1 Polarity

Reproduction of the tape record shall be without regard to the polarity of the recorded flux on the helical tracks.

6.6.2 Recorded equalization

The record head current applied to a head should generate a constant magnetic flux level within a gap from the lowest recorded frequency (i.e. approximately one-third the Nyquist frequency) to the Nyquist frequency.

6.6.3 Record level

The level of the record head current applied to a head with a gap should be optimized for best reproduced signal-to-noise ratio at the highest constant recorded frequency (i.e. the Nyquist frequency of the channel). Other methods of setting the record level are permitted, providing they achieve the same results.

7 Video interface (informative)

The video signal is compressed in compliance with SMPTE 342M and formatted into the recording stream. Figure D.1 shows the relationship between the recording format (this document) and other format on the recorder. Annex D describes the video interface.

8 Audio data interface (informative)

The audio data interface for serial digital input shall conform to AES3 and for embedded AES3 audio data shall conform to SMPTE 299M.

8.1 Encoding parameters

Figure 15 shows the data flow of sampled audio data for each field rate and data structure for encoded audio data and auxiliary data. Signal processing of the standard is based on the field as shown in figure 16 and the audio data flow shown in figure 15 is classified by the field for convenience.

The digital audio data signal is encoded according to the following parameters:

8.1.1 Sampling

a) The audio sampling frequency is 48.000 kHz and shall be related to the video horizontal frequency as follows:

$$\begin{aligned}
 48 \text{ kHz} &= F_H \times 8008 / 5625 \quad (1080/59.94i \text{ system}); \\
 48 \text{ kHz} &= F_H \times 2002 / 1875 \quad (720/59.94p \text{ system}); \\
 48 \text{ kHz} &= F_H \times 128 / 75 \quad (1080/50i \text{ system}); \\
 48 \text{ kHz} &= F_H \times 128 / 75 \quad (1080/25p \text{ system}); \\
 48 \text{ kHz} &= F_H \times 16 / 9 \quad (1080/24p \text{ system}); \\
 48 \text{ kHz} &= F_H \times 2002 / 1125 \quad (1080/23.98p \text{ system}).
 \end{aligned}$$

b) The resolution of each sample is 20 bits minimum, 24 bits maximum.

c) The coding is two's complement linear PCM.

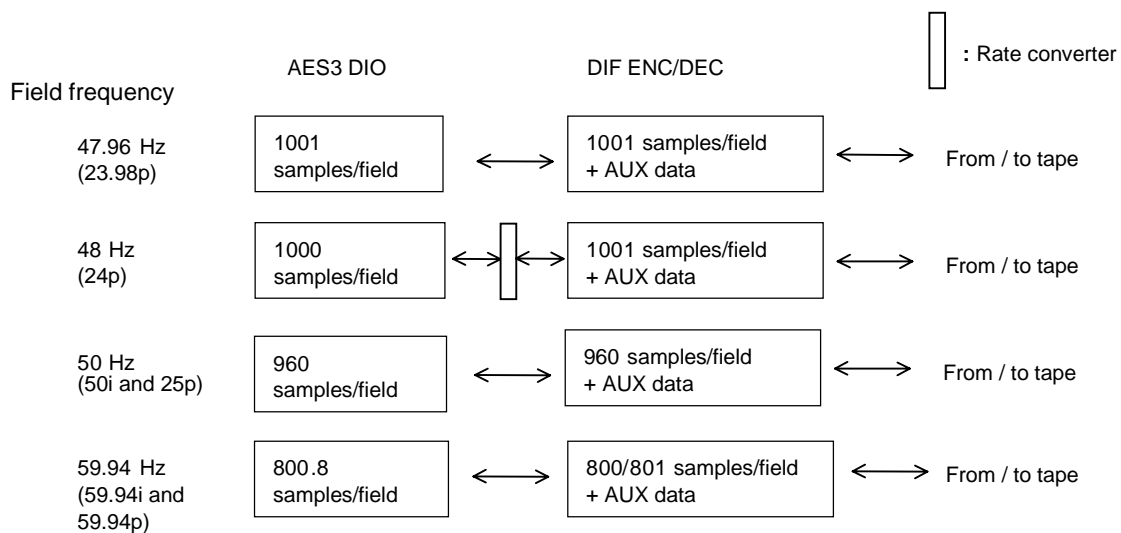


Figure 15 – AES3 audio data flow

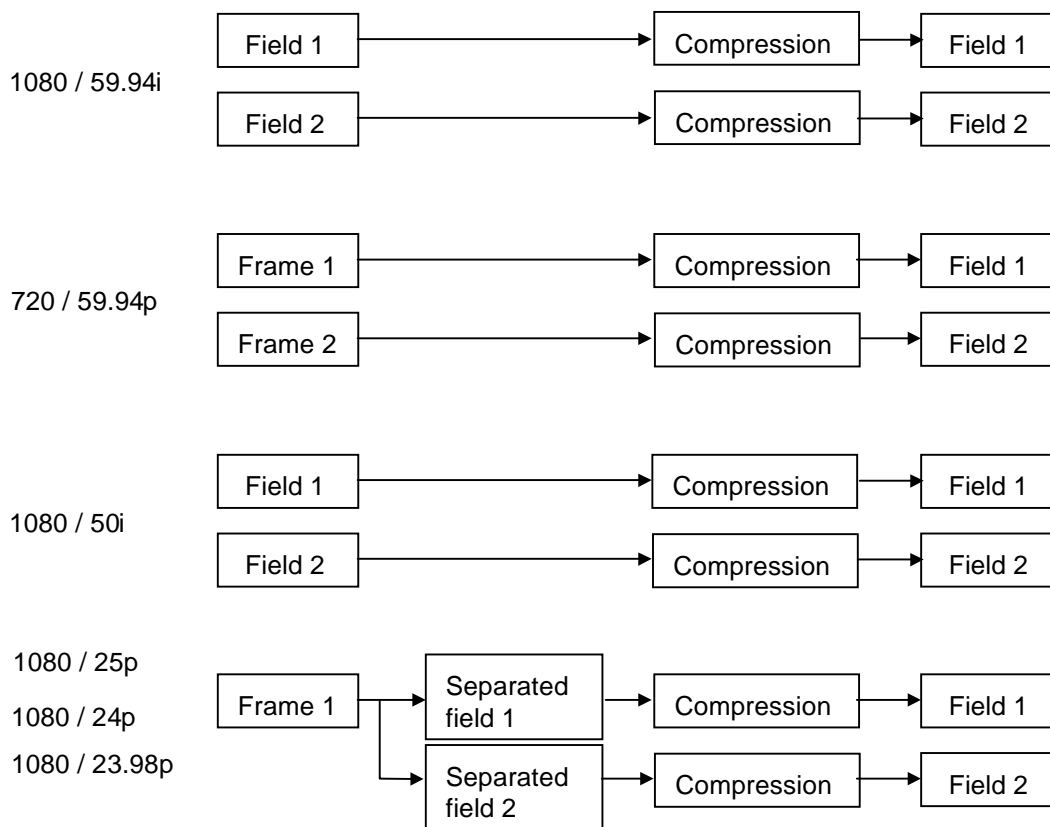


Figure 16 – Relationship between video signal and recorded data (informative)

8.1.2 Reference level

The recommended recorded audio data levels should conform to SMPTE RP 155.

8.2 Digital signal interface

The audio data signal may be input and output digitally in a bit-serial form. The bit-serial interface, if present, shall conform to AES3 without error checking.

9 Compressed video data processing

9.1 Introduction

The purpose of the compressed video processing operation is to transform the HD video compressed data into a form suitable for tape recording.

The HD video compressed data are re-configured and supplemented with the signal format information, and are distributed into 12 compressed video data blocks (4 channels, each channel with 3 compressed video data blocks).

For the data, randomization, column shuffling, outer error correction code addition, and interleaving operations are performed.

The ID is multiplexed with the interleaved data and applied to the Inner error correction coder. A sync word is added to each code block to form a sync block, the smallest data block.

Prior to recording, randomization and 8–14 conversion are performed.

9.2 Recorded data

9.2.1 Reconfiguration of DIF data

The HD compressed video data is composed of 5760 DIF blocks and each DIF block is composed of 85 bytes of data, defined in SMPTE 342M.

Each data $D(DN, BN)$ of DIF blocks are reconfigured into a matrix as data $P(S, L, H)$ (Where $S=0, 1, 2, 3$; $L = 0, 1, \dots, 254$; $H = 0, 1, \dots, 959$) as shown in figure 17.

The rule of reconfiguration is described as:

$$\begin{aligned} S &= (85 \times DN + BN) \bmod 4 \\ L &= (\text{int}((85 \times DN + BN) / 4)) \bmod 255 \\ H &= 8 \times ((\text{int}(DN/12)) \bmod 120) + 2 \times (\text{int}(DN/1440)) + \text{int}(S/3) \end{aligned}$$

where DN : DIF block number ($DN = 0, 1, \dots, 5759$)

BN : Byte location number in DIF block ($BN = 0, 1, \dots, 84$)

9.2.2 Signal format information

To identify the signal format, the signal format Information shown in table 8 replaces the following five data. $P(0,0,0)$ and $P(1,0,0)$ are replaced by byte 0 of signal format information. $P(3,0,1)$ is replaced by byte 1; $P(1,0,2)$ is replaced by byte 2; $P(3,0,3)$ is replaced by byte 3 of the signal format information. These data exist at the first part of $L = 0$.

If the remaining data P(S,0,H) of L=0 is not filled by other data, the rest of P(1,0,H) and P(3,0,H) shall be set to 10_h, and the rest of P(0,0,H) and P(2,0,H) shall be set to 80_h.

Table 8 – Signal format information

| | Byte 0 | Byte 1 | Byte 2 | Byte 3 |
|-------------|--------|--------|--------|--------|
| 1080/59.94i | 21 h | 02 h | 02 h | 20 h |
| 720/59.94p | 23 h | 01 h | 02 h | 20 h |
| 1080/50i | 24 h | 01 h | 02 h | 20 h |
| 1080/25p | 27 h | 01 h | 02 h | 20 h |
| 1080/24p | 28 h | 01 h | 02 h | 20 h |
| 1080/23.98p | 28 h | 02 h | 02 h | 20 h |

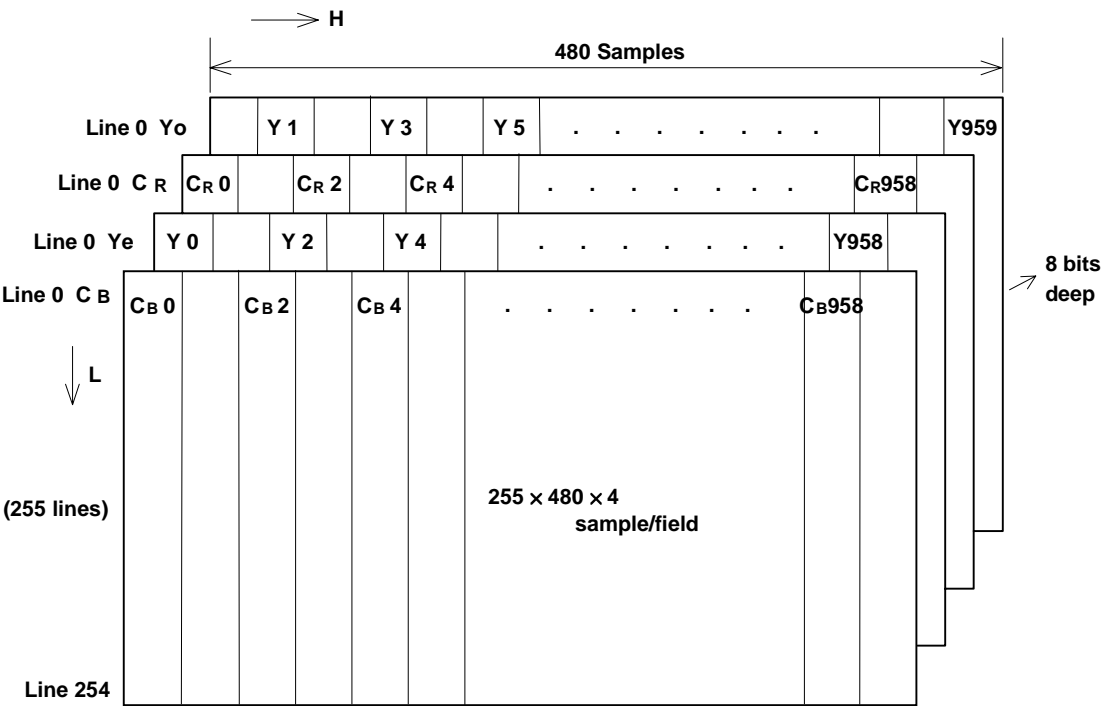


Figure 17 – Reconfigured data

9.3 Channel and compressed video block distribution

The data $P(S,L,H)$ shall be distributed by channel and segment as follows:

The actual index for channel distribution (Ch) and compressed video data block distribution (Vblk) is indicated below:

$$\text{Ch} = \{\text{int} (H/2)\} \bmod 4,$$

$$\text{Vblk} = \text{int} (H/320)$$

Spls means the data position of the horizontal direction of figure 18.

