SMPTE 247M-2003
Revision of
ANSI/SMPTE 1993

SMPTE STANDARD

for Television Digital Recording — 19-mm Type D-2 Composite Format — Helical Data and Control Records

1 Scope

1.1 This standard specifies the content, format, and recording method of the data blocks forming the helical records on the tape containing video, audio, and ancillary data in the 19-mm type D-2 helical-scan television recorder. In addition, clause 4 of 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. Track dimensions and locations are specified in ANSI/SMPTE 245M.

1.2 The standard applies to recorders operating in the 525-line television system with a frame frequency of 29.97 Hz nominal and in accord with SMPTE 244M. One video channel and four independent audio channels are recorded. Audio channels operate in accord with ANSI S4.40 at a nominal 48-kHz sampling frequency.

1.3 Figures 1 and 2 show a block diagram of the processes involved in the recorder.

2 Normative references

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

ANSI S4.40-1992 (R1998), Digital Audio Engineering — Serial Transmission Format for Two-Channel Linearly Represented Digital Audio Data

ITU-R BT.470-6 (11/98), Conventional Television Systems

3 Helical record content

3.1 Introduction

Six helical tracks are used to record each TV field.

The helical track is recorded with the digital data from the video channel and the four audio channels. The audio data is contained in four recorded sectors per track, two at the beginning of the track and two at the end of the track. The audio data is recorded twice. The video data is recorded in a sector in the middle part of each track. An edit gap between sectors accommodates timing errors during editing. Figure 3 shows the arrangement of video and audio sectors on the tape.

Approved
February 7, 2003

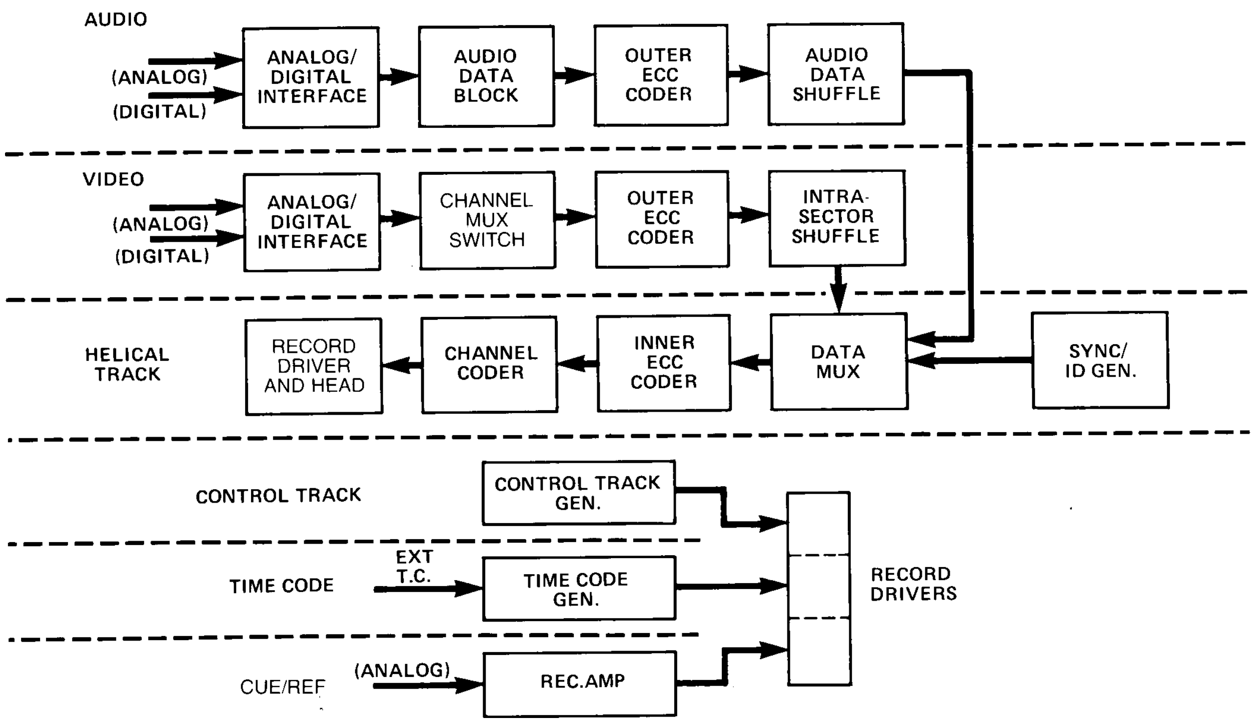


Figure 1 – Block diagram – Record

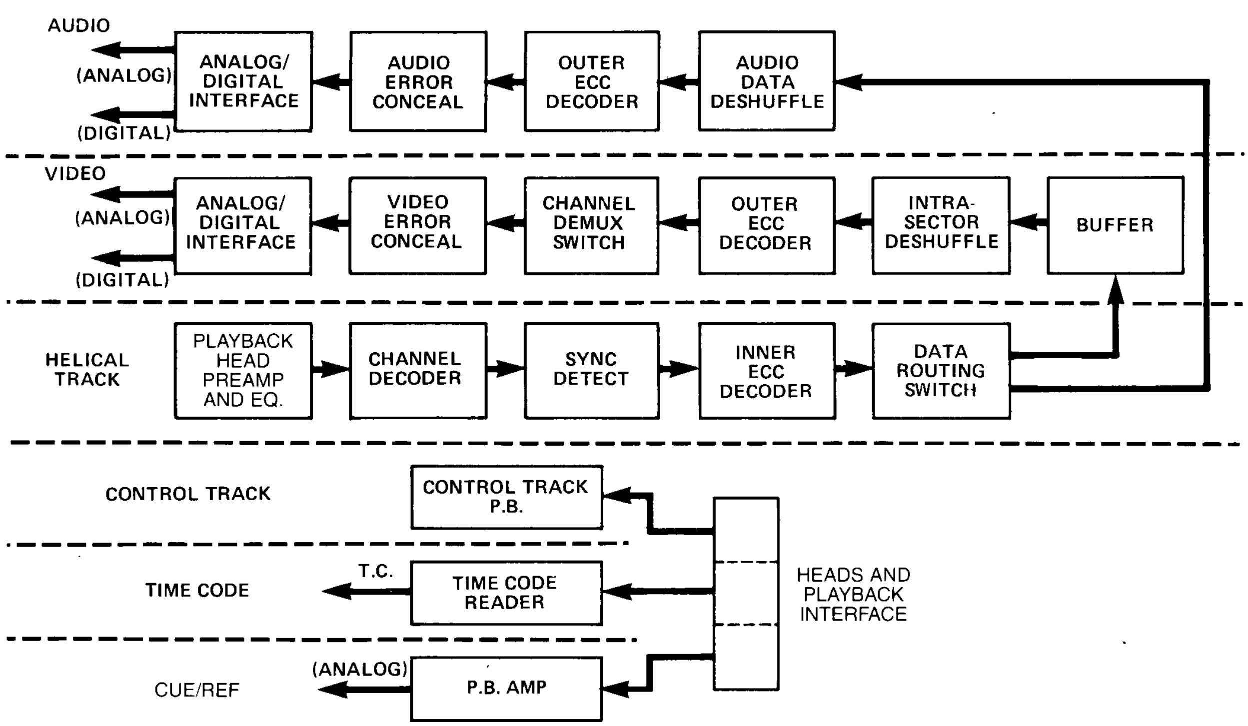
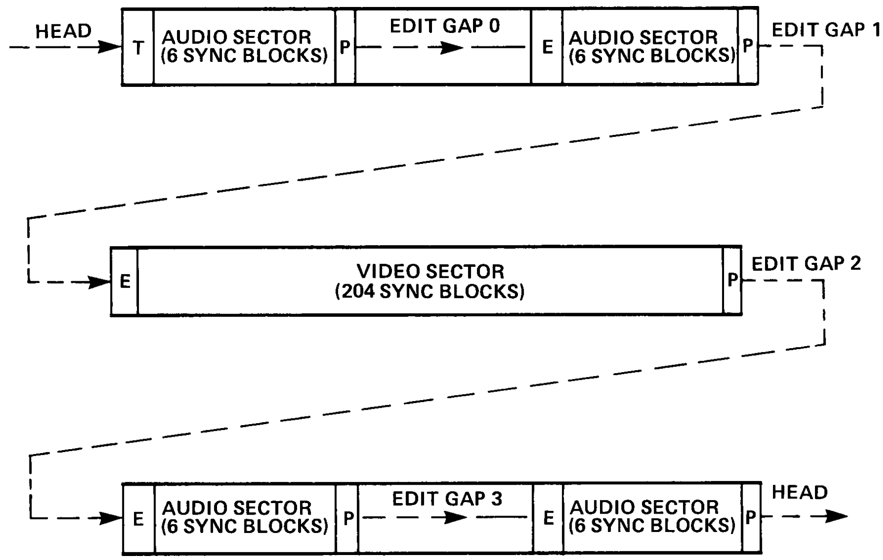


Figure 2 – Block diagram – Reproduce



NOTES
1 T = Track preamble (62 bytes)
2 E = in-track preamble (28 bytes)
3 P = Postamble (6 bytes)
4 Sync block = 190 bytes
5 Edit gap = 156 bytes nominal

Figure 3 – Sector arrangement on helical track

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

– Preamble containing clock run-up sequence, sync pattern, and identification 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.

