ANSI/SMPTE 277M-1996

SMPTE STANDARD

for Television Digital Recording — 19-mm Type D-6 — Helical Data, Longitudinal Index, Cue and Control Records

1 Scope

1.1 This standard specifies the format and recording method of the data blocks and associated data which form the helical records on 19-mm tape in cassettes as specified in SMPTE 226M. The data recorded may be digital video and audio data of various image standards up to approximately 1 Gbit/s as specified in ANSI/SMPTE 278M.

1.2 Also specified are the content, format, and recording method of the longitudinal record containing tracking information for the scanning heads associated with the helical records, and the longitudinal index and cue tracks.

1.3 In addition, this standard specifies the principal properties of the magnetic tape used for 19-mm type D-6 digital recording.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the edition indicated was 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 standard indicated below.

ANSI/SMPTE 278M-1996, Television Digital Recording — 19-mm Type D-6 — Content of Helical Data and Time and Control Code Records

3 Measurement environment

3.1 Dimensions are in the metric system.

3.2 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:	96 kPa ± 10 kPa
– Tape conditioning:	Not less than 24 hours
– Center span tension:	0.65 N ± 0.05 N

4 Tape specification

4.1 Base

The base material shall be polyester or equivalent.

4.2 Width

The tape width shall be 19.010 mm ± 0.015 mm.

4.2.1 The tape, covered with a glass plate, shall be measured without tension at a minimum of five different positions along the tape using a calibrated microscope or profile projector having an accuracy of at least 1.0 μm. Tape width is defined as the average of the five readings.

4.3 Width fluctuation

Width fluctuation shall not exceed 6 μm p-p.

4.3.1 Measurement of width fluctuation shall be over a tape length of 900 mm at least 1 m from the beginning of the tape. The width fluctuation shall be evaluated by measuring the tape width at 10 points, each separated by a distance of 100 mm.

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American National Standard

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4.4 Reference edge straightness

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

4.4.1 Edge straightness fluctuation is measured at the edge of a moving tape guided by three guides having contact with the same reference edge and having a distance of 125 mm from the first to the second guide, and 125 mm from the second to the third guide. Edge measurements are averaged over 10-mm lengths and are made near the midpoint between the first and second guide which is 62.5 mm from the first guide.

4.5 Tape thickness

The magnetic tape used shall have a thickness of 11 μm + 0 μm – 0.8 μm.

4.6 Transmissivity

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

4.7 Offset yield strength

Offset yield strength shall be greater than 14 N.

4.7.1 The force to produce 1% elongation of a 200-mm test sample with a pull rate of 100 mm per minute shall be used to confirm the offset yield strength. The initial tangential slope is extended and read at 1% elongation.

4.8 Magnetic coating

The magnetic tape used shall have a metal particle coating or equivalent.

4.8.1 The coating coercivity shall be a class 1700 Oe (135300 A/m), as measured by a VSM or a 50/60-Hz BH meter.

4.8.2 The metal particles shall be longitudinally oriented.

5 Track arrangements

5.1 Definitions

5.1.1 block: A packet of data including the preceding synchronization and identification information. All blocks of one recording configuration have the same number of bytes.

5.1.2 cluster: An array of eight adjacent tracks (see figure 1). The numbering of the clusters starts with cluster 0 at the program reference point.

5.1.3 data field: A group of segments which starts with cluster 0 as defined by the program reference point (see figure 1). Up to four data fields (0 ... 3) may be defined. The start of even-numbered data fields coincides with the two data field pulse as defined in 9.2.8.