$$\text{Spls} = \{\text{int} (H/8)\} \bmod 40$$

where

$$\text{Spls} = 0, 1, 2, \dots, 39$$

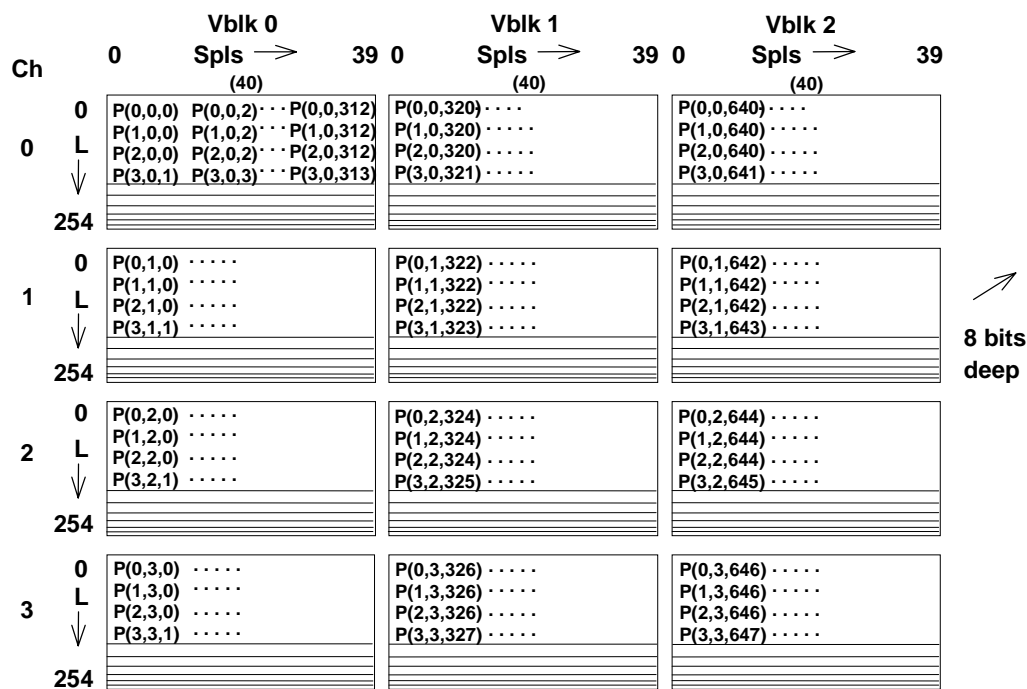


Figure 18 – Channel and compressed video data block distribution

9.4 Word data arrangement

Each data word consists of 8 bits.

Let O_c ($= 0, 1, 2, 3$) be the outer code number.

$O_c = 0$: for $S=0$

$O_c = 1$: for $S=2$

$O_c = 2$: for $S=1$

$O_c = 3$: for $S=3$

Let $Splo$ be the sample number within an outer code block.

$$Splo = 40 \times Vblk + Spls$$

$$Splo = 0, 1, \dots, 119$$

9.5 Compressed video data randomization

Compressed video data randomization is performed to further reduce the direct current content of the compressed video data stream. It is done prior to the integration of the outer code. Each compressed video data word (byte) is replaced by a new word produced by an exclusive-OR operation between the original word and a random word. The random words are serial-to-parallel converted words (LSB-first order) from the random serial bit stream generated by the following polynomial function:

$$x^8 + x^4 + x^3 + x^2 + 1, \text{ (in GF(2))}$$

The random bit stream shall be pre-set to the following value for each outer code block:

$$M0 = 128 + (L \bmod 128)$$

The next word of the random bit stream shall be exclusive-OR operated to the 1st word of the outer code block.

9.6 Outer error protection

Eight rows of each compressed video data field data array contain the error correction check data associated with each column of 8-bit bytes.

Type: Reed-Solomon.

Galois field: GF(256).

Field generator polynomial: $x^8 + x^4 + x^3 + x^2 + 1$,
where x^i are place-keeping variables in GF(2), the binary field.

Order of use: The left-most term is most significant, and oldest in time computationally.

Code Generator Polynomial in GF(256):

$$G(x) = (x+1)(x+a)(x+a^2)(x+a^3)(x+a^4)(x+a^5)(x+a^6)(x+a^7),$$

where a is given by 02h in GF(256).

Check characters: $K_7, K_6, K_5, K_4, K_3, K_2, K_1, K_0$ in $K_7x^7 + K_6x^6 + K_5x^5 + K_4x^4 + K_3x^3 + K_2x^2 + K_1x + K_0$ are obtained as the remainder after dividing $x^8D(x)$ by $G(x)$, where $D(x)$ is the polynomial given by $D(x) = B_{119}x^{119} + B_{118}x^{118} + \dots + B_2x^2 + B_1x + B_0$.

Equation of full code is given by: $B_{119}x^{127} + B_{118}x^{126} + B_{117}x^{125} \dots + B_1x^9 + B_0x^8 + K_7x^7 + K_6x^6 + K_5x^5 + K_4x^4 + K_3x^3 + K_2x^2 + K_1x + K_0$.

9.7 Field data array block

The columns and rows for each field are 1020 and 128 respectively.

The field data array block is shown in figure 19.

Column shuffling is the relocation of the column of the field data array.

The sample number of the data in the outer code block Oc, Splo, is written into the field memory at the coordinates shown below:

Row = Splo

$$Col = 4 \times L + B \text{ (Oc)}$$

where $B(0) = 0$; $B(1) = 1$; $B(2) = 2$; $B(3) = 3$.

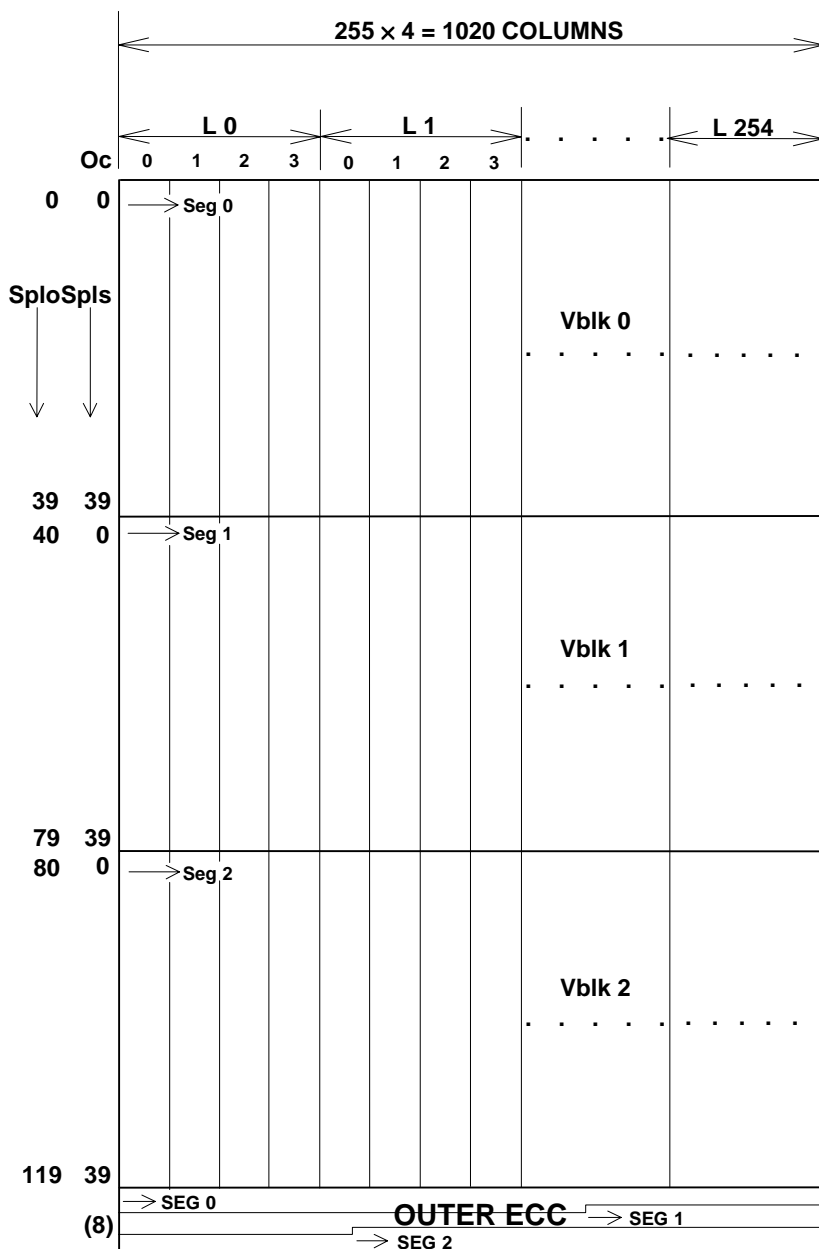


Figure 19 – Field data array block

9.8 Order of transmission to inner coding

The field memory array data is written to tape first by ascending column order, then by ascending row order. Compressed video data bytes and outer check bytes shall be divided into 3 segments. The outer check bytes are written to tape first and followed by data bytes.

Let Seg be the segment number within a compressed video data field:

$$\text{Seg} = 0, 1, 2$$

Let Fld be the field number within a colour frame:

$$\text{Fld} = 0, 1, 2, 3$$

The start point address number Xin of the field memory array is as follows:

For the outer check bytes:

$$\text{Xin} = 1440 + 32 \times \text{Seg}$$

For the outer data bytes:

$$\text{Xin} = 480 \times \text{Seg} \bmod 1440$$

The relationship between Xin and Row or Col of the field memory is:

$$\text{Xin} = 12 \times \text{Row} + \text{int}(\text{Col}/85)$$

10 AES3 audio data processing

10.1 Introduction

Audio data in each of the eight channels is processed independently and identically into a product block for each channel of dimensions 85 x 4 columns by 8 rows. The audio data samples of each channel are shuffled in a field before the addition of error correction data in the vertical (row) direction. Error correction in the horizontal (column) dimension is common with compressed video data.

Auxiliary words are multiplexed with the audio data in the product block to provide housekeeping in the interface and in processing. Figures 20 (1080/59.94i and 720/59.94p system) and 21 (1080/50i, 1080/25p, 1080/24p and 1080/23.98p system) show the audio data block field array.

10.2 Source coding

Audio data records that meet the requirements of AES3 are formed independently for each of eight AES3 audio data channels, from audio data and ancillary data at the input interface. The data include AES3 audio data, channel status data (C), user data (U), and validity data (V). Parity bits are discarded. The remaining bit positions in the audio data words are reserved (R) for future use. Block sync marks for ancillary data are also processed. CCITT J.17 pre-emphasis is not recognized.

Source data is defined as follows:

a) AES3 audio data:

- Sampling frequency: $48 \text{ kHz} \pm 3 \text{ parts in } 10^6$, synchronous with video

b) Channel status data:

- Bit rate: 48 kbit/s (nominal)
- Word rate: 6 kByte/s
- Word length: 8 bits
- Block length: 192 bits, 24 words
- Coding: See AES3

NOTES

1 Bytes 0 and 1 of AES status data are selected only for special processing in the DVTR. The contents of bytes 0 and 1 are shown in tables 9 and 10, respectively.

2 Bytes 22 and 23 of AES status data contain protection and validity information for bytes 0-21 and may be used in some source decoders.

c) User data:

- Bit rate: One bit associated with each audio data word
- Coding: Undefined

d) Validity data:

- Bit rate: One bit associated with each audio data word
- Coding: 0 = sample valid
1 = sample defective

e) Parity bit:

- Bit rate: One bit associated with each audio data word
- Coding: Even parity of associated word including audio data, status, user, and validity data

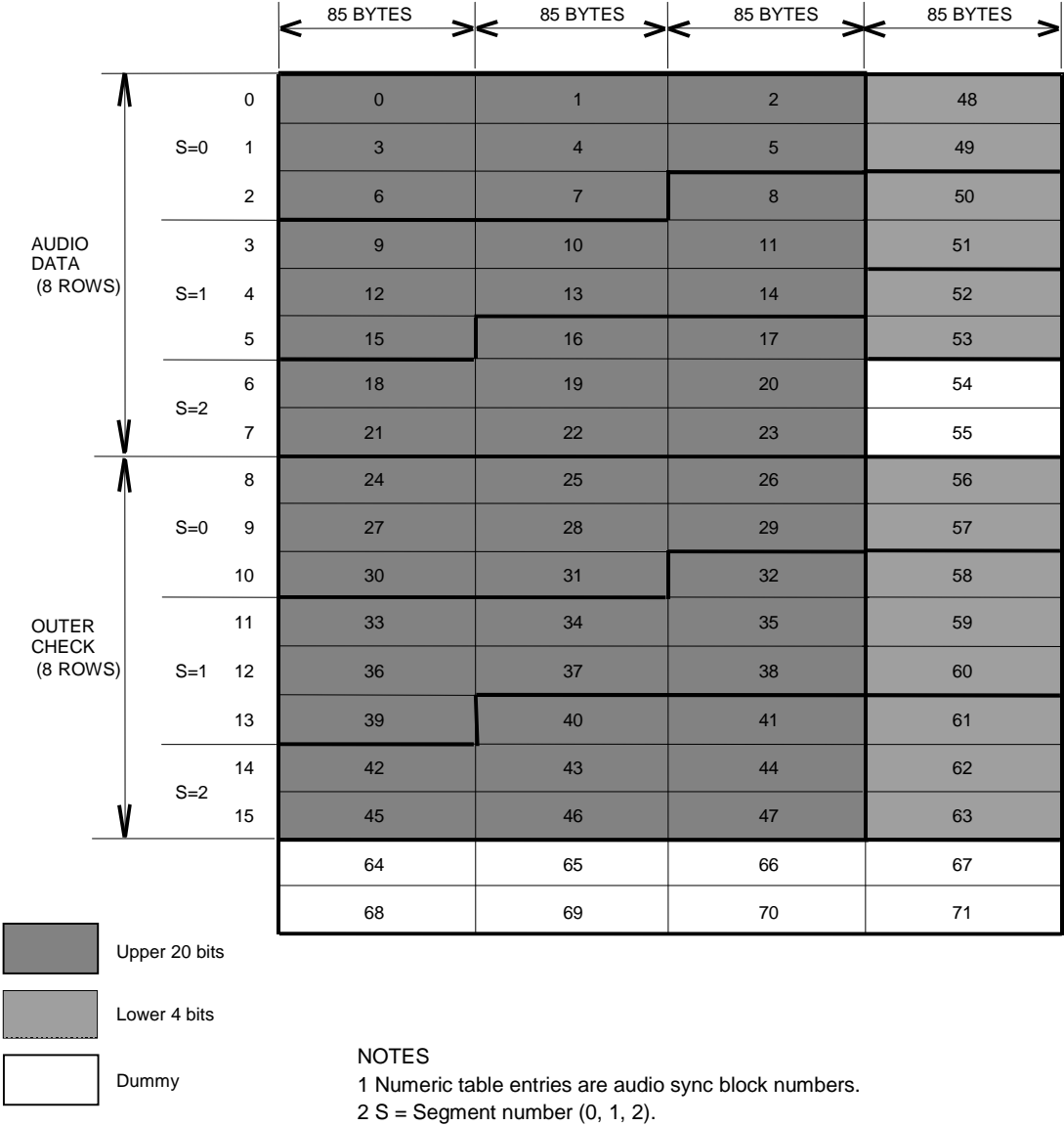


Figure 20 – Audio data block field array (1080/59.94i and 720/59.94p system)