3.2 Labelling conventions for audio and video data

In this standard, the least significant bit is shown on the left and is the first 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.

3.3 Sync block

The sync block format is common to both audio and video sectors. Each sync block contains a sync pattern (2 bytes), and two inner code blocks. Each inner code block contains 85 data bytes (outer check bytes are considered data) plus 8 inner check bytes. Inner code block 0 includes and protects the two bytes of an identification pattern.

Figure 4 shows the sync block format.

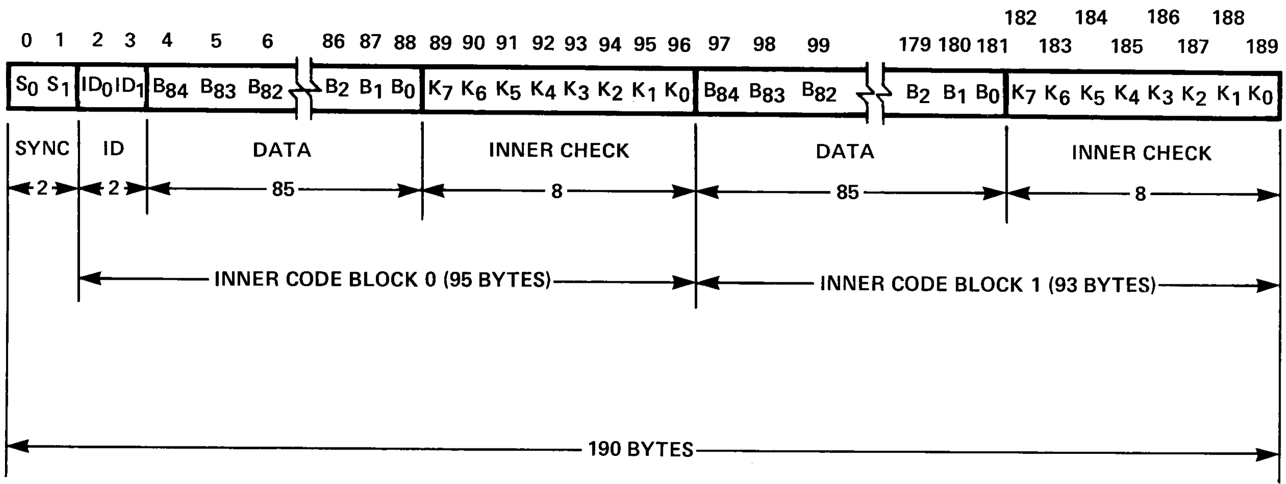


Figure 4 – Sync block format

3.3.1 Sync pattern

(a) Length: 16 bits (2 bytes)

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

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

(c) Protection: None

3.3.2 Identification pattern

The first byte of the identification pattern identifies a particular sync block of a helical track. The second byte of the identification pattern identifies a particular track. Figure 5 shows the format of the identification pattern.

The first and second audio copies have the same segment numbers. The audio segment number located at the start of a track (second copy) is the same as the video segment number on the same track. Each audio field is composed of 3 segments, the first segment number is 0_h.

(a) Length: 16 bits (2 bytes)

(b) Arrangement:

The sync block number (byte 2) follows a coded sequence along the track. Figure 6 shows the sequence of sync block numbers.

The sector ID (byte 3) identifies a particular sector. The V/A bit distinguishes between audio and video sectors. The T bit distinguishes between two tracks corresponding to channels 0 and 1.

The segment count is modulo 3, the field count for video sectors is modulo 4, and the field count for audio sectors is modulo 5. (See figure 7.)

c) The field address F0, F1 (bits 4 and 5 of the sector ID for video sync blocks) shall identify the 4-field color sequence as defined in ITU-R BT.470-6, figure 5(c), and has the following values:

		F_0	F_1
Color frame A	Field I	0	0
Color frame A	Field II	1	0
Color frame B	Field III	0	1
Color frame B	Field IV	1	1

(d) Protection: The identification pattern is protected by inner code block 0.