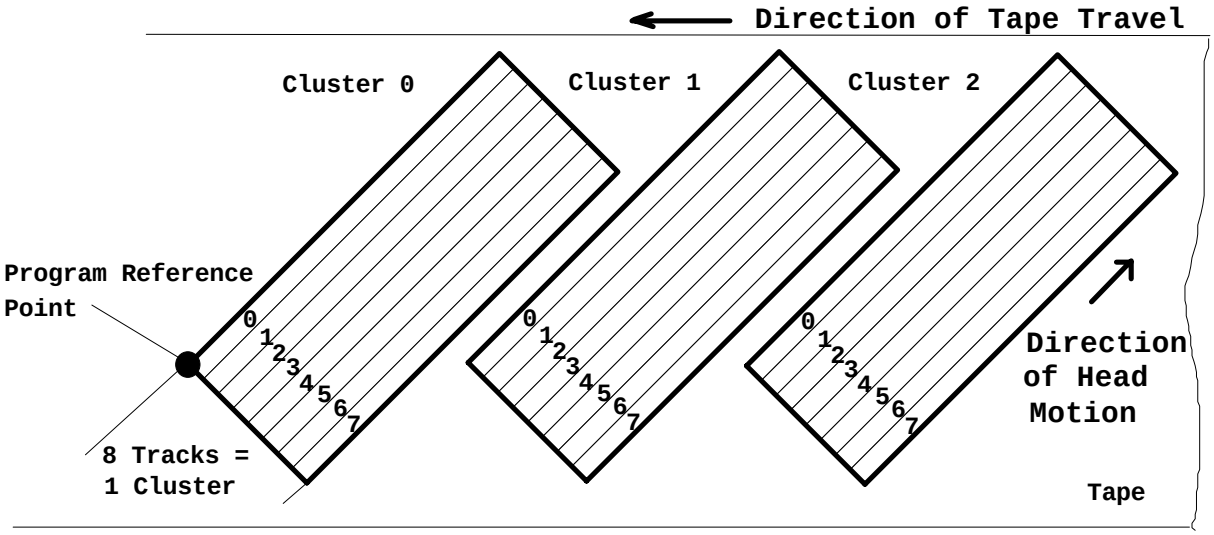


Figure 1 – Cluster of tracks

5.1.4 sector: Part of a cluster created by partitioning of all eight tracks in the same way (see figures 2 and 3). Each part of a partitioned track will start with a preamble and end with a postamble.

5.1.5 segment: A group of sectors. The format allows a segment to contain sectors of different clusters. Two possible examples are shown in figures 2 and 3.

5.1.6 track: A track contains 270 blocks. Blocks within a track are numbered 1 through 270 in the direction of recording. The first block is a preamble and the 270th block is a postamble. Tracks are numbered 0 to 7 as shown in figure 1.

5.2 Data configurations

All recorded blocks along a slant track have the same size in order to record a data pattern independent of any video-, audio-, and edit-gap parts of the track.

The total number of bytes per block depends on the recording configuration. For a given configuration, all blocks contain the same number of bytes. Two configurations are allowed:

– Configuration I: Total block length = 229 bytes;
– Configuration II: Total block length = 239 bytes.

All blocks consist of data preceded by a synchronization pattern, SYNC (see figure 4). Sync is not subject to channel modification and is 24 bits on tape. This is equivalent to the length of two data bytes before channel modulation. The 24-bit sync pattern may be unique and not contained in the modulation tables given in clause 11. The task of the sync is to synchronize the channel decoder and to control word and block synchronization. The sync depends on the recorded data or video standard.

Two types of data are used: inner code blocks and preambles/ postambles.

The inner code blocks contain the RData bytes and the preceding block identification (ID), both protected by check bytes (see figure 5). For details of the error protection, see ANSI/SMPTE 278M.

The preambles/postambles contain a runup pattern of 224 (234) bytes of CC(hex) preceded by a block identification (ID) (see figures 6 and 7). Preambles/postambles are of sufficient length to make additional edit gaps unnecessary. Preambles and postambles may be altered on tape by editing within a cluster without any negative effects.

The identification (ID) bytes within each block contain the block-, track-, segment-, and field-numbering, as well as some bits to identify the recorded data or video standards (see figure 8). Each block has a three-byte ID (ID 0, ID 1, ID 2) which will also be protected by the check bytes. ID 0 is recorded first.

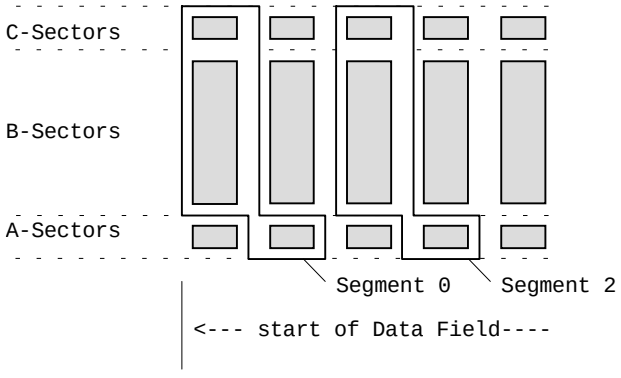


Figure 2 – Segment and sector counting (Example a)