| | | 85 BYTES | 85 BYTES | 85 BYTES | 85 BYTES |
|----------------------------|--------|----------|----------|----------|----------|
| AUDIO DATA (10 ROWS) | 0 | 0 | 1 | 2 | 3 |
| | S=0 1 | 4 | 5 | 6 | 7 |
| | 2 | 8 | 9 | 10 | 11 |
| | 3 | 12 | 13 | 14 | 15 |
| | 4 | 16 | 17 | 18 | 19 |
| | S=1 5 | 20 | 21 | 22 | 23 |
| | 6 | 24 | 25 | 26 | 27 |
| | 7 | 28 | 29 | 30 | 31 |
| | S=2 8 | 32 | 33 | 34 | 35 |
| | 9 | 36 | 37 | 38 | 39 |
| OUTER CHECK (8 ROWS) | 10 | 40 | 41 | 42 | 43 |
| | S=0 11 | 44 | 45 | 46 | 47 |
| | 12 | 48 | 49 | 50 | 51 |
| | 13 | 52 | 53 | 54 | 55 |
| | S=1 14 | 56 | 57 | 58 | 59 |
| | 15 | 60 | 61 | 62 | 63 |
| | 16 | 64 | 65 | 66 | 67 |
| | S=2 17 | 68 | 69 | 70 | 71 |

NOTES

1 Numeric table entries are audio sync block numbers.

2 S = Segment number (0, 1, 2).

Figure 21 – Audio data block field array (1080/50i, 1080/25p, 1080/24p and 1080/23.98p system)

Table 9 – AES status data (Byte 0)

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

Bit 0: 0 = Consumer use
1 = Professional use

Bit 1: 0 = Audio
1 = Data

Bit 2: Preemphasis 0

Bit 3: Preemphasis 1

Bit 4: Preemphasis 2

Bit 5: 0

Bit 6: Sampling frequency 0

Bit 7: Sampling frequency 1

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

Table 10 – AES status data (Byte 1)

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

Bit 0: Channel mode bit 0

Bit 1: Channel mode bit 1

Bit 2: Channel mode bit 2

Bit 3: Channel mode bit 3

Bit 4: Reserved

Bit 5: Reserved

Bit 6: Reserved

Bit 7: Reserved

| Mode | 0 | 1 | 2 | 3 | Definition |
|------|---------|---|---|---|-----------------------------|
| 0 | 0 | 0 | 0 | 0 | Undefined-2 channel |
| 1 | 0 | 0 | 0 | 1 | 2 Channel |
| 2 | 0 | 0 | 1 | 0 | Single channel |
| 3 | 0 | 0 | 1 | 1 | Primary/secondary 2 channel |
| 4 | 0 | 1 | 0 | 0 | Stereophonic |
| 5 | 0 | 1 | 0 | 1 | Reserved |
| | through | | | | |
| F | 1 | 1 | 1 | 1 | Reserved |

NOTE – Bits 0, 1, and 3 of this byte are recorded in an auxiliary word.

10.3 Source processing

10.3.1 Introduction

AES3 audio data is processed in fields. Each field contains 801 or 800 AES3 audio data samples (1080/59.94i and 720/59.94p system) or 960 AES3 audio data samples (1080/50i and 25p system) or 1001 AES3 audio data samples (1080/23.98p and 24p system) for an AES3 audio data channel with associated status, user, and validity data. In addition, a number of control and user words are added to the data.

10.3.2 Relative audio video signal timing

An audio data field begins with the audio data sample acquired zero samples (± 20 sample periods) before the first preequalizing pulse of the vertical interval of the analog input video signal. For digital input video signal a corresponding point (mark) to analog input is chosen as the beginning of the sampled audio field. That point depends on a relevant system line number (different for interlaced or progressive system) and status of the F and V bits on the digital interface.

Audio signal timing relative to video signal timing at the output interface during playback shall be the same (temporal skew is equal to zero) as it was at the input interface

10.3.3 Audio data in fields

Audio data in fields is processed into an audio data block of $85 \times 6 \times 12$ bytes, each corresponding to 12 audio data sectors on tape. The data portion of the block is 85×30 bytes and the outer error check bytes portion of the block is also 85×32 bytes (1080/59.94i and 720/59.94p system). The data portion of the block is $85 \times 4 \times 10$ bytes and the outer error check bytes portion of the block is also $85 \times 4 \times 8$ bytes (1080/23.98p and 24p system and 1080/50i and 25p system).

AES3 audio data words:

801 or 800 words (1080/59.94i and 720/59.94p system) or 960 words (1080/50i and 25p system) or 1001 words (1080/23.98p and 24p system — see note in 6.3.3.d) with associated C, U, V, R bits (20 bits total per word).

Auxiliary data words:

15 words (20 bits per word) + 170 words (8 bits per word) + 219 words (4 bits per word) (1080/59.94i and 720/59.94p system); 160 words (24 bits per word) + 40 words (8 bits per word) (1080/50i and 25p system); 119 words (24 bits per word) + 40 words (8 bits per word) (1080/23.98p and 24p system).

10.3.4 Intrafield shuffling

The audio data for each channel in each field is shuffled. The intrafield shuffling process operates identically for all fields.

For 1080/59.94i and 720/59.94p system

For upper 20 bits data:

Let Col be the column number within an audio data field:

$$\text{Col} = 0, 1, \dots, 115.$$

Let Row be the row number within an audio data field:

$$\text{Row} = 0, 1, \dots, 15$$

Rows 8 to 15 contain the error correction data.

Let Oblk be the data block number:

$$\text{Oblk} = 3 \times \text{Row} + \text{int}(\text{Col} / 34)$$

The data block array for upper 20 bits is shown in figures 22. Then sample number Smp within an audio data field is obtained according to the following formula:

$$\text{Smp} = 24 \times (\text{Col} \bmod 34) + \text{int}(\text{Oblk} / 8) + 3 \times (\text{Oblk} \bmod 8)$$

When Smp is larger than 800, Smp = 801, 802, ..., 815 are replaced by AUX 0, AUX 1, ..., AUX 14, respectively.

For lower 4 bits data.

Let Col be the column number within an audio data field:

$$\text{Col} = 0, 1, \dots, 169.$$

Let Row be the row number within an audio data field:

$$\text{Row} = 0, 1, \dots, 15$$

Row 8 to 15 contain the error correction data.

The data block array for lower 4 bits is shown in figures 23. Then sample number Smp within a lower 4 bits audio data field is obtained according to the following formula:

$$\text{Smp} = 6 \times (\text{col} - 2 \text{int}(\text{Row} / 2)) + 3 \times (\text{Row} \bmod 2) + \text{int}(\text{Row}/2). \\ \text{(Lower 4 bits)}$$

When Smp is larger than 800, Smp = 801, 802, ..., 815 are replaced by AUX 0, AUX 1, ..., AUX 14. When Smp is smaller than 0, Smp is replaced by AUX 219 + Smp respectively.

For 1080/50i; 1080/23.98p, 1080/24p and 1080/25p system.

Let Col be the column number within an audio data field:

$$\text{Col} = 0, 1, \dots, 115.$$

Let Row be the row number within an audio data field:

$$\text{Row} = 0, 1, \dots, 15$$

Rows 8 to 15 contain the error correction data.

Let Oblk be the data block number:

$$\text{Oblk} = 4 \times \text{Row} + \text{int}(\text{Col} / 29) \text{ (Upper 20 bits)}$$

The data block arrays are shown in figures 24 (1080/50i and 25p system) and figure 25 (1080/23.98p and 1080/24p system).

Then sample number Smp within an audio data field is obtained according to the following formula:

$$\text{Smp} = 40 \times (\text{Col} \bmod 29) + \text{int}(\text{Oblk} / 14) + 3 \times (\text{Oblk} \bmod 14) \text{ (} 0 \leq \text{Oblk} \leq 26 \text{).} \\ \text{Smp} = 40 \times (\text{Col} \bmod 29) + 2 \times \text{int}(\text{Oblk} / 27) + 3 \times (\text{Oblk} \bmod 27) \text{ (} 27 \leq \text{Oblk} \leq 39 \text{).}$$

When Smp is larger than 959, Smp = 960, 961, ..., 1159 are replaced by AUX 0, AUX 1, ..., AUX 158, respectively, for the 1080/50i and 25p system; When Smp is larger than 959, Smp = 960, 961, ..., 1159 are replaced by AUX 0, AUX 1, ..., AUX 199, respectively, for 1080/23.98p and 24p system).

Figures 22 and 23 (1080/59.94i and 720/59.94p system), 24 (1080/50i and 25p system) and 25 (1080/23.98p and 1080/24p system) show the layout of the shuffled samples in a field array. Outer ECC codes are situated at Row = 8 to 15 for 1080/59.94i and 720/59.94p system and Row = 10 to 19 for 1080/50i, 1080/23.98p, 1080/24p and 25p system.

10.3.5 Block shuffling

The block shuffling process operates after the intrafield shuffling identically for all fields. Let N be the recording order of the data block in an audio data sector:

$$N = 0, 1, 2, 3$$

Let Seg be the segment number:

$$\text{Seg} = 0, 1, 2$$

Let T be the track number:

$$T = 0, 1, 2, 3$$

Then the data block Oblk within a field array is mapped according to the following formula:

$$\text{Oblk} = N' + T' + 8 \times \text{Seg} + 2 \times (12 - T') \times (N' \bmod 2) \quad (1080/59.94i \text{ and } 720/59.94p \text{ system})$$

$$\text{Oblk} = N' + T' + 8 \times \text{Seg} + 2 \times (16 - T') \times (N' \bmod 2) \quad (1080/50i \text{ and } 25p \text{ system})$$

where

$$N' = N + 4 \times \text{int}(T/2)$$

$$T' = T \bmod 2$$

Figure 26 shows the data block arrangement of an audio data channel in three groups of sectors for the 1080/59.94i and 720/59.94p system. Figure 27 shows the data block arrangement of an audio data channel in three groups of sectors for the 1080/50i, 1080/23.98p, 24p and 25p system.

10.3.6 Audio data word processing

Input data are formed into words of 24 bits in the sequence:

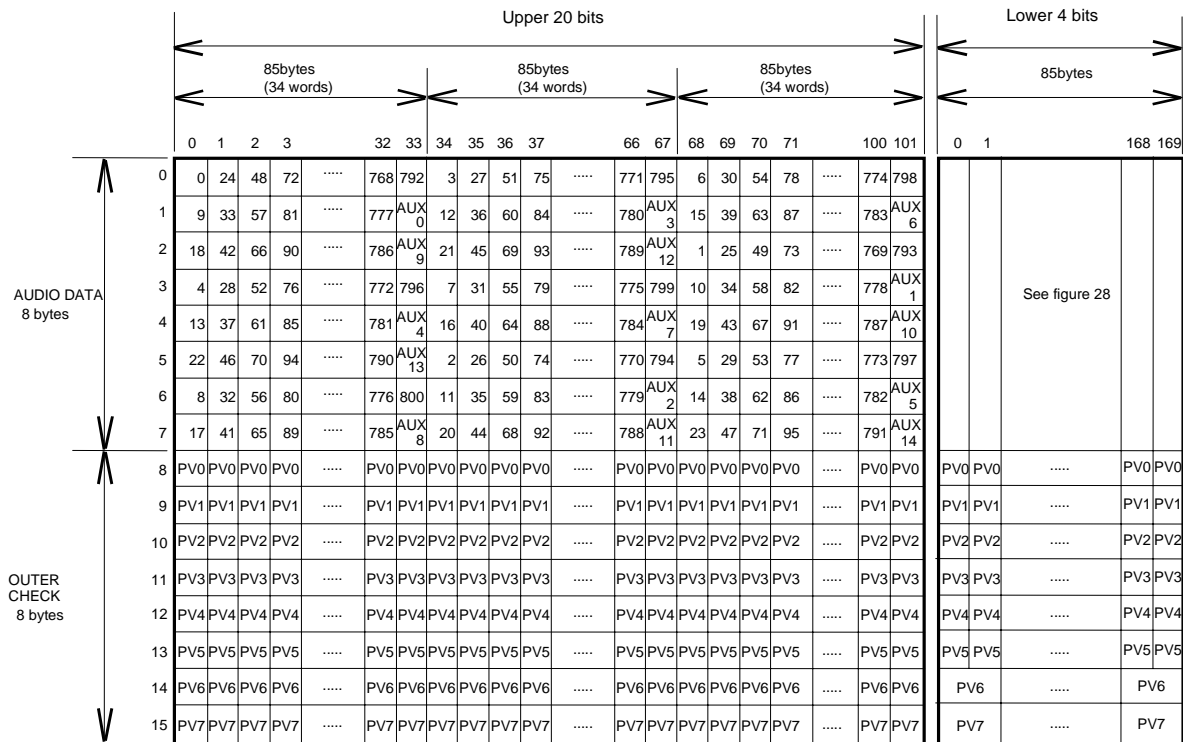
a) Assignment of the 24-bit word to audio data and associated data is controlled by user input (see table 11 (1080/59.94i and 720/59.94p) and 12 (1080/50i, 1080/23.98p, 24p and 25p system)).