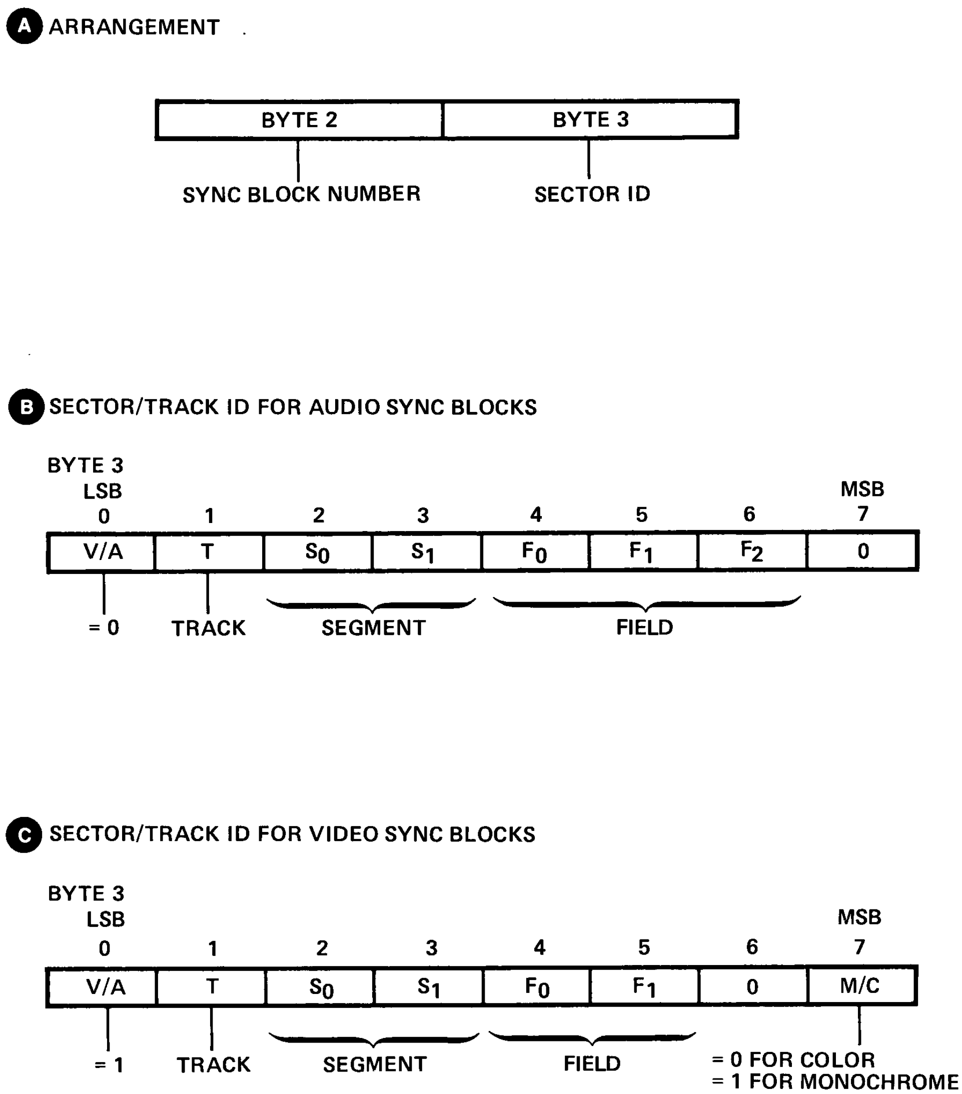


Figure 5 – Sync block identification format

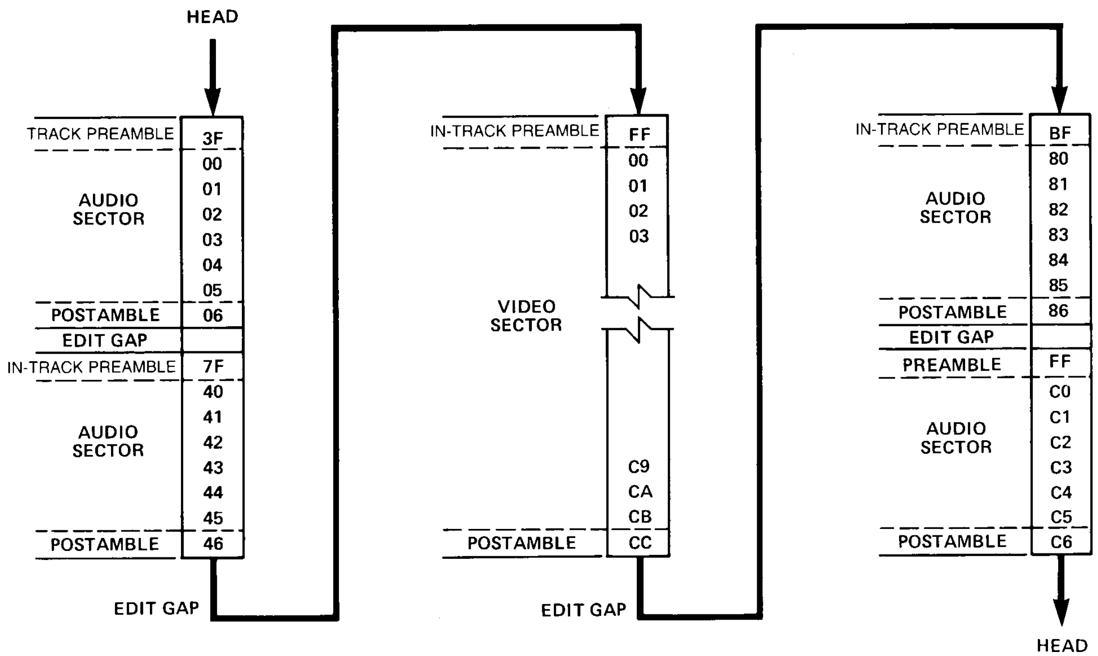
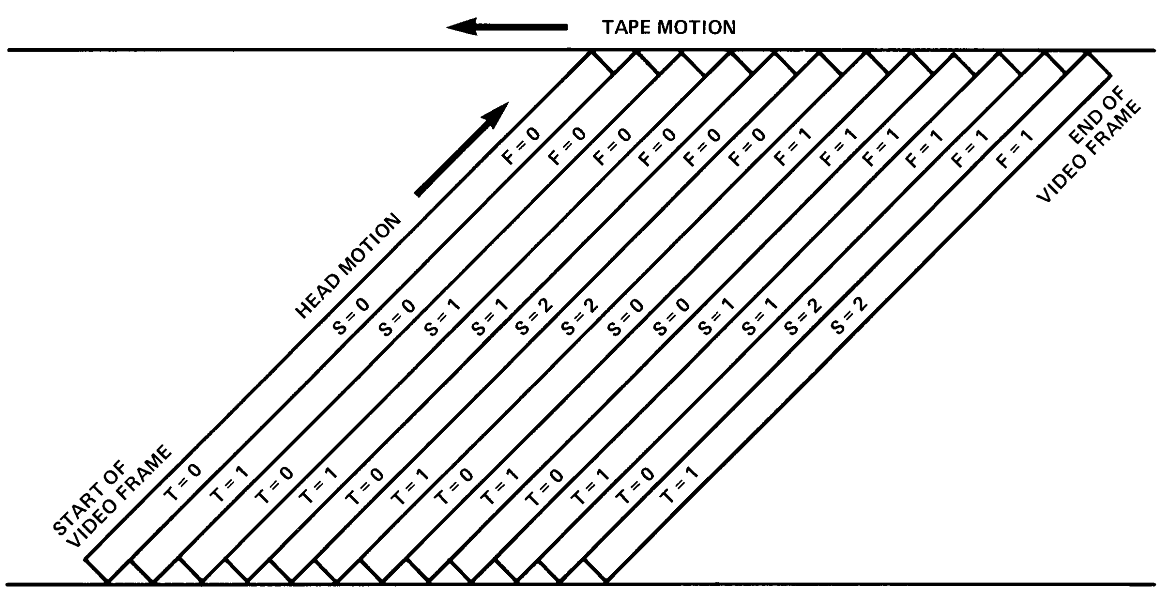


Figure 6 – Sync block ID number



NOTES
1 T = Track number (0, 1)
2 S = Segment number (0...2)
3 F = Field number (0...3)
4 Audio sectors not shown

Figure 7 – Track, segment and field numbers

3.3.3 Sync block data field/error correction coding

The sync block format is common to both audio and video data, and the associated inner ECC code blocks.

(a) Length: 2 inner code blocks. Inner code block 0 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. Inner code block 1 contains 93 bytes consisting of 85 data bytes plus 8 inner ECC check bytes.

(b) Arrangement: See figure 4

(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.

Code generator polynomial 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 $(02)_H$ in GF(256).

Check characters are $K_7, K_6, K_5, K_4, K_3, K_2, K_1, K_0$ 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 for

Inner code block 0: $D(x) = ID_0x^{86} + ID_1x^{85} + B_{84}x^{84} + ... + B_2x^2 + B_1x + B_0$

Inner code block 1: $D(x) = B_{84}x^{84} + B_{83}x^{83} + ... + B_2x^2 + B_1x + B_0$

Equation of full inner code block 0: $ID_0x^{94} + ID_1x^{93} + B_{84}x^{92} + B_{83}x^{91} + ... + B_1x^9 + B_0x^8 + K_7x^7 + K_6x^6 + ... + K_2x^2 + K_1x + K_0$

Equation of full inner code block 1: $B_{84}x^{92} + B_{83}x^{91} + ... + B_1x^9 + B_0x^8 + K_7x^7 + K_6x^6 + ... + K_2x^2 + K_1x + K_0$

3.4 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 and pattern 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.

3.4.1 Track preamble for start of field track pair

This preamble precedes the first sector of the first pair of tracks of every field (segment 0). The run-up sequence is 54 bytes long and consists of 18 repetitions of the three-byte pattern $B6_H$, $6D_H$, DB_H.

(a) Length: 62 bytes

(b) Arrangements: See figure 8A

(c) Run-up pattern: $B6_H$, $6D_H$, DB_H

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

(d) Protection: None

3.4.2 Track preamble

This preamble precedes the first sector of every track other than the first pair of tracks of every field. The run-up sequence is 54 bytes long and contains AA_H.

(a) Length: 62 bytes

(b) Arrangement: See figure 8B

(c) Run-up pattern: AA_H

LSB							MSB
0	1	0	1	0	1	0	1

(d) Protection: None

3.4.3 In-track preamble

This preamble precedes every sector which is not the first sector of a track. The run-up sequence is 20 bytes long and contains AA_H.

(a) Length: 28 bytes

(b) Arrangement: See figure 8C

(c) Run-up pattern: AA_H

LSB							MSB
0	1	0	1	0	1	0	1

(d) Protection: None.

3.5 Postamble

All sectors are followed by a postamble containing a sync pattern (2 bytes), identification pattern (2 bytes), and fill pattern (2 bytes).

When a sector is edited, the postamble shall be recorded together with the new data.