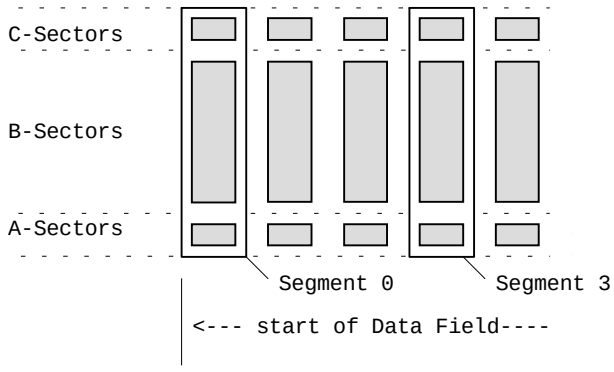


Figure 3 – Segment and sector counting (Example b)

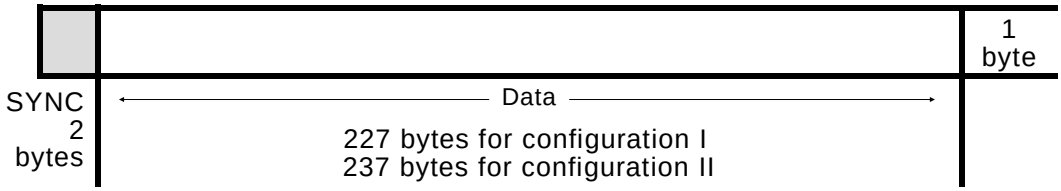


Figure 4 – Block structure in bytes

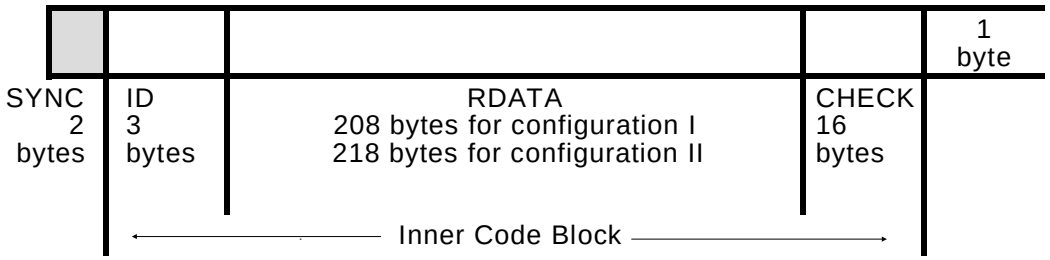


Figure 5 – Structure, in bytes, of the inner code block before channel modulation

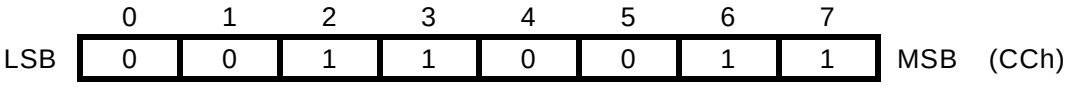


Figure 6 – One byte of run-up pattern before channel modulation

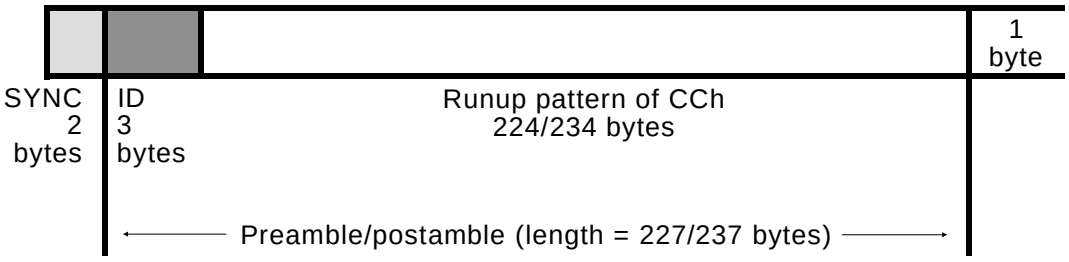


Figure 7 – Structure, in bytes, of preamble/postamble before channel modulation