The most significant bit of the audio data word is bit 23 and unused bits of lower significance are removed. The auxiliary word LNGH (four bits) signals the word mode selected.

b) Each group of 24-bit words is divided into 8-bit bytes as shown in figures 28 (1080/59.94i and 720/59.94p system) and 29 (1080/50i, 1080/23.98p, and 24p and 25p system) and arranged alternately by the MSB and the LSB of the first word of the word group.

c) Each group is distributed into the product block in accordance with figures 22 and 23 (1080/59.94i and 720/59.94p system), figure 24 (1080/50i and 25p system) and figure 25 (1080/23.98p and 24p system)

d) For the 1080/59.94i and 720/59.94p system, every fifth field shall contain 800 samples. All other fields shall contain 801 samples. The 5-field sequence of the number of audio data samples begins at an arbitrarily chosen field. Continuity of the 5-field sequence shall be preserved throughout the recording, including editing. The 5-field sequence is indicated by the value of the auxiliary word FNCT, as defined in 10.4.5. Furthermore, every fifth field of 800 samples is identified by the field address AF2 for audio data sync blocks, as defined in 6.3.3.



NOTES

1 Numeric table entries are audio sample numbers.

2 PV0 to PV7 represent outer check corresponding to audio data of each column.

Figure 22 – Audio data block layout – upper 20 bits (1080/59.94i and 720/59.94p system)

| | 0 | 1 | 2 | 3 | 4 | 5 | | 132 | 133 | 134 | 135 | 136 | 137 | 138 | 139 | | 168 | 169 |
|---|---------|---------|---------|---------|----|----|-------|---------|---------|---------|---------|--------|--------|--------|--------|-------|---------|---------|
| 0 | 0 | 6 | 12 | 18 | 24 | 30 | ..... | 792 | 798 | AUX 3 | AUX 9 | AUX 15 | AUX 21 | AUX 27 | AUX 33 | ..... | AUX 207 | AUX 213 |
| 1 | 3 | 9 | 15 | 21 | 27 | 33 | ..... | 795 | AUX 0 | AUX 6 | AUX 12 | AUX 18 | AUX 24 | AUX 30 | AUX 36 | ..... | AUX 210 | AUX 216 |
| 2 | AUX 208 | AUX 214 | 1 | 7 | 13 | 19 | ..... | 781 | 787 | 793 | 799 | AUX 4 | AUX 10 | AUX 16 | AUX 22 | ..... | AUX 196 | AUX 202 |
| 3 | AUX 211 | AUX 217 | 4 | 10 | 16 | 22 | ..... | 784 | 790 | 796 | AUX 1 | AUX 7 | AUX 13 | AUX 19 | AUX 25 | ..... | AUX 199 | AUX 205 |
| 4 | AUX 197 | AUX 203 | AUX 209 | AUX 215 | 2 | 8 | ..... | 770 | 776 | 782 | 788 | 794 | 800 | AUX 5 | AUX 11 | ..... | AUX 185 | AUX 191 |
| 5 | AUX 200 | AUX 206 | AUX 212 | AUX 218 | 5 | 11 | ..... | 773 | 779 | 785 | 791 | 797 | AUX 2 | AUX 8 | AUX 14 | ..... | AUX 188 | AUX 194 |
| 6 | AUX 219 | AUX 220 | AUX 221 |  |  |  | ..... | AUX 285 | AUX 286 | AUX 287 | AUX 288 |  |  |  |  | ..... | AUX 303 | |
| 7 | AUX 304 | AUX 305 | AUX 306 |  |  |  | ..... | AUX 370 | AUX 371 | AUX 372 | AUX 373 |  |  |  |  | ..... | AUX 388 | |

Figure 23 – Audio data block layout – lower 4 bits (1080/59.94i and 720/59.94p system)

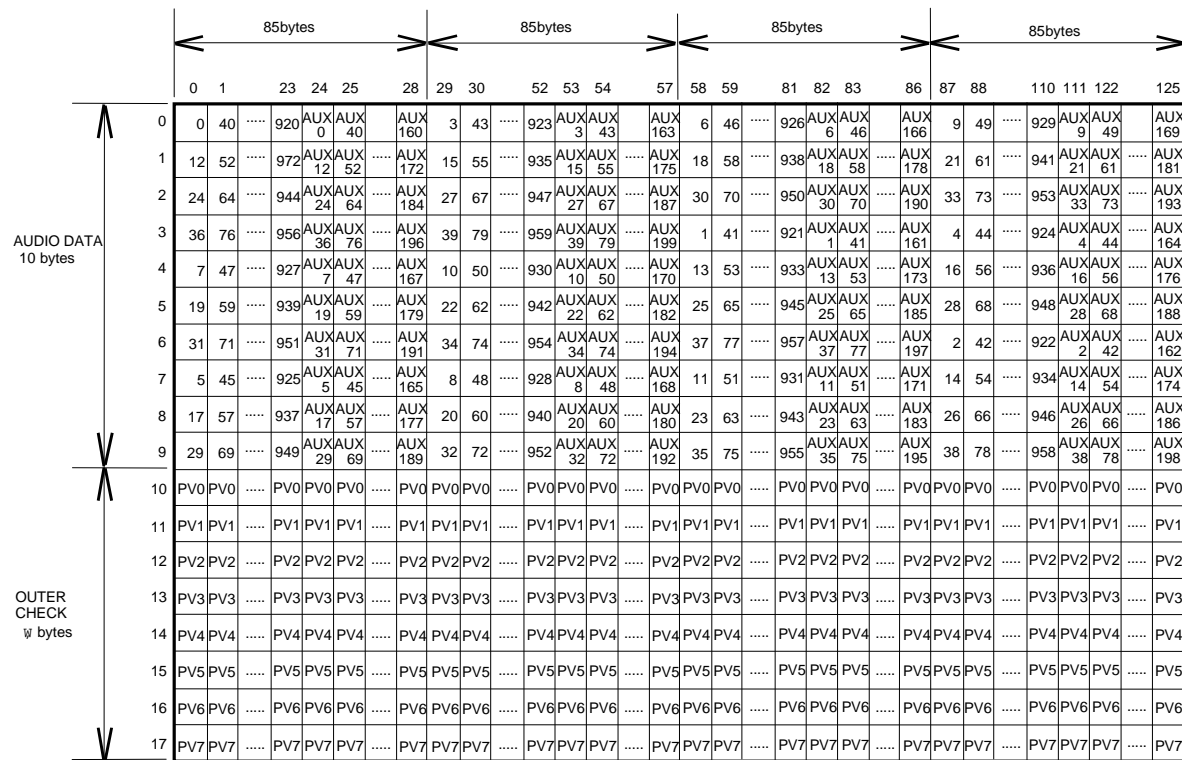


Figure 24 – Audio data block layout (1080/50i and 25p system)

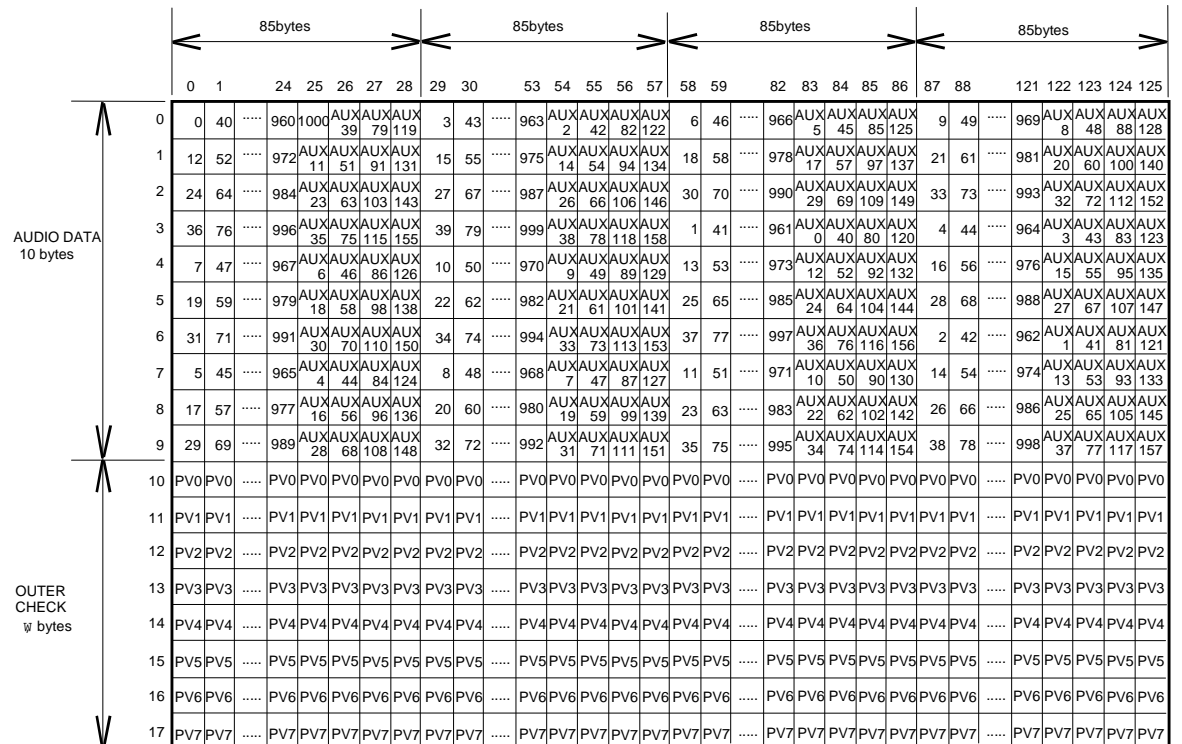


Figure 25 – Audio data block layout (1080/23.98p and 1080/24p system)

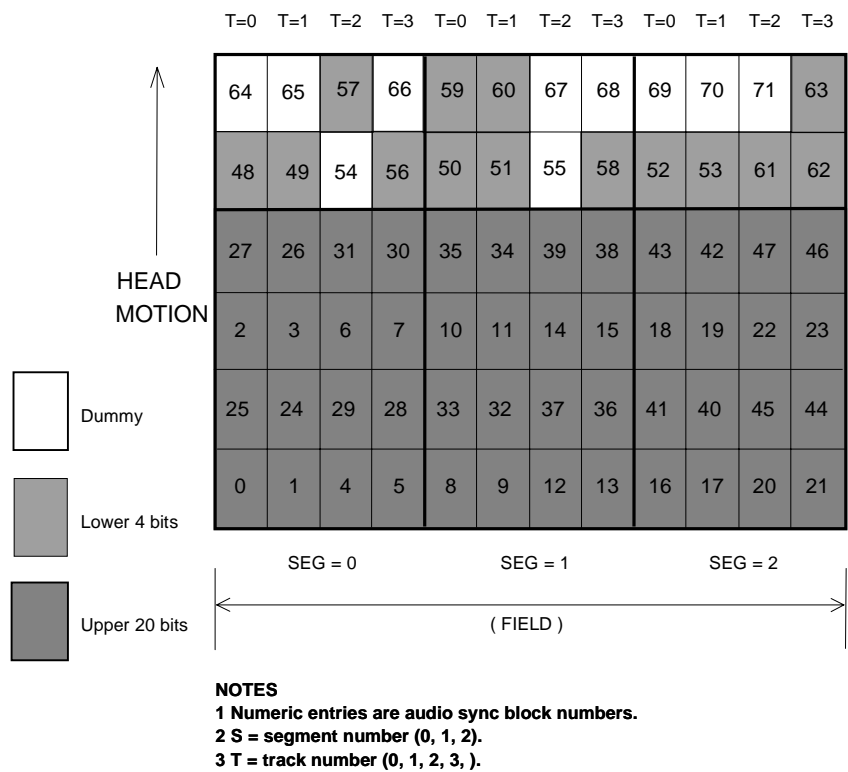


Figure 26 – Audio data block arrangement (1080/59.94i and 720/59.94p system)