(a) Length: 6 bytes

(b) Arrangement: See figure 8D

(c) Protection: None

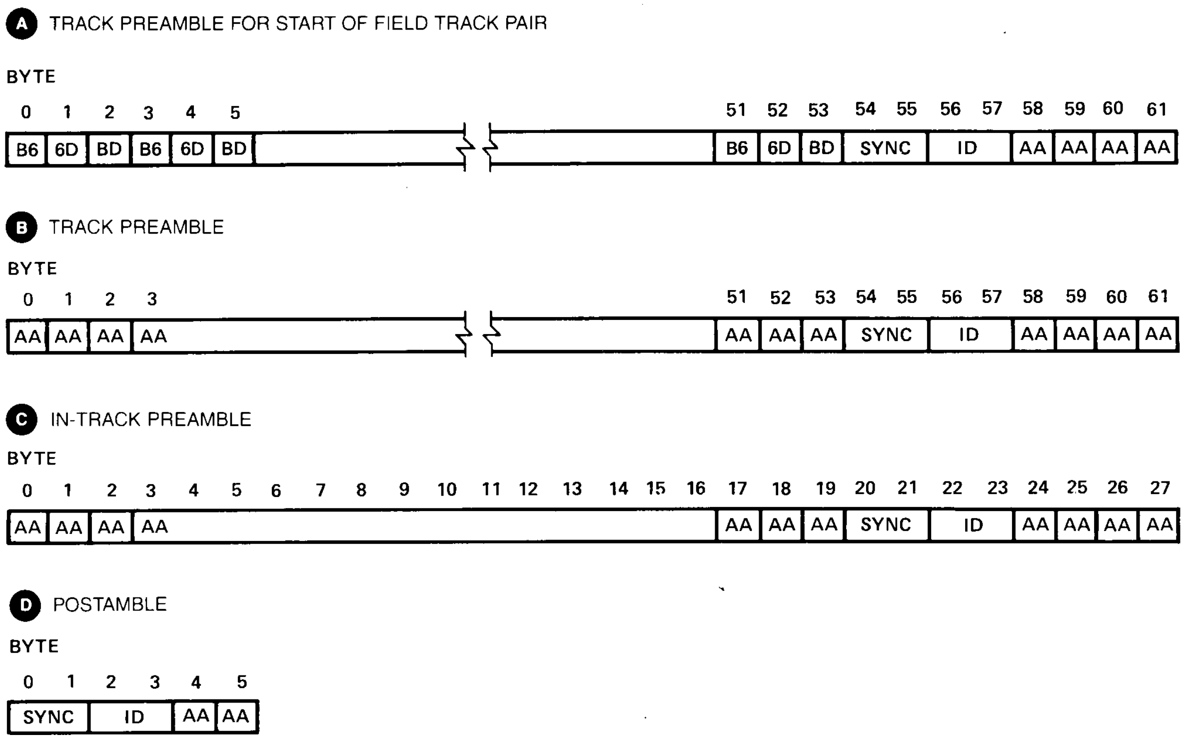


Figure 8 – Sector preamble and postamble

3.6 Edit gaps

The space between sectors on a track, exclusive of postamble and preamble, is nominally 156 bytes long and is used to accommodate timing errors during editing. In an original recording, the edit gap shall contain the pattern AA_H repeated 156 times.

During an edit, the edit gap may be partially rewritten with AA_H, provided that the preamble and postamble of adjacent unedited sectors are not overwritten.

3.7 Channel code

The channel code shall be the Miller-squared code which is defined by the following code rules:

(1) The data stream is divided into the following types of sequences:

- (a) Any number of consecutive ones;
- (b) Two zeros separated by either no ones or any odd number of ones;
- (c) One zero followed by any even number of ones.

Note that a sequence of type (c) cannot be followed by a sequence of type (a).

(2) Sequences of types (a) and (b) are encoded according to the Miller code (equivalent to modified FM (MFM)) rules. That is, data ones are encoded as transitions in the middle of the bit cell, isolated data zeros are ignored, and transitions are inserted at the boundary of a bit cell between adjacent data zeros.

(3) Sequences of type (c) are encoded according to the Miller code rules except that the transition associated with the last bit of the sequence is suppressed.

3.8 Magnetization

The recorder shall operate in reproduce without regard to the polarity of data flux during recording on the helical tracks. The record current will be constant for all recorded frequencies involved in the Miller-squared spectrum. The record magnetization shall be optimized for best signal-to-noise ratio at a frequency of one-half the maximum channel data rate.

3.9 Video processing

3.9.1 Sampling

Signals are sampled at $4f_{SC}$ (14.31818 MHz), using 8-bit linear quantization from 01_H to FF_H inclusive. The sample value of (00_H) shall not be recorded on tape nor should it occur at the interface. (See SMPTE 244M.)

3.9.2 Recorded data

Information received during the horizontal blanking interval and vertical sync interval is not recorded on tape.

3.9.2.1 Recorded samples of the television line 768 samples per line are recorded, centered about the active picture. Figure 9 shows the relationship between video signals in the analog and digital domains together with the address numbers of the digitized samples for zero-degree ScH phase of the incoming signal.

Under this condition, sample number 785 occurs 44.2 ns (57° of color subcarrier) after the 50-percent point of the leading edge of the horizontal sync pulse.

The first active sample to be recorded at address location 0 (decimal) of line 10 of field 1 of color frame A, as defined in ITU-R BT.470-6, is the I sample.

3.9.2.2 Recorded lines of the television frame

From each field, 255 consecutive lines are recorded (3 segments of 85 lines each). The first recorded line of each field varies over a four-field sequence as follows, with the line numbers defined as in ITU-R BT.470-6 (figure 5c), except the line numbers repeat on a television frame basis:

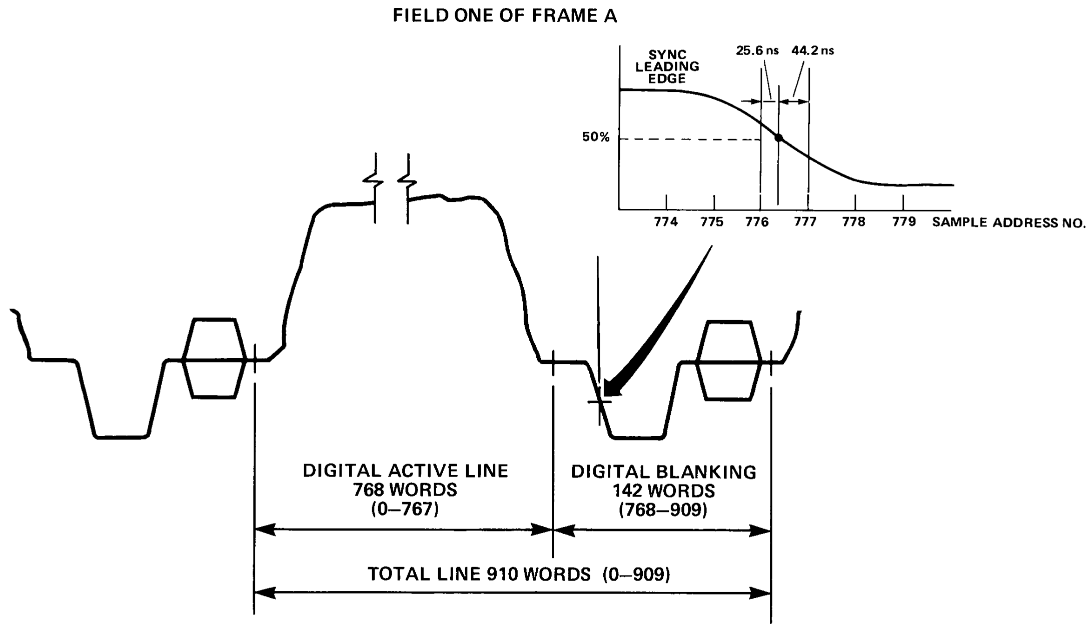
- From field I of color frame A, the first recorded line is number 10;
- From field II of color frame A, the first recorded line is number 272 (line 9 of field II);
- From field III of color frame B, the first recorded line is number 9 (line 9 of field III);
- From field IV of color frame B, the first recorded line is number 271 (line 8 of field IV).

3.9.3 Channel distribution of samples

The samples are distributed between 2 channels in a checkerboard pattern which alternates from line to line.

Figure 10 shows the distribution of samples.

In figure 10, the channel number (0 or 1) coincides with the track number as defined in 3.3.2(b) and figure 7.



NOTE – Zero-degree ScH.