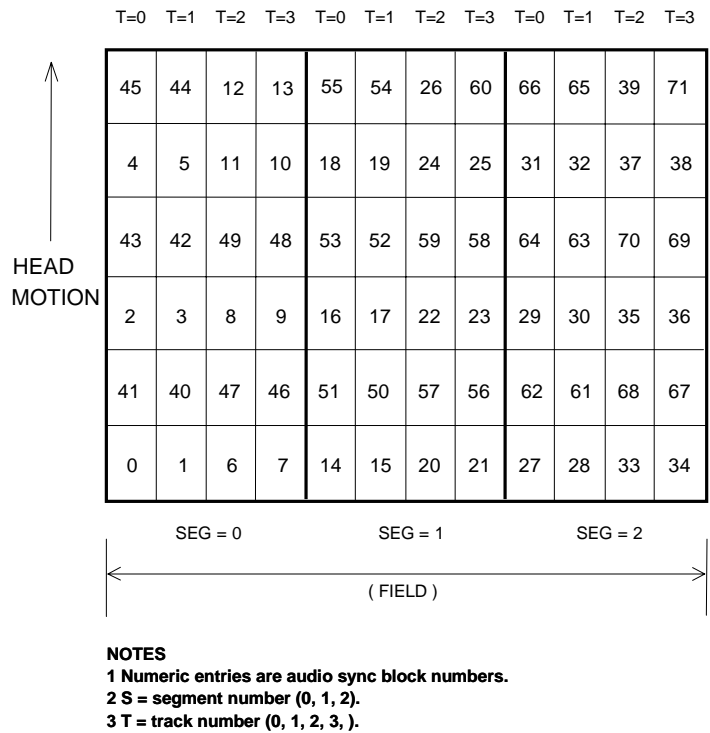


Figure 27 – Audio data block arrangement (1080/50i, 1080/25p, 1080/23.98p and 1080/24p system)

Table 11 – Audio data word mode (1080/59.94i and 720/59.94p)

| Word Mode | Bit | | | | | |
|-----------|-----------|---------|---------|---------|---------|------------|
| | 0-3 | 4 | 5 | 6 | 7 | 8-23 |
| 0 (0001) | Audio 0-3 | C | U | V | R | Audio 4-20 |
| 1 (0011) | Audio 0-3 | C | U | V | Audio 4 | Audio 5-21 |
| 2 (0101) | Audio 0-3 | C | V | Audio 4 | Audio 5 | Audio 6-22 |
| 3 (0111) | Audio 0-3 | C | U | Audio 4 | Audio 5 | Audio 6-22 |
| 4 (1001) | Audio 0-3 | C | Audio 4 | Audio 5 | Audio 6 | Audio 7-23 |
| 5 (1011) | Audio 0-3 | V | Audio 4 | Audio 5 | Audio 6 | Audio 7-23 |
| 6 (1101) | Audio 0-3 | U | Audio 4 | Audio 5 | Audio 6 | Audio 7-23 |
| 7 (1111) | Audio 0-3 | Audio 4 | Audio 5 | Audio 6 | Audio 7 | Audio 8-23 |

NOTES

- 1 Example, “audio 1” represents bit 1 of audio sample.
- 2 C = channel status bit, U = user bit, V = validity bit, R = reserved bit.
- 3 Audio data will be rounded from the 20-bit length of the interface word (auxiliary data truncated) to the length above with the elimination of the least significant bit(s).
- 4 Modes 0, 3, and 7 are the recommended modes for general use.

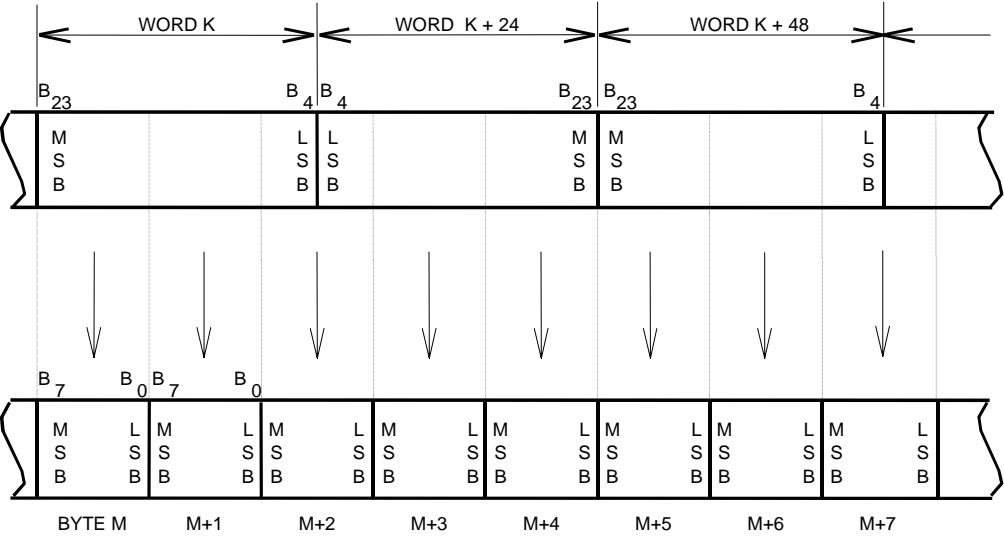
Table 12 – Audio data word mode (1080/50i, 1080/25p, 1080/23.98p and 1080/24p system)

| Word Mode | Bit | | | | | |
|-----------|-----------|---------|---------|---------|---------|------------|
| | 0-3 | 4 | 5 | 6 | 7 | 8-23 |
| 0 (0000) | Audio 0-3 | C | U | V | R | Audio 4-20 |
| 1 (0010) | Audio 0-3 | C | U | V | Audio 4 | Audio 5-21 |
| 2 (0100) | Audio 0-3 | C | V | Audio 4 | Audio 5 | Audio 6-22 |
| 3 (0110) | Audio 0-3 | C | U | Audio 4 | Audio 5 | Audio 6-22 |
| 4 (1000) | Audio 0-3 | C | Audio 4 | Audio 5 | Audio 6 | Audio 7-23 |
| 5 (1010) | Audio 0-3 | V | Audio 4 | Audio 5 | Audio 6 | Audio 7-23 |
| 6 (1100) | Audio 0-3 | U | Audio 4 | Audio 5 | Audio 6 | Audio 7-23 |
| 7 (1110) | Audio 0-3 | Audio 4 | Audio 5 | Audio 6 | Audio 7 | Audio 8-23 |

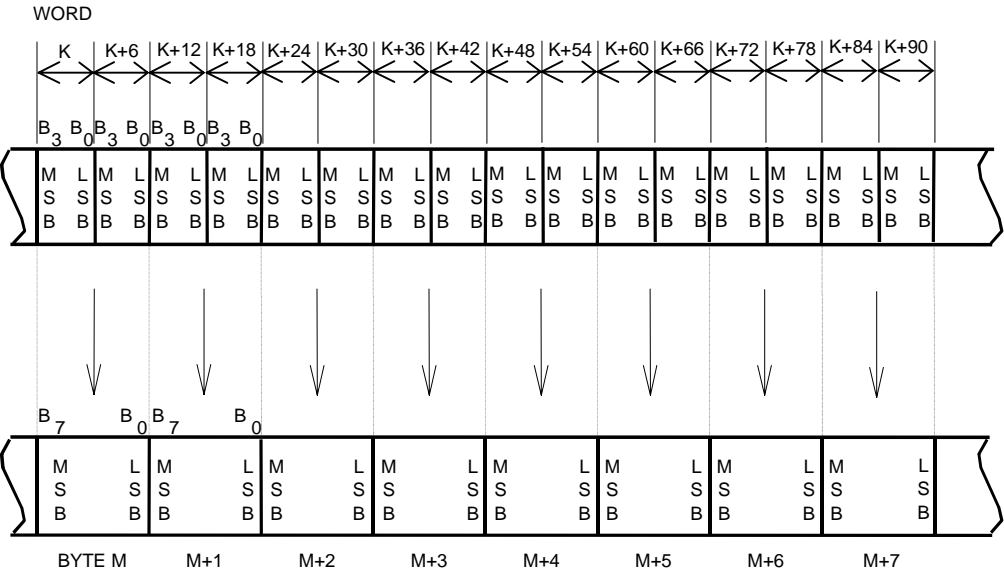
NOTES

- 1 Example, “audio 1” represents bit 1 of audio sample.
- 2 C = channel status bit, U = user bit, V = validity bit, R = reserved bit.
- 3 Audio data will be rounded from the 20-bit length of the interface word (auxiliary data truncated) to the length above with the elimination of the least significant bit(s).
- 4 Modes 0, 3, and 7 are the recommended modes for general use.

Upper 20 bits

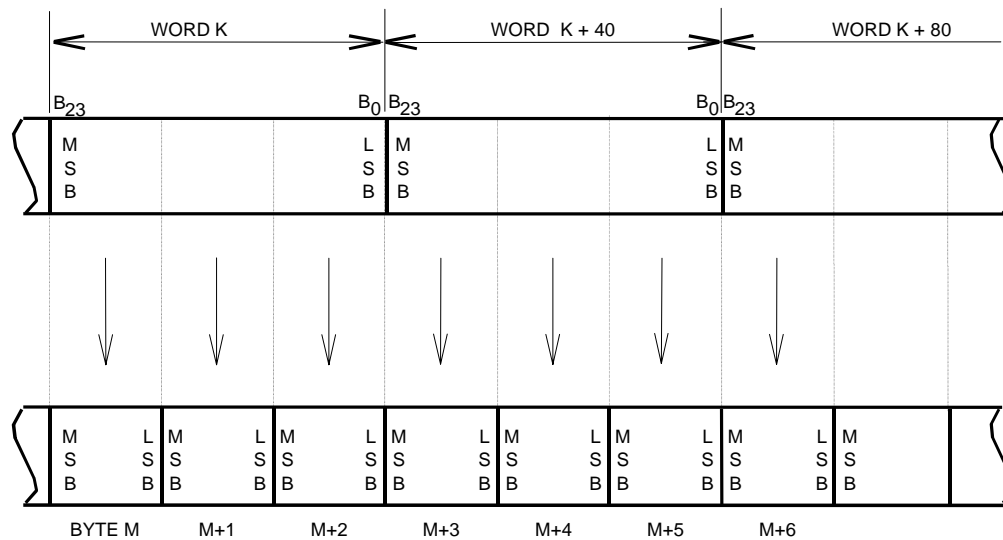


Lower 4 bits



NOTE - K = 0, 9, 18, 4, 13, 22, 8, and 17 in figure 22.

Figure 28 – Digital audio data word to byte conversion (1080/59.94i nd 720/59.94p system)



NOTE - K = 0, 12, 24, 36, 7, 19, 31, 5, 17 and 29 in figures 24 and 25.

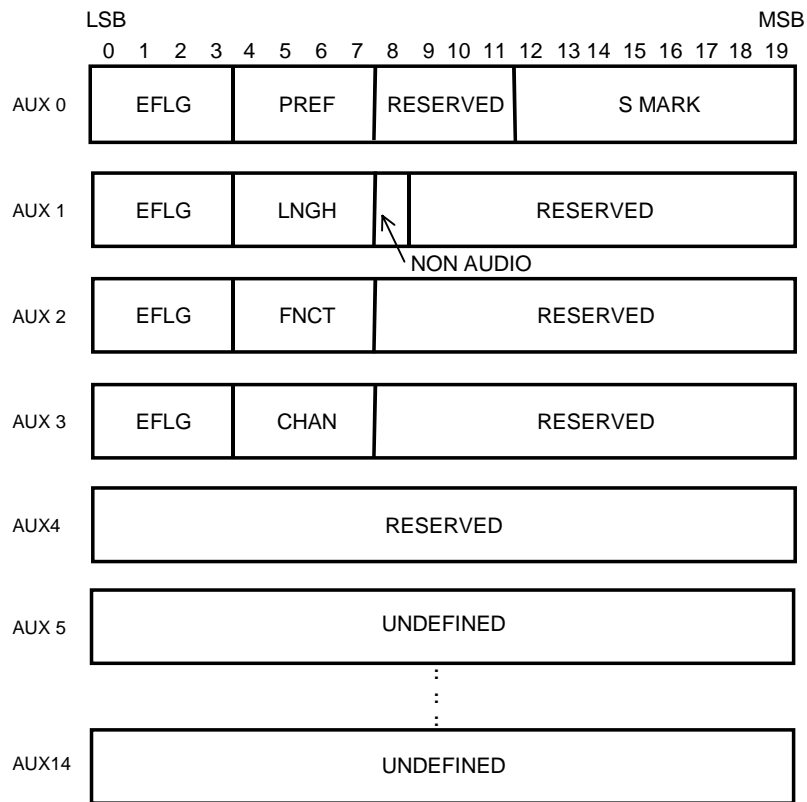
Figure 29 – Digital audio data word to byte conversion (1080/50i, 1080/25p, 1080/24p and 1080/23.98p system)

10.4 Auxiliary words

Auxiliary words are generated at the input interface from incoming data or user selection and serve to signal this information to the output interface. Auxiliary words are five words of four bits plus one word of one bit and one word of eight bits as defined in figures 30 (1080/59.94i and 720/59.94p system) and 31 (1080/50i and 25p system) and 32 (1080/24p and 1080/23.98p system). The word EFLG is written four times in each audio data block.

Figures 30 (1080/59.94i and 720/59.94p system) and 31 (1080/50i and 25p system) and 32 (1080/24p and 1080/23.98p system) show the format of the auxiliary words in the audio data block.

AUX DATA (upper 20 bits)

NOTE - Reserved = 0_h or 000_h or 00000_h.