Figure 9 – Horizontal sync relationship

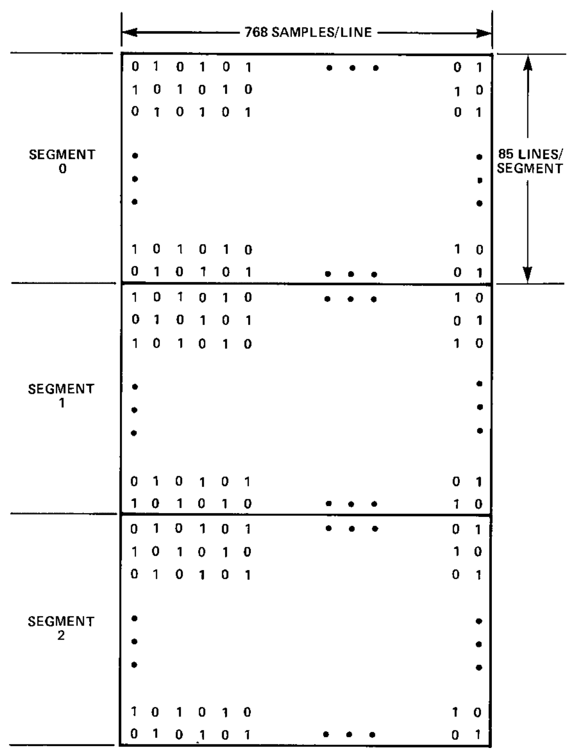


Figure 10 – Channel distribution of samples

3.9.4 Data shuffling

3.9.4.1 Introduction

The video data for each channel in each segment is shuffled before being written to tape. The shuffling distance is over all the television lines within a segment. The outer ECC check data is not shuffled, but is recorded at the beginning of the video sector on tape.

The shuffling algorithm may be considered as a combination of an intraline shuffle process preceding the outer ECC coder, and a sector memory shuffle process following the outer ECC coder.

Each television line contains 6 outer code blocks per channel. The samples within each outer code block are spaced 12 samples horizontally within the television line, although they appear in a permuted order within the outer block.

The horizontal sample number of the first sample in each outer block is given by an algebraic function which depends on the line number and outer block number within a line. The horizontal sample number increment between consecutive samples within an outer block is a constant which generates a permutation of the samples spaced 12 apart within a television line.

The sector array shuffle is a permutation of the columns, which results in each inner ECC code block containing one sample from each television line within a segment.

In addition, when data is recorded on tape, the data for channel 1 is read from the segment memory with a segment memory row offset relative to the data for channel 0.

3.9.4.2 Algebraic definition

The shuffling process operates identically for all segments of all video fields.

Let L be the television line number within a video segment:

L = 0, 1, ..., 84

Let h be the horizontal sample location within line L:

h = 0, 1, ..., 767

Let ih be the horizontal sample index following the channel distribution process described in 3.9.3:

ih = int (h/2), ih = 0, 1, ..., 383

where int(x) means largest integer less than or equal to x

Let Oblock be the outer block number within line L:

Oblock = 0.1, ..., 5

Let Obyt be the sample number within outer block Oblock:

Obyt = 0, 1, ..., 63

(Outer code check bytes are not included in the intraline shuffle process.)

Then sample Obyt within outer block Oblock is mapped to the television screen according to the following formula:

$$ih = (12 \cdot L + 277 \cdot Oblock + 258 \cdot Obyt) \bmod 384$$

The outer ECC coder places check bytes K_3, K_2, K_1, and K_0 in locations Obyt = 64, 65, 66, and 67, respectively.

The byte at location Obyt in outer block Oblock is placed in the sector memory array at location (Row, Col) where:

$$Row = Obyt \text{ and } Col = L + 85 \cdot Oblock$$

The sector memory array data of channel 0 is written to tape first by column order (0, 1, ..., 509) then by descending row order (67, 66, ..., 2, 1, 0).

For the sector memory of channel 1, the column order is the same as for channel 0 but the row order is different.

Let R_0 and R_1 be the row address for the segment memory of channel 0 and channel 1, respectively, as the data is written to tape. Then R_1 is given by the following formula:

$$R_1 = \begin{cases} (R_0 + 32) \bmod 64, & 0 \le R_0 \le 63 \\ R_0, & 64 \le R_0 \le 67 \end{cases}$$

3.9.5 Sector array

The sector array, positioned between the inner and outer ECC codes, is dimensioned 510 columns (6 times 85 bytes), and 68 rows (64 video data plus 4 outer check bytes). Figure 11 illustrates the sector array.

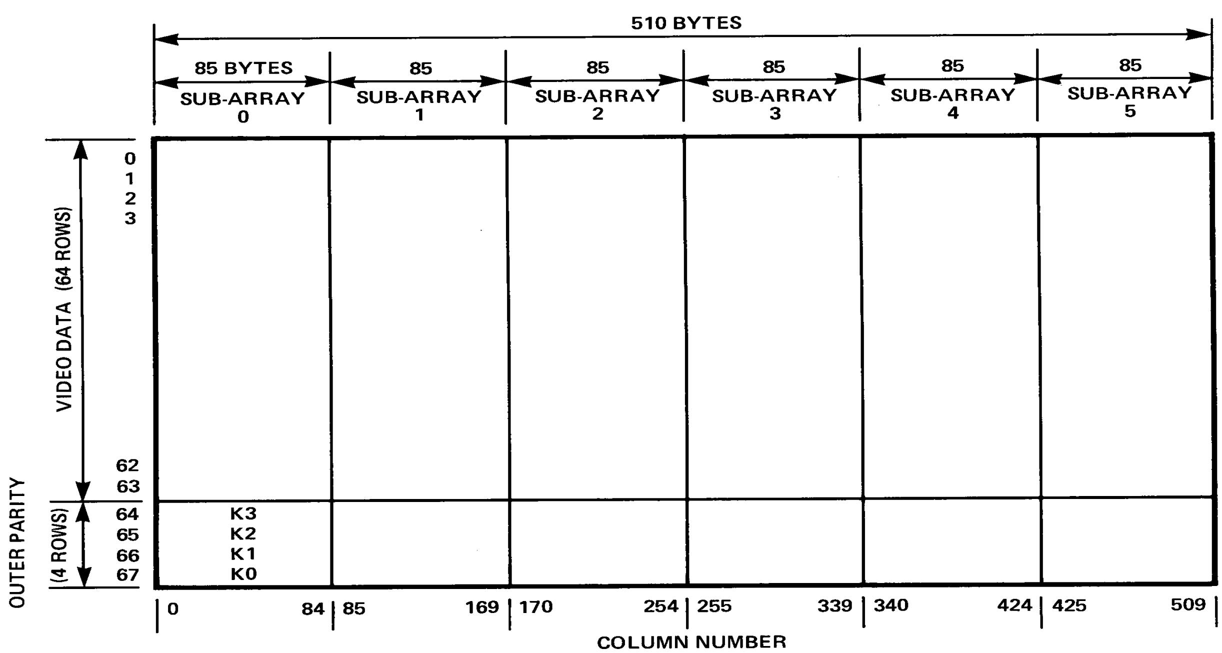


Figure 11 – Video sector array

3.9.6 Outer error protection

Four rows of each video sector 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: Left-most term is most significant.

Code generator polynomial GF(256): $G(x) = (x + 1)(x + a)(x + a^2)(x + a^3)$, where a is given by 02(H) in GF(256).

Check characters are K_3, K_2, K_1, K_0 in $K_3x^3 + K_2x^2 + K_1x + K_0$ obtained as the remainder after dividing X^4D by G(x), where D(x) is the polynomial given by $D(x) = B_{63}x^{63} + B_{62}x^{62} + ... + B_2x^2 + B_1x + B_0$.

Equation of full code is given by $B_{63}x^{67} + B_{62}x^{66} + ... + B_1x^5 + B_0x^4 + K_3x^3 + K_2x^2 + K_1x + K_0$.

3.10 Audio processing

3.10.1 Introduction

Audio in each of the four channels is processed independently and identically into a product block for each channel of dimension 85 columns by 8 rows. The audio samples of each channel are shuffled after the addition of error-correction data in the vertical (row) direction. Error correction in the horizontal (column) dimension is common with video data, as is synchronization. Auxiliary words are multiplexed with the audio data in the product block to provide housekeeping in the interface and in processing. Figure 12 shows the layout of the audio data block.