AUX DATA (lower 4 bits)

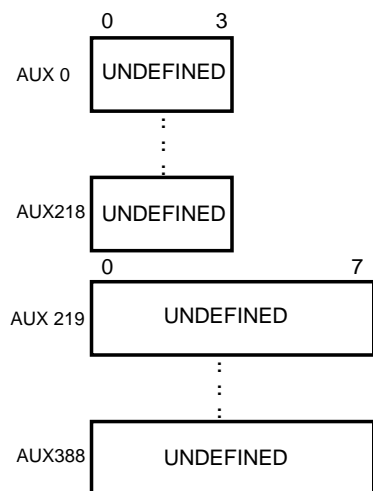
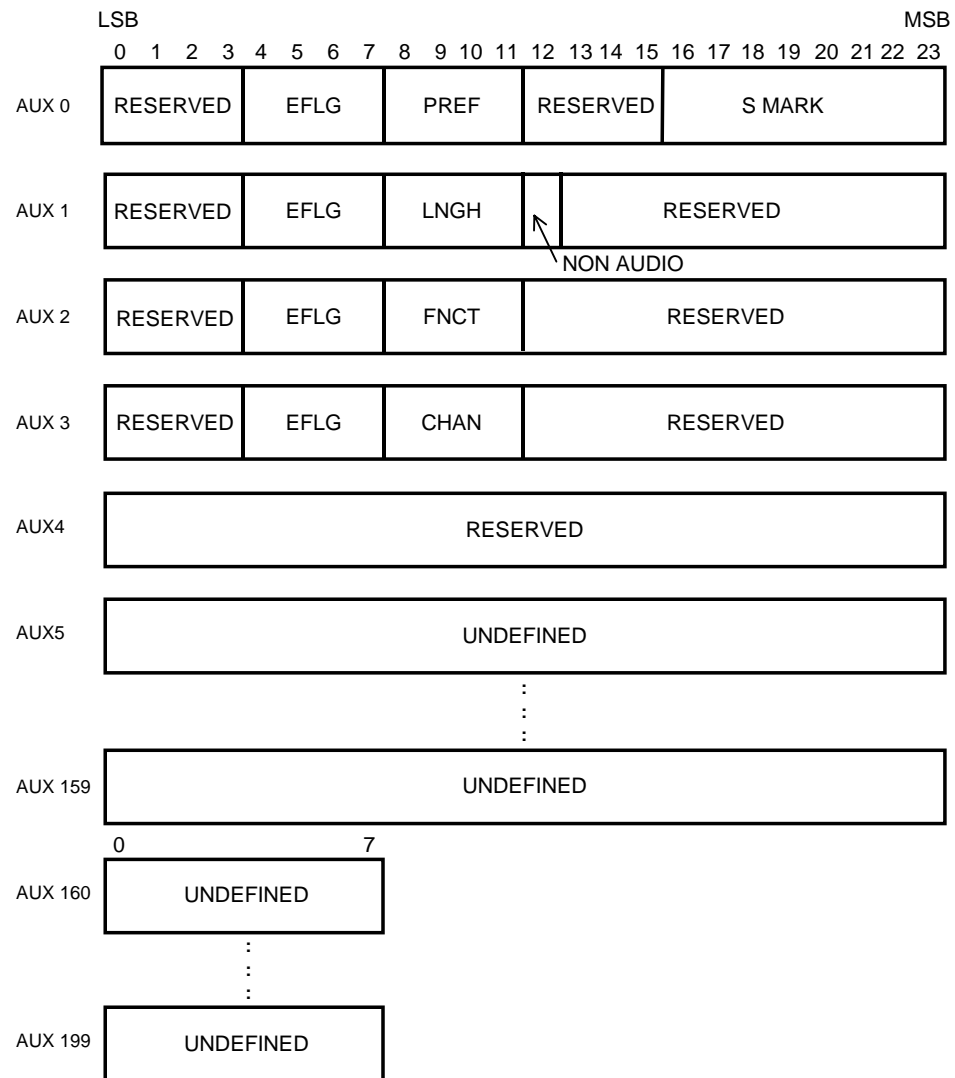


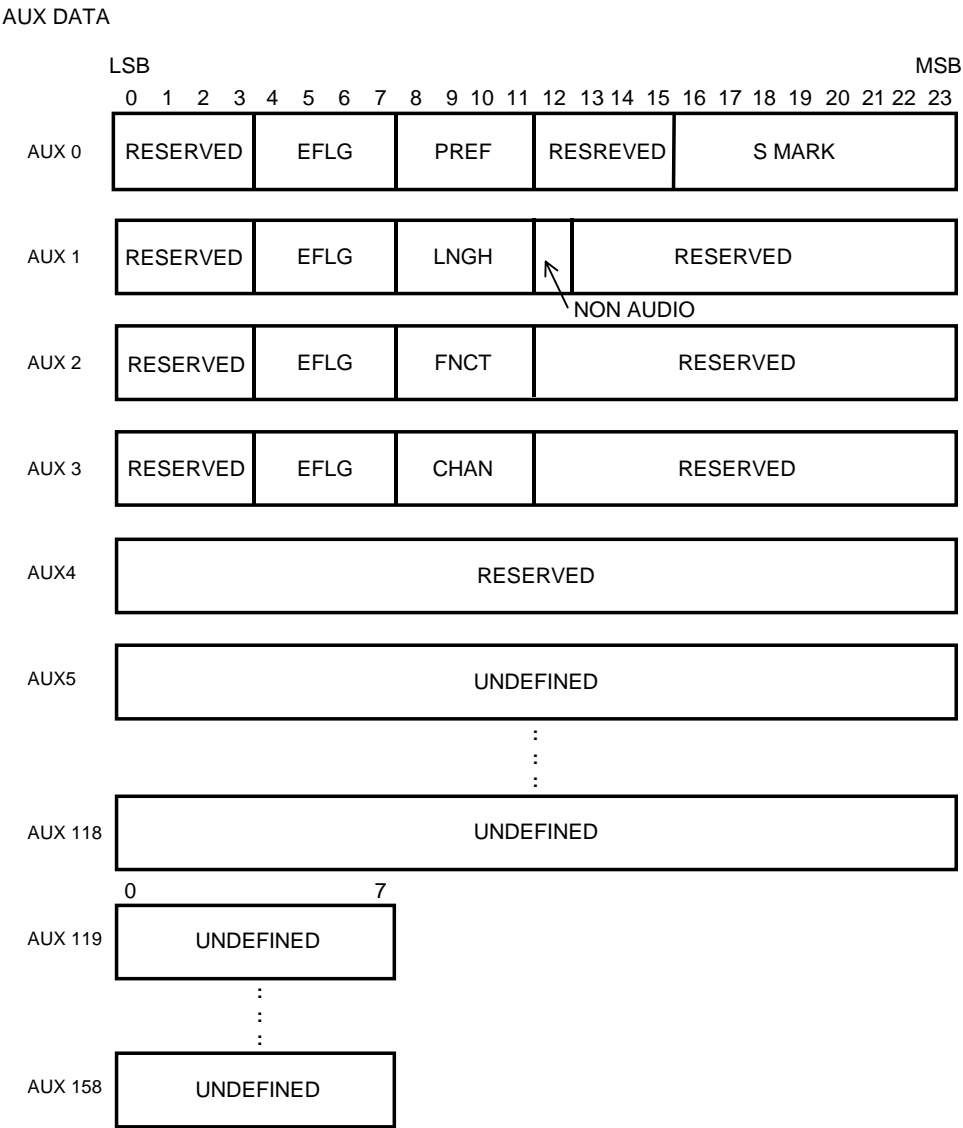
Figure 30 – Audio data block auxiliary data (1080/59.94i and 720/59.94p system)

AUX DATA



NOTE - Reserved = 0_h or 000_h or 000000_h.

Figure 31 – Audio data block auxiliary data (1080/50i and 25p system)

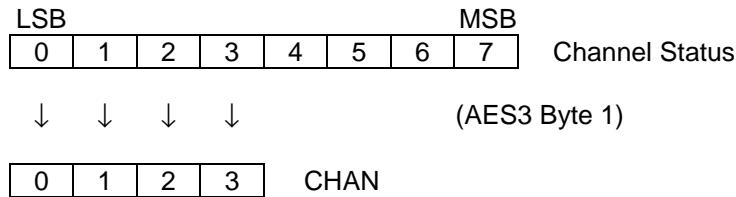


NOTE - Reserved = 0_h or 000_h or 000000_h .

Figure 32 – Audio data block auxiliary data (1080/24p and 1080/23.98p system)

10.4.1 Channel use (CHAN)

This word is four bits and specifies the usage of the two input channels in an interface data stream. CHAN is derived from channel status byte 1. CHAN is inserted in bits 4-7 (1080/59.94i and 720/59.94p system) or bits 8-11 (1080/50i, 1080/23.98p, 24p, 25p system) of AUX 3. (See table 13, figures 30, 31 and 32.)



Bit 0: Channel mode bit 0

Bit 1: Channel mode bit 1

Bit 2: Channel mode bit 2

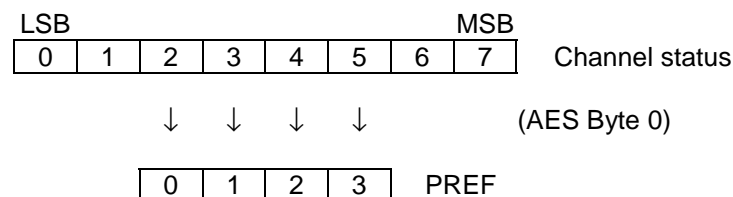
Bit 3: Channel mode bit 3

Table 13 – Channel use control word

| Mode | CHAN bit | | | | Value |
|------|----------|---|---|---|-----------------------------|
| | 0 | 1 | 2 | 3 | |
| 0 | 0 | 0 | 0 | 0 | 2 Channel-default |
| 1 | 0 | 0 | 0 | 1 | 2 Channel |
| 2 | 0 | 0 | 1 | 0 | Single channel |
| 3 | 0 | 0 | 1 | 1 | Primary/secondary 2 channel |
| 4 | 0 | 1 | 0 | 0 | Stereophonic |
| 5 | 0 | 1 | 0 | 1 | Undefined |
| | through | | | | |
| F | 1 | 1 | 1 | 1 | Undefined |

10.4.2 Preemphasis (PREF)

This word is four bits and specifies the usage of preemphasis in the audio data coding. PREF is derived from channel status byte 0. PREF is inserted in bits 4-7 (1080/59.94i and 720/59.94p system) or bits 8-11 (1080/50i, 1080/23.98p, 24p, 25p system) of AUX 0 (see table 14, figures 30, 31 and 32).



Bit 0: Preemphasis bit 0

Bit 1: Preemphasis bit 1

Bit 2: Preemphasis bit 2

Bit 3: 0

Table 14 - Preemphasis control word

| Mode | PREF bit 0 1 2 | Value |
|------|-------------------|-----------------------------|
| 0 | 0 0 0 | Preemphasis off - (default) |
| 1 | 0 0 1 | Reserved |
| 2 | 0 1 0 | Reserved |
| 3 | 0 1 1 | Reserved |
| 4 | 1 0 0 | Preemphasis off |
| 5 | 1 0 1 | Reserved |
| 6 | 1 1 0 | 50/15 microsecond |
| 7 | 1 1 1 | Reserved |

10.4.3 Audio data word mode (LNGH)

This word is four bits and specifies the audio data word length and the usage of the ancillary bits status, user, and validity. LNGH is derived from user control inputs and inserted in bits 4-7 (1080/59.94i and 720/59.94p system) or bits 8-11 (1080/50i, 1080/23.98p, 24p, 25p system) of AUX 1 (see table 15, figures 30, 31 and 32).

| LSB | | | | MSB | |
|-----|---|---|---|-----|------|
| 0 | 1 | 2 | 3 | | LNGH |

Bit 0: 0

Bit 1: LNGH 1 (LSB)

Bit 2: LNGH 2

Bit 3: LNGH 3 (MSB)

Table 15 – Word mode control word

| Mode | LNGH bit 3 2 1 | Audio data Length | Ancillary bits C U V R |
|------|-------------------|----------------------|---------------------------|
| 0 | 0 0 0 | 20 bits | X X X X |
| 1 | 0 0 1 | 21 bits | X X X – |
| 2 | 0 1 0 | 22 bits | X – X – |
| 3 | 0 1 1 | 22 bits | X X – – |
| 4 | 1 0 0 | 23 bits | X – – – |
| 5 | 1 0 1 | 23 bits | – – X – |
| 6 | 1 1 0 | 23 bits | – X – – |
| 7 | 1 1 1 | 24 bits | – – – – |

NOTE – "X" means the ancillary bit is recorded.

10.4.4 Block sync location (S MARK)

S MARK is an 8-bit word. S MARK specifies the location of the block sync associated with channel status and user data, as defined in AES3-1992. S MARK contains the word count, in the current block, of the first block sync detected; i.e., the word address in the block pointing to the first sample after the block sync mark.

| LSB | | | | | | | | MSB | |
|-----|---|---|---|---|---|---|---|-----|--------|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | | S MARK |

where S MARK is from 00_h to BF_h inclusive.

S MARK = FF_h if no mark is found within the defined range.

S MARK is inserted in bits 12-19 (1080/59.94i and 720/59.94p system) or bits 16-23 (1080/50i, 1080/23.98p, 24p, 25p system) of AUX 0 (see figures 30, 31, and 32).