3.10.2 Source coding

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

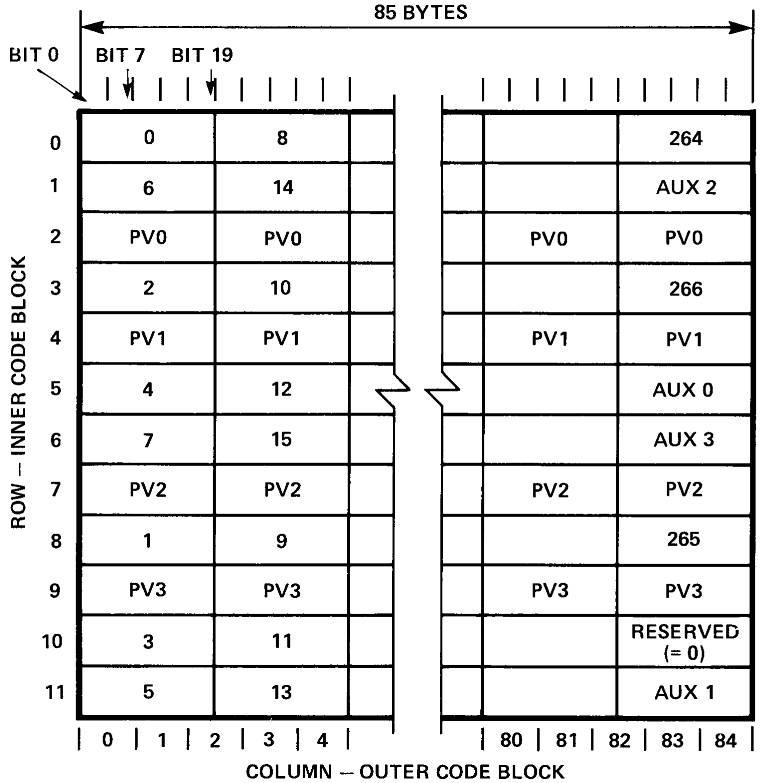
Source data is defined as follows:

(a) Audio data

Sampling frequency: 48 kHz ± 3 parts in 10^6, synchronous with video
Word length: 20 bits
Coding: Twos complement linear PCM

(b) Channel status data

Bit rate: 48 kbit/sec (nominal)
Byte rate: 6 kbyte/sec
Block length: 192 bits, 24 bytes
Coding: See ANSI S4.40



NOTES
1 Numeric table entries are audio sample number.
2 Sample 266 is equal to sample 265 for one block in every 5 fields.

Figure 12 - Audio data block layout

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

Bytes 0 and 1 of status data only are selected for special processing in the DTTR. The contents of bytes 0 and 1 are shown in tables 1 and 2, respectively.

(c) User data

As status data but data coding is undefined.

(d) Validity data

Bit rate: One bit associated with each audio word.

Coding: 0 = sample valid; 1 = sample defective

(e) Parity bit

Bit rate: One bit associated with each audio word.

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

Table 1 – 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 (CCITT J.17, not supported)

Bit 5: 0

Bit 6: Sampling frequency 0

Bit 7: Sampling frequency 1

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

Table 2 – 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

3.10.3 Source processing

3.10.3.1 Introduction

Audio data is processed in segments nominally corresponding in duration to one video segment. Each segment contains approximately 267 audio samples for an audio channel with associated status, user, and validity data. In addition, a number of control and user words are added to the data.

3.10.3.2 Relative audio-video timing

For the purposes of audio timing, the duration of one audio segment is defined as one-third of a video field. Audio segment zero begins with the audio sample acquired 128 samples (± 20 sample periods) before the first preequalizing pulse of the vertical interval of the input video signal.

The location on tape of the first video segment and its associated audio segment is given in figure 13.

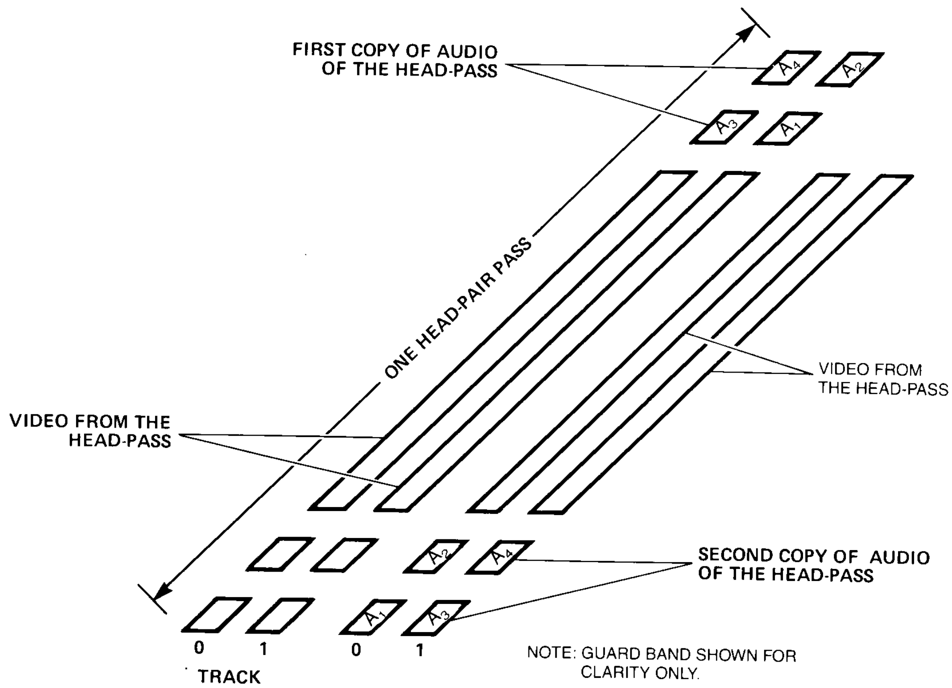


Figure 13 – Relative audio-video timing

3.10.3.3 Segment

Each segment of audio data is processed into an audio block of dimension 12 x 85 bytes each corresponding to an audio sector on tape. The data portion of the block is 8 x 85 bytes with the balance being outer error correction words.

Audio data words: 266 or 267 words with associated C, U, V, and R bits (20 bits total per word). (For security, the word EFLG is written four times in each audio block.)

Auxiliary words: Five words of four bits, plus two words of nine bits.

3.10.3.4 Audio data word processing

Input data is formed into words of 20 bits in the sequence shown below (see 3.10.4.3).

(a) Assignment of the 20-bit word to the audio sample and associated data is controlled by user input as shown in table 3.

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

(b) Each group of 20-bit words is divided into 8-bit bytes as shown in figure 14, beginning with the LSB of the first word of the word group.

(c) Each group is distributed into the product block in accordance with figure 12.

Table 3 – Audio data word mode

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

NOTE – Audio 1 represents bit 1 of the audio sample.

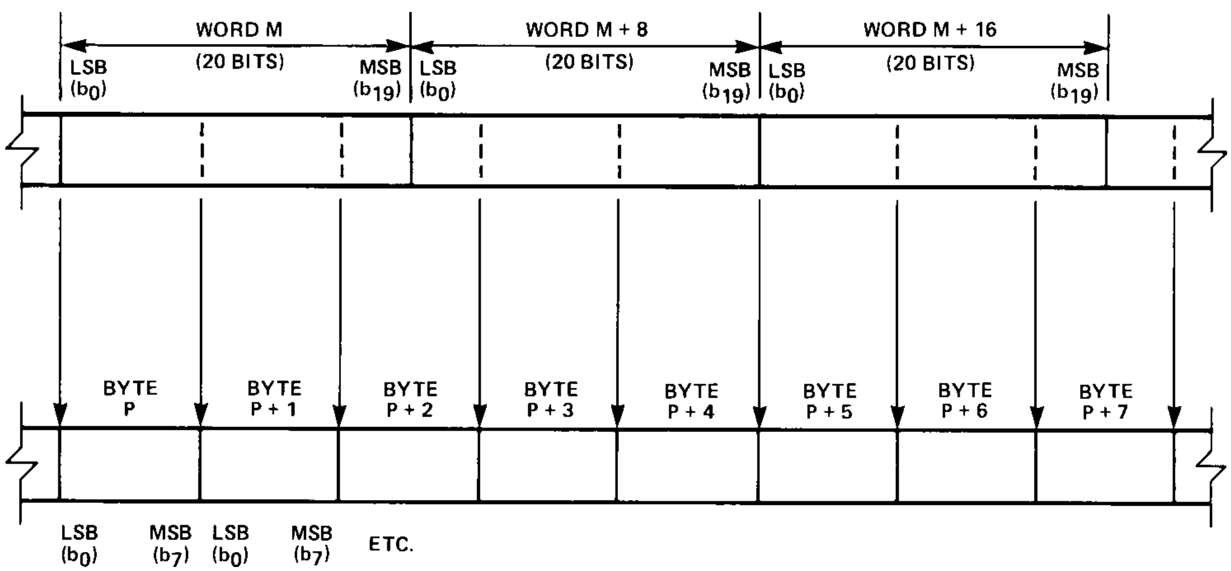


Figure 14 – Allocation of audio words to bytes

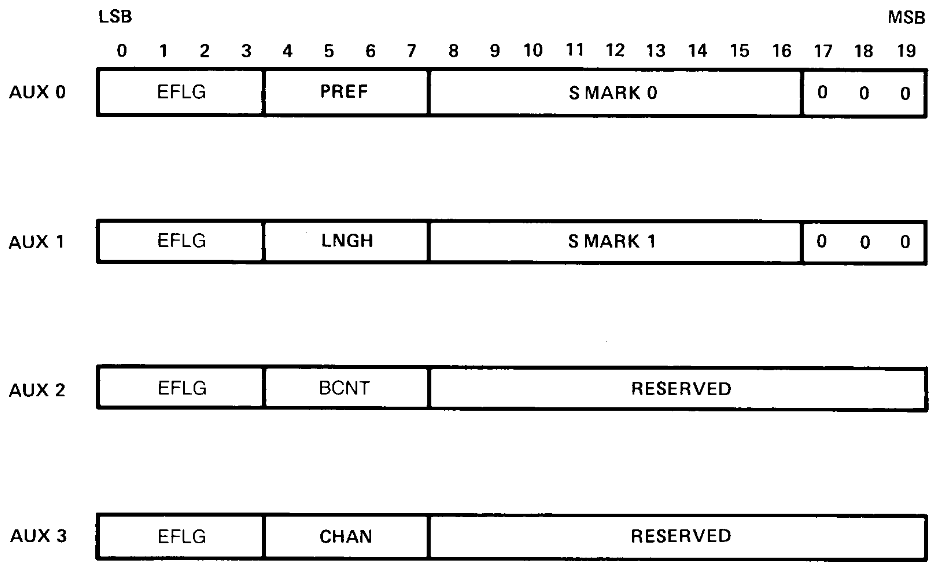
(d) Sample number 266 is unoccupied for one block in every 5 fields. Its value should be equated to that of sample number 265. Audio segment zero of every 5th field shall contain 266 samples. All other segments shall contain 267.

The 5-field sequence of the number of audio samples begins at an arbitrarily chosen field. Continuity of the 5-field sequence shall be preserved throughout the recording, including editing. The beginning of the 5-field sequence is indicated by the value of the auxiliary word BCNT, as defined in 3.10.4.5, as well as by a segment count and field count of zero in the audio sector ID, as defined in 3.3.2.

3.10.4 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 have a length of 20 bits.

Figure 15 shows the format of the auxiliary words in the audio data block.



NOTE – Reserved = 000_H

Figure 15 – Audio data block auxiliary data

3.10.4.1 Channel use (CHAN) — 4 bits

Specifies the usage of the two input channels in an interface data stream. CHAN is derived from channel status byte 1.

LSB MSB

Bit 0 1 2 3 4 5 6 7 Channel status (AES/EBU byte 1)

↓ ↓ ↓ ↓

0 1 2 3 CHAN

Bit 0: Channel mode bit 0

Bit 1: Channel mode bit 1

Bit 2: Channel mode bit 2

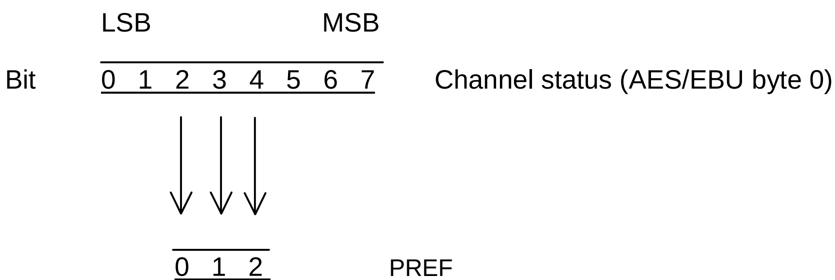
Bit 3: Channel mode bit 3

	CHAN				
Mode	0	1	2	3	Value
0	0	0	0	0	2 channel, default
1	0	0	0	1	2 channel
2	0	0	1	0	Single channel
3	0	0	1	1	Primary / secondary 2 channel
4	0	1	0	0	Stereophonic
5	0	1	0	1	Undefined
•	•	•	•	•	•
•	•	•	•	•	•
•	•	•	•	•	•
•	•	•	•	•	•
•	•	•	•	•	•
F	1	1	1	1	Undefined

NOTE – CHAN is inserted in bits 4-7 of AUX 3.

3.10.4.2 Preemphasis (PREF) — 4 bits

Specifies the usage of preemphasis in the audio coding. Pref is derived from channel status byte 0.



Bit 0: Preemphasis bit 0

Bit 1: Preemphasis bit 1

Bit 2: Preemphasis bit 2

Bit 3: 0

	PREF BIT			
Mode	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 (CD type)
7	1	1	1	Reserved

NOTE – PREF is inserted in bits 4-7 of AUX 0.

3.10.4.3 Audio data word mode (LNGH) — 4 bits

Specifies the word length and usage of the ancillary bits status, user, and validity. LNGH is derived from user control inputs.

	LSB			SB	
Bit	0	1	2	3	LNGH

Bit 0: Not used = 0

Bit 1: LNGH 1 (LSB)

Bit 2: LNGH 2

Bit 3: LNGH 3 (MSB)

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

NOTES
1 X means that the ancillary bit is recorded.
2 LNGH is inserted in bits 4-7 of AUX 1

3.10.3.4 Block sync location S MARK 0, S MARK 1

S MARK 0 and S MARK 1 are 9-bit words that specify the location of the first and last block sync associated with channel status and user data as defined in clause 6 of ANSI S4.40. S MARK 0 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. S MARK 1 identifies the last block sync detected. Where multiple marks are encountered, only the last one will be stored in S MARK 1.

LSB								MSB	
0	1	2	3	4	5	6	7	8	S MARK 0, S MARK 1

where S MARK 0, S MARK 1 is from 00_H to $10A_H$ inclusive.

S MARK 0, S MARK 1 = 155_H if no mark is found within the defined range.

S MARK 0 is inserted in bits 8-16 of AUX 0. S MARK 1 is inserted similarly in AUX 1.

3.10.4.5 Word count (BCNT) — 4 bits

BCNT specifies the number of useful samples in the current block, either 266 or 267.

LSB MSB

0 1 2 3 BCNT

Bit 0: BC
Bit 1: 0
Bit 2: 0
Bit 3: 0

Number samples	BC
266	1
267	1

BCNT = 1 in the audio segment for which the segment count = 0 and the field count = 0, as defined in 3.3.2.

BCNT is inserted in bits 4-7 of AUX 2.

3.10.4.6 Edit flag (EFLG)

This word is four bits and specifies a segment associated with an edit transition. Figure 16 shows the audio sectors recorded during an edit on audio channel A2.

LSB MSB

0 1 2 3 EFLG

EFLG = B_H for the first segment of the edit
EFLG = E_H for the last segment of the edit
EFLG = 0_H otherwise

EFLG is inserted in bits 0-3 of AUX 0, AUX 1, AUX 2, and AUX 3 of both copies of the segment.