10.4.5 Field number count (FNCT)

In the 1080/59.94i and 720/59.94p system, this word is four bits and specifies the number of audio samples in the current field. FNCT is inserted in bits 4-7 (1080/59.94i and 720/59.94p system) or bits 8-11 (1080/50i, 1080/23.98p, 24p, 25p system) of AUX 2 (see table 16, figures 30, 31, and 32).

| LSB | | | MSB | |
|-----|---|---|-----|------|
| 0 | 1 | 2 | 3 | FNCT |

Bit 0: FNCT 0 (LSB)
 Bit 1: FNCT 1
 Bit 2: FNCT 2 (MSB)
 Bit 3: 0

Table 16 – FNCT mode

| Number of samples | FNCT bit | | |
|-------------------|----------|---|---|
| | 2 | 1 | 0 |
| 801 | 0 | 0 | 0 |
| 801 | 0 | 0 | 1 |
| 801 | 0 | 1 | 0 |
| 801 | 0 | 1 | 1 |
| 800 | 1 | 0 | 0 |

10.4.6 Edit flag (EFLG)

This word is four bits and specifies the field associated with an edit transition. EFLG is inserted in bits 0-3 (1080/59.94i and 720/59.94p system) or bits 4-7 (1080/50i, 1080/23.98p, 24p, 25p system) of AUX 0, AUX 1, AUX 2, and AUX 3 (see figures 30, 31 and 32).

| LSB | | | MSB | |
|-----|---|---|-----|------|
| 0 | 1 | 2 | 3 | EFLG |

EFLG = D_h for the first field of the edit
 EFLG = 7_h for the last field of the edit
 EFLG = 0_h otherwise

10.4.7 Non-audio flag (NON AUDIO)

This word is one bit and specifies whether the data is audio or non-audio (data). NON AUDIO is inserted in bit 8 (1080/59.94i and 720/59.94p system) or bit 12 (1080/50i, 1080/23.98p, 24p, 25p system) of AUX 1 (see figures 30, 31 and 32).

NON AUDIO = 0 for audio
 NON AUDIO = 1 for non audio data

10.5 Outer error protection

Rows 8 through 15 of the data block, as shown in figures 22 (1080/59.94i and 720/59.94p system) and 24 (1080/50i and 25p system) and 25 (1080/23.98p and 24p system), contain the error check bytes associated with each column.

Type: Reed-Solomon.
Galois field: GF(256).

Field generator polynomial:

$$x^8 + x^4 + x^3 + x^2 + 1,$$

where x^i are place-keeping variables in GF(2), the binary field.

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

Code generator polynomial:

$$G(x) = (x+1)(x+a)(x+a^2)(x+a^3)(x+a^4)(x+a^5)(x+a^6)(x+a^7),$$

where a is given by α_{2h} in GF(256).

Check characters : $K_7, K_6, K_5, K_4, K_3, K_2, K_1, K_0$ (also identified respectively as $PV_7, PV_6, PV_5, PV_4, PV_3, PV_2, PV_1, PV_0$) in $K_7x^7 + K_6x^6 + K_5x^5 + K_4x^4 + K_3x^3 + K_2x^2 + K_1x + K_0$ are obtained as the remainder after dividing the polynomial $x^8D(x)$ by $G(x)$, where $D(x)$ is the polynomial given by

$$D(x) = B_7x^7 + B_6x^6 + B_5x^5 + \dots + B_2x^2 + B_1x + B_0.$$

Polynomial of full code :

$$B_7x^{15} + B_6x^{14} + B_5x^{13} + \dots + B_1x^9 + B_0x^8 + K_7x^7 + K_6x^6 + \dots + K_2x^2 + K_1x + K_0.$$

Outer-code check characters in each column of the 85 x 4 x 8 blocks are calculated using the data order existing prior to the rearrangement into the pattern shown in figures 22 (1080/59.94i and 720/59.94p system) and 24 (1080/50i and 25p system) and 25 (1080/23.98p and 24p system); i.e., in ascending sample order.

The check characters K_7 through K_0 are used as the vertical protection characters identified as PV_7 through PV_0 , respectively.

10.6 Inner protection

The inner protection and sync block formats are identical to those for compressed video data (see 6.3 and 6.4).

10.7 Order of transmission to inner coding

Audio data bytes (outer check bytes considered as data) are sent to the inner coder after the block shuffling.

10.8 Channel code

The channel code is identical to that for compressed video data (see 6.5).

10.9 Allocation of audio data sectors

The data blocks of an audio data channel are arranged in three groups of four sectors (12 sectors) as shown in figure 26 (1080/59.94i and 720/59.94p system) and 27 (1080/50i, 1080/25p, 1080/24p, and 1080/23.98p system). A group of six sectors from each of the eight audio data channels is recorded according to figures 33. Audio data sectors labeled Ac_1 to Ac_8 correspond to audio data input channels from one to eight, respectively.

The allocation of a group of sectors is a four-field sequence. The field address AF_0, AF_1 of the sector ID of four audio data sync blocks is defined in 6.3.3.

Time code signal timing relative to video signal timing at the output interface during playback shall be the same (temporal skew is equal to zero) as it was at the input interface during recording.

11.1.2 Time and control code information

The time and control code information shall refer to the video frame during which it is recorded (see 6.1).

11.1.3 Cue information

Cue information shall be recorded on the tape at a point referenced to the associated video information as defined by dimension P2 of figure 4, and table 1.

11.1.4 Control track servo pulse

Control track servo pulse record timing is described in 11.2.

11.2 Control track

11.2.1 Method of recording

The control track shall be recorded using the hysteresis (direct recording) method.

11.2.2 Servo reference pulse

The control track servo reference pulse, at the time of recording, shall be a series of pulses with a period of $11.122 \text{ ms} \pm 6 \mu\text{s}$ as shown in figure 34 (59.94i and 720/59.94p system), $13.333 \text{ ms} \pm 6 \mu\text{s}$ as shown in figure 35 (1080/50i and 25p system), $13.903 \text{ ms} \pm 6 \mu\text{s}$ as shown in figure 36 (1080/24p system) or $13.889 \text{ ms} \pm 6 \mu\text{s}$ as shown in figure 36 (1080/23.98p system).

11.2.3 Flux polarity

The polarities of the recorded flux shall be as shown in figure 4.

11.2.4 Flux level

The recording shall attenuate any previous recording by at least 30 dB.

11.2.5 Pulse width

The recorded pulses shall have periods of 3T, 4T, 5T, 6T or 7T where T equals to 1.1122 ms nominal (1080/59.94i and 720/59.94p system), 1.3333 ms nominal (1080/50i and 25p system), 1.3903 ms nominal (1080/24p system) or 1.3889 ms nominal (1080/23.98p system). The rise and fall times of the record current (10% to 90% points) shall be less than 150 μs .

11.2.6 Servo reference pulse timing

The servo reference pulses and the data of the program reference point, when recorded according to figure 4, shall occur at the same time.

11.2.7 Color frame pulse

A color frame sequence at the time of the start of each recording shall be indicated by a pulse rising transition point which follows a sequence of 6T-4T duration pulses. The color frame commences with color frame A field 1. It shall be located at the rising point after the 6T-4T duration pulses, coinciding with a segment count and a field count of zero in the compressed video data sector identification pattern, as defined in 6.3.3.

11.2.8 Video frame pulse

The first segment of a compressed video data frame at the time of the start of each recording shall be indicated by a pulse rising transition point, which follows a sequence of 6T-4T or 4T-6T duration pulses. It shall be located at the rising points after the 6T-4T or 4T-6T duration pulses, coinciding with a segment count and an even field count of zero in the compressed video data sector identification pattern, as defined in 6.3.3.

11.2.9 Number of audio data channels identification

Eight audio data channels recording shall be indicated by a sequence of 3T-7T pulses. These shall be located after the 6T-4T or 4T-6T duration pulses¹⁾ (see figures 34, 35 and 36).

NOTE – The sequence of 3T-7T pulses is unique to eight audio data tracks recording and may be used as a method for detection and differentiation of a HD-D5 recording with 4 audio data tracks.

11.3 Cue record

11.3.1 Recording method

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

11.3.2 Flux level

The recorded reference audio level shall correspond to an rms magnetic short circuit flux level of 125 nWb/m \pm 3 nWb/m of track width at 1000 Hz.

11.4 Time and control code record

11.4.1 Recording method

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

11.4.2 Flux level

The recorded peak-to-peak flux shall correspond to a magnetic short circuit flux level of 250 nWb/m \pm 20 nWb/m of track width.

11.4.3 Input signal

The signal recorded on this track shall be in accordance with SMPTE 12M.

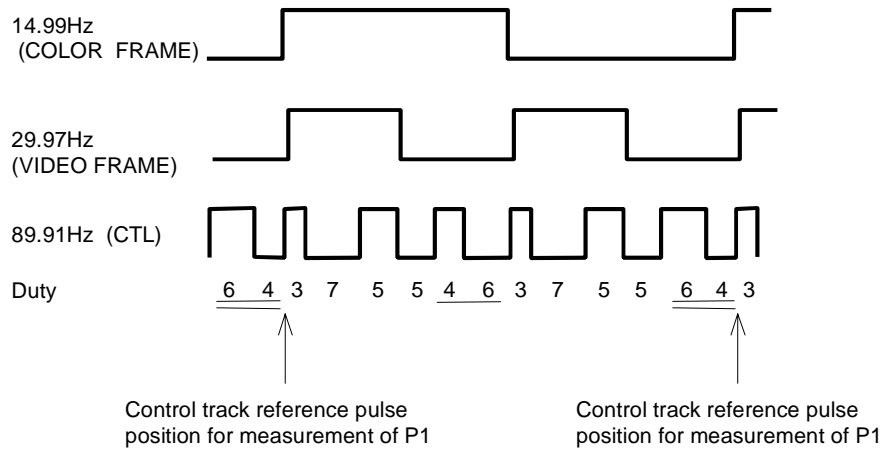


Figure 34 – Recorded control record waveform timing (1080/59.94i and 720/59.94p system)

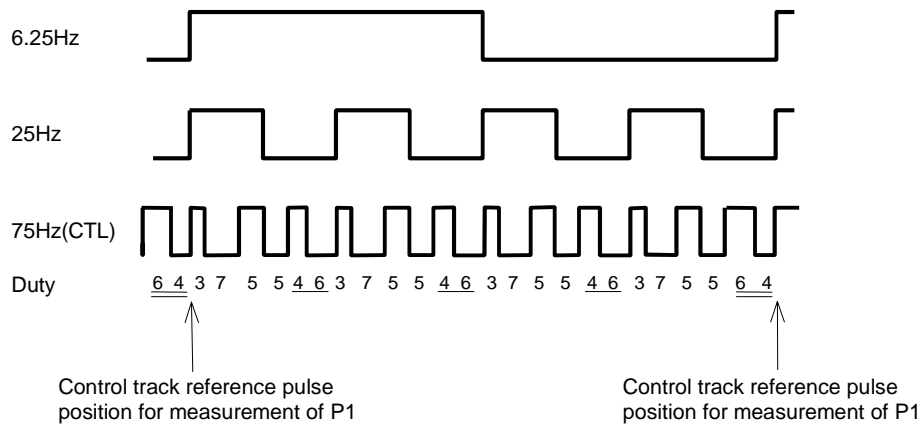


Figure 35 – Recorded control record waveform timing (1080/50i and 25p system)

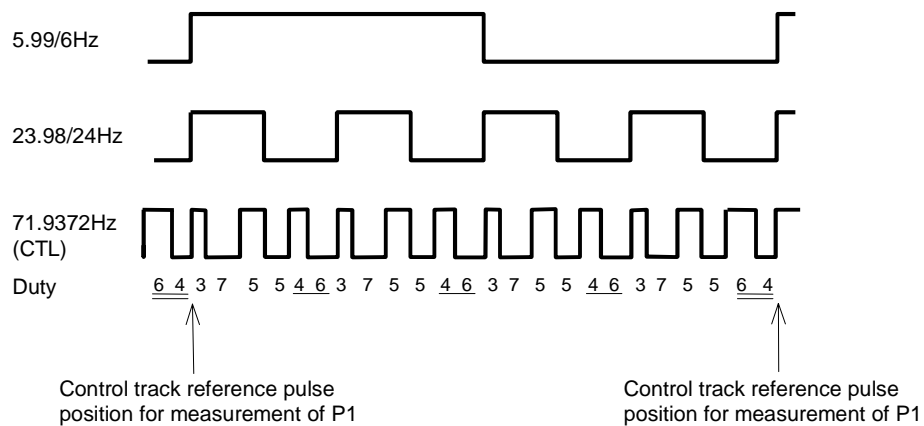


Figure 36 – Recorded control record waveform timing (1080/23.98p and 1080/24p system)

Annex A (normative)**Tape tension**

The value measured with a tension monitor on the entrance side of the scanner may vary among manufacturers, but would typically be $0.31 \text{ N} \pm 0.05 \text{ N}$.

Annex B (normative)**Cross-tape track measurement technique**

The cross-tape measuring technique utilizes the fact that all tracks of a helical-scan video recording, recorded by the same head at constant tape speed, have the same longitudinal track pitch, the same track angle, and the same track curvature.

From a ferrofluid development, measurements are made of the actual track positions and the distance between a minimum of 200 control track pitches. All measurements shall be made under the environmental conditions described in 3.1, except that the measurements are made without tape tension (see table B.1). The tape is then mathematically stretched to account for tape tension (see figure B.2). The theoretical track position is calculated from the corrected longitudinal track pitch and the theoretical track angle. The track location error is calculated as the difference between the theoretical track position and the actual track position (see table B.1 and figure B.3).