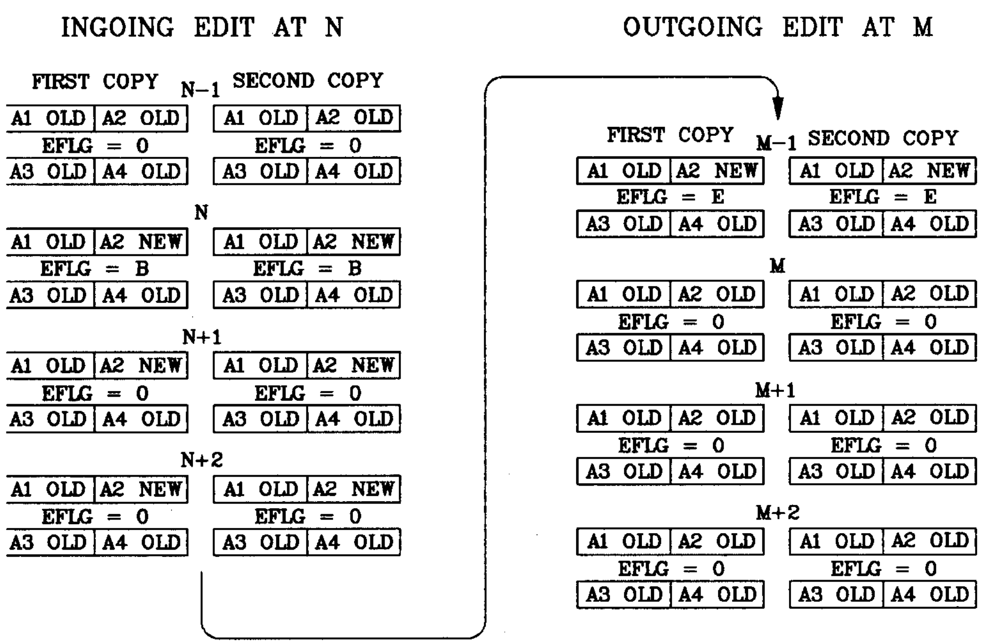


Figure 16 – Audio edit (channel A2 only)

3.10.5 Outer error protection

Rows 2, 4, 7, and 9 of the blocks contain the error protection data 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: Left-most term is the most significant.

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

Check characters are K_3, K_2, K_1, K_0 (identified respectively as PV_3, PV_2, PV_1, PV_0) in $K_3x^3 + K_2x^2 + K_1x + K_0$ obtained as the remainder after dividing the polynomial $x^8D(x)$ by G(x), where D(x) is the polynomial given by:

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

Equation of full code is given by: $B_7x^{11} + B_6x^{10} + B_5x^9 + ... + B_1x^5 + B_0x^4 + K_3x^3 + K_2x^2 + K_1x + K_0$

Outer-code check characters in each column of the 85 x 8 blocks are calculated using the data order existing prior to the rearrangement into the pattern shown in figure 12; i.e., in ascending sample order.

The check characters K_3 through K_0 are used as the vertical protection characters PV_3 through PV_0, respectively, and inserted in their associated column at rows 9, 7, 4, and 2.

3.10.6 Inner protection and channel coding

The inner protection, sync block format, and channel code are identical to that for video (see 3.3 through 3.7).

3.10.7 Order of transmission to inner coding

The block of data shown in figure 12 is passed sequentially to the inner coding process as follows:

Row 0 – Column 0 to 84
Row 1 – Column 0 to 84
Row 2 – Column 0 to 84
Row 3 – Column 0 to 84
Row 4 – Column 0 to 84
Row 5 – Column 0 to 84
Row 6 – Column 0 to 84
Row 7 – Column 0 to 84
Row 8 – Column 0 to 84
Row 9 – Column 0 to 84
Row 10 – Column 0 to 84
Row 11 – Column 0 to 84

3.10.8 Relative audio-video recording arrangement

Data from each of the four audio channels is recorded twice on tape or different helical tracks, and at opposite ends of the tracks, according to the arrangement of figure 13. The audio sectors labeled A1, A2, A3, and A4 correspond to audio input channels 1, 2, 3, and 4, respectively.

4 Control track

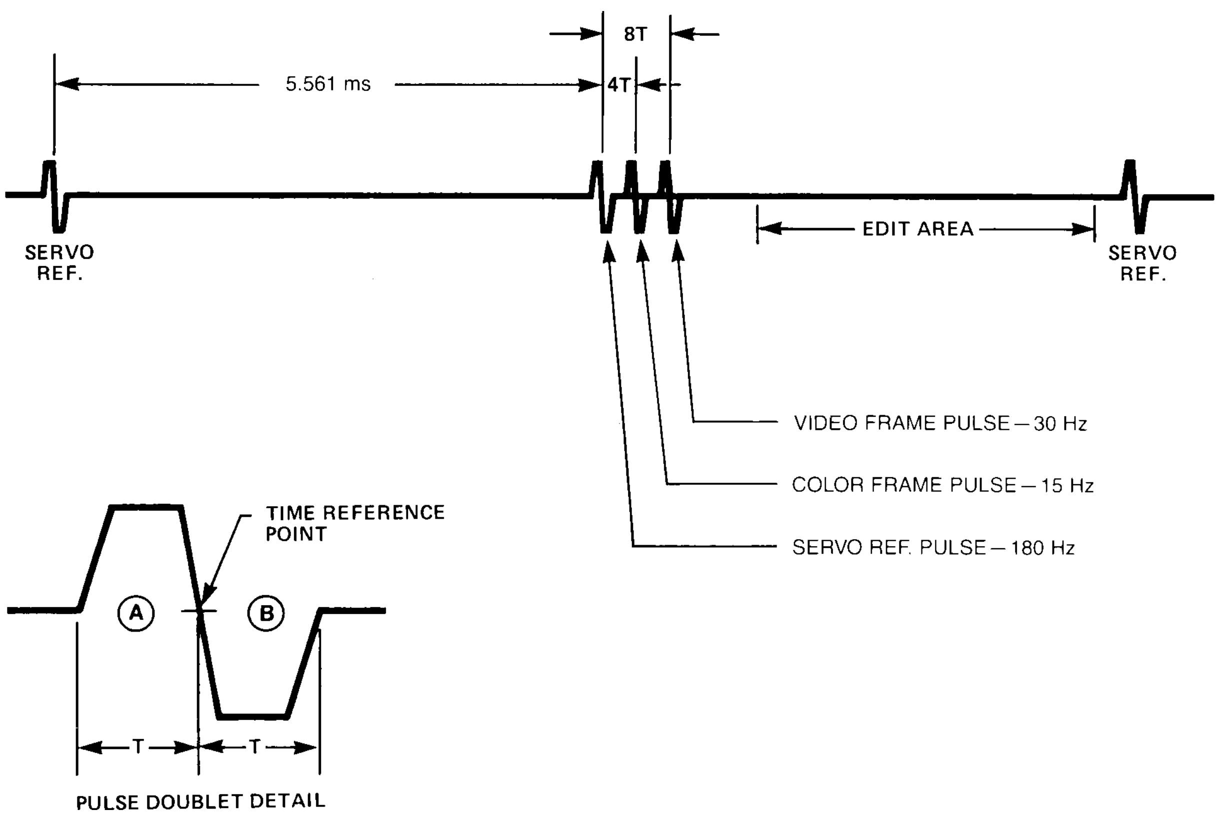
4.1 The control track shall be recorded using the anhysteretic (AC bias) method.

4.1.1 The control track servo reference pulse, at the time of recording, shall be a series of pulse doublets with a period of 5.561 ms ± 6 µs, as shown in figure 17.

4.1.2 During time interval A of the record, the polarity of the recorded flux shall be such that the south pole of the magnetic domains points in the direction of normal tape movement. During time B, the north pole shall be similarly oriented.

4.1.3 The peak-to-peak recorded flux level shall be 250 nWb/m ± 20 nWb/m of track width. The recording shall attenuate any previous recording by at least 30 dB.

4.1.4 The recorded pulse doublets shall each have a half-width T of 104 µs nominal. The rise and fall times of the record current (10% to 90% points) shall differ by less than 5 µs, and shall be less than 15 µs.



NOTES
1 T = 104 µs.
2 Rise time < 15 µs.

Figure 17 – Control waveform-timing

4.1.5 Servo reference pulse doublets shall be separated by a pitch equivalent to a pair of helical tracks.

The servo reference pulse doublet and the data of the program reference point shall be recorded according to figure 2(a) of ANSI/SMPTE 245M and shall occur at the same time.

4.1.6 A second pulse doublet shall, when present, indicate the start of a color frame sequence at the time of the start of each recording. The color frame commences at color frame A, field one as defined in ITU-R BT.470-6, figure 5(c). It shall be located at a distance of 4T after the servo reference pulse doublet, coinciding with a segment count and field count of zero in the video sector identification pattern, as defined in 3.3.2(b).

4.1.7 A third pulse doublet shall, when present, indicate the first segment of a video frame at the time of the start of each recording. It shall be located at a distance 8T after the servo reference pulse doublet, coinciding with a segment count of zero and an even field count in the video sector identification pattern, as defined in 3.3.2(b).

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

Annex A (informative)
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