Track location error, which is expressed by the lower edge error of the tracks, includes track angle errors, track straightness errors, and track pitch errors. The starting point for calculations and measurements is, for example, the cross point of the lower edge of the track containing the program reference point and the line along the measurement path in figure B.2. The values for every eighth track are the errors for tolerance zone one. Shifting one track, the second tolerance zone may be measured and so on. It is not necessary to measure all tracks; a suitable number may be 20 samples per zone. A plot of the track location error against the track number must be computed (see figure B.3). The peak-to-peak value shall lie within the tolerance zones specified in 5.3.

Table B.1 – Nomenclature and calculation of track location error

| | | | |
|---|--|--|-----------------|
| | | 1080/59.94i, 720/59.94p, 1080/50i, 1080/25p 1080/23.98p system | 1080/24p system |
| Y_0 | Program area reference (basic) | 1.639 mm | 1.634 mm |
| θ | Track angle (basic) | 4.9384° | |
| T | Tension | 0.31 N | |
| E | Young's modulus | 8 000 N/mm ² | |
| A | Cross sectional area | Thickness × Width | |
| CTM | Distance of n control track pitches without tape tension | | |
| CTM' | Distance of n control track pitches with tape tension | CTM' = CTM(1+ T/(A × E)) | |
| g | Longitudinal track pitch | g= CTM'/4n | |
| i | Track number, i = 0 for track containing reference point | | |
| Y_i | Measured position of track i at the recorded pattern | | |
| ΔY | Cross section track pitch | $\Delta Y = g \times \tan \theta$ | |
| Y_{it} | Theoretical position of track i at the recorded pattern | $Y_{it} = Y_0 + i \times \Delta Y$ | |
| l | Track pitch | $l = g \times \sin \theta$ | |
| TLE | Track location error | $TEL = Y_i - Y_{it}$ | |
| Z | Tolerance zone | Z4 = 0.004 mm Z1, Z2, Z3, Z5, Z6, Z7, Z8 = 0.006 mm | |
| NOTE - For tolerance zone Z1: i = ... -8, 0, +8, +16, ... Z2: i = ... -9, -1, +7, +15, ... Z3: i = ... -10, -2, +6, +14, ... Z4: i = ... -11, -3, +5, +13, ... Z5: i = ... -12, -4, +4, +12, ... Z6: i = ... -13, -5, +3, +11, ... Z7: i = ... -14, -6, +2, +10, ... Z8: i = ... -15, -7, +1, +9, ... | | | |

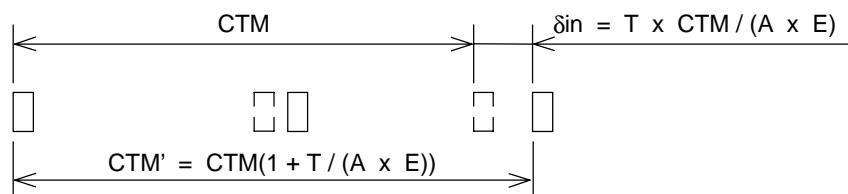
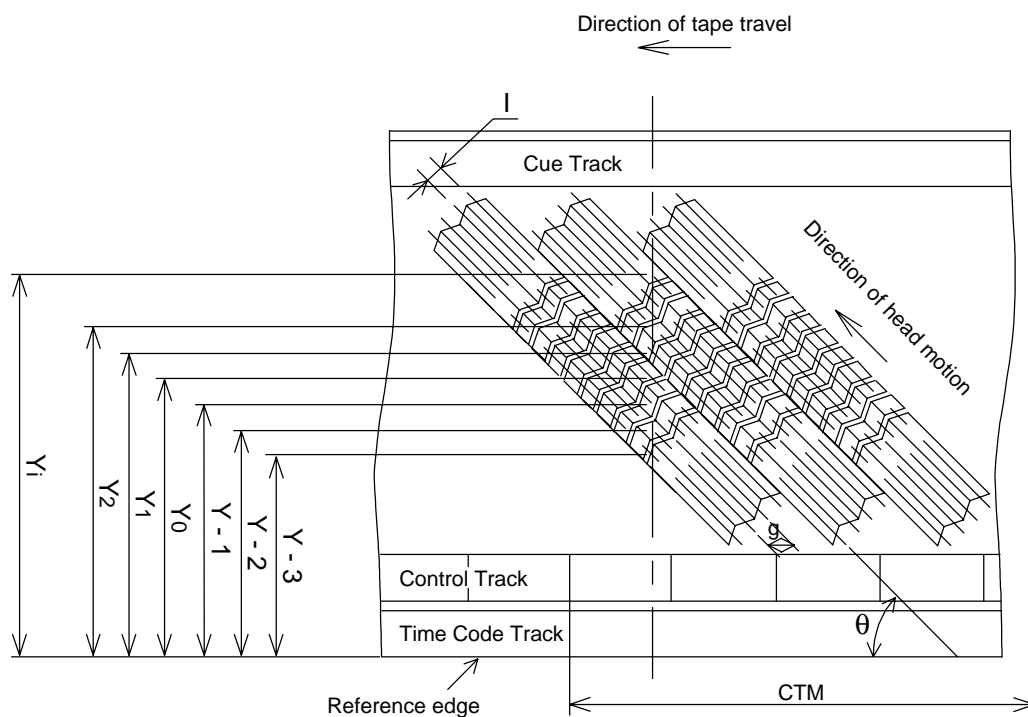


Figure B.1 – Correction factors (actual tape speed and tension)



NOTE – The same head must be used for Y_i measurement (i.e., every eighth track); CTM is the distance of n control track pitches ($n = 200$ minimum).

Figure B.2 – Cross-tape measurement technique

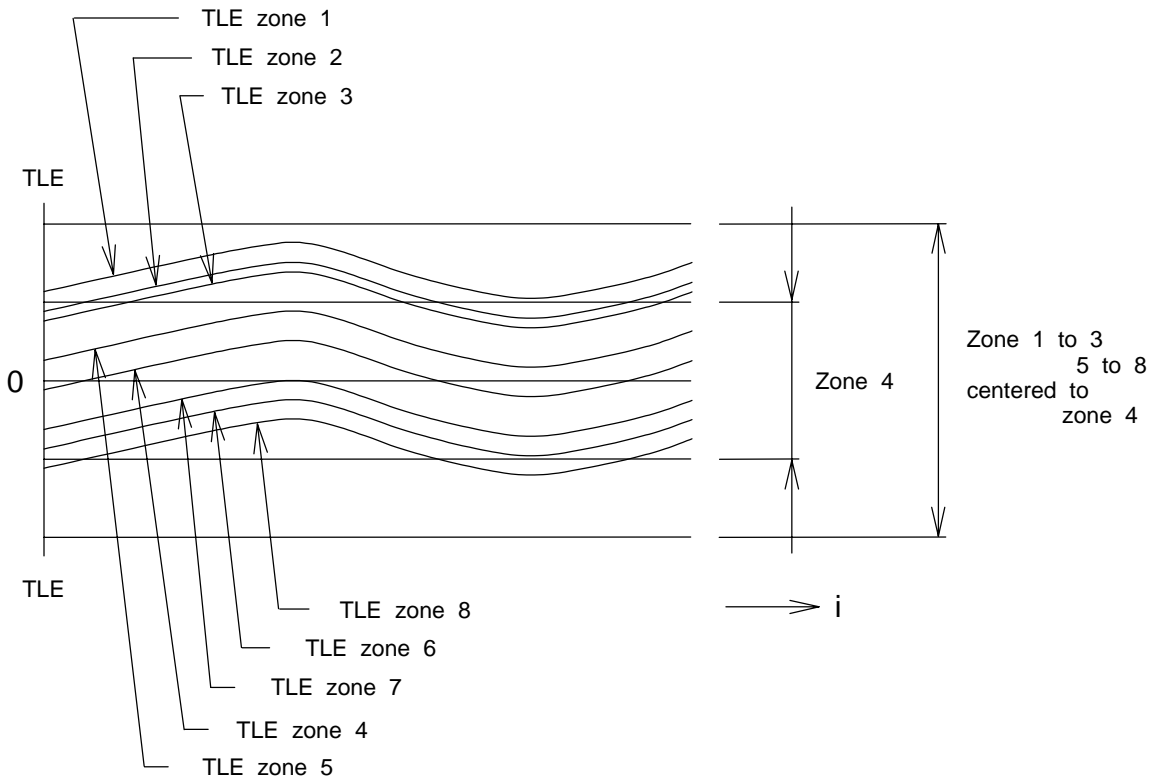
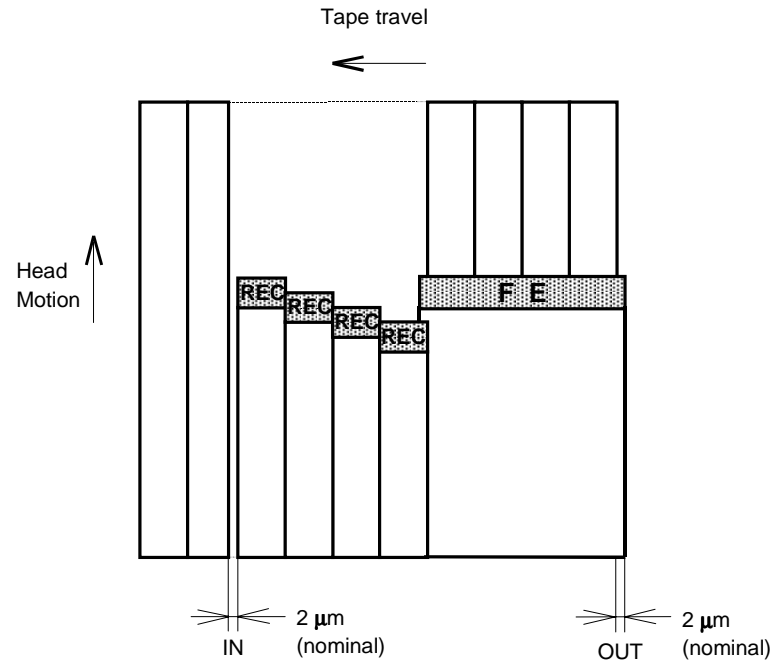


Figure B.3 – Track location error plot (example)

Annex C (normative)
Track pattern during insert editing

A guard band of 2 μm (nominal) at editing points only is shown in figure C.1.



NOTES - 1 REC is a recording head.
2 FE is a flying erase head.

Figure C.1 – A typical pattern during insert editing

Annex D (informative)

Video interface

D.1 Video parameters

The component signal source to be processed should comply with the video parameters as defined by SMPTE 274M and SMPTE 296M.

D.2 Serial digital interface

The interface of the digital video signal, if present, should conform to the component serial digital interface format interface as defined in SMPTE 292M.

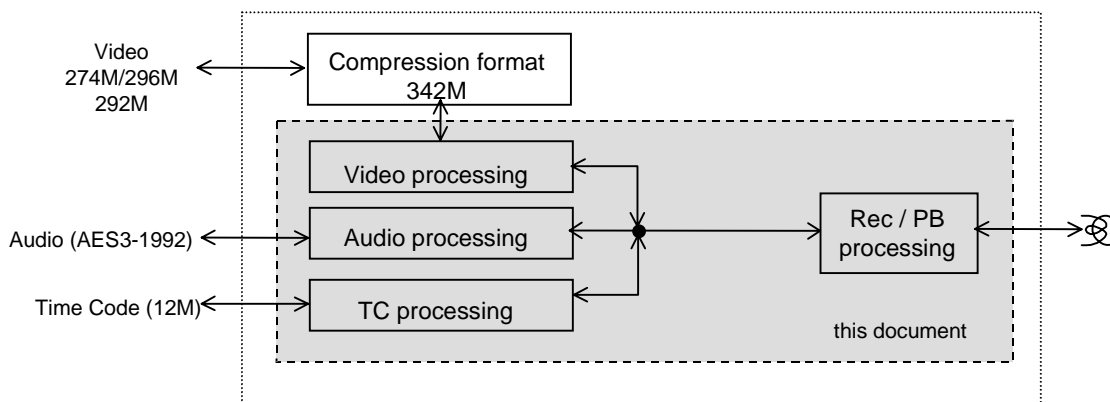


Figure D.1 – Block diagram of a recorder

Annex E (informative)
Reference and calibration tape

Blank tape for reference recordings should be available from any source meeting the tape characteristics as defined by this standard.

The calibration tapes meeting the requirements of 3.3.1 and 4 should be available from manufacturers who produce DTTs and players in accordance with this standard. Tolerances of the record locations and dimensions shown in table 1 will be reduced by 50%.

Two sets of signals should be recorded on the calibration tape:

- a) Video: 100% color bars
Audio: 1-kHz tone at 20 dB below full scale on each of the audio data channels
Cue: 1-kHz tone at reference level; 10-kHz tone at reference level

- b) A signal of constant recorded frequency (i.e., one half the Nyquist frequency) only on tracks of field 0, segment 0 for the purpose of mechanical alignment. Recording level should conform to 6.6.3.

Annex F (informative)
Tape cassette

Tape enclosure (tape cassette) is specified in SMPTE 263M.

Annex G (informative)
Abbreviations

| | | |
|--------|---|----------------------|
| AUX | Auxiliary | |
| CHAN | Channel use | |
| EFLG | Edit flag | |
| FNCT | Field number count | |
| HD-D5 | Recording format described by SMPTE 279LNGH | Audio data word mode |
| PREF | Preemphasis | |
| S MARK | Block sync location | |

Annex H (informative)
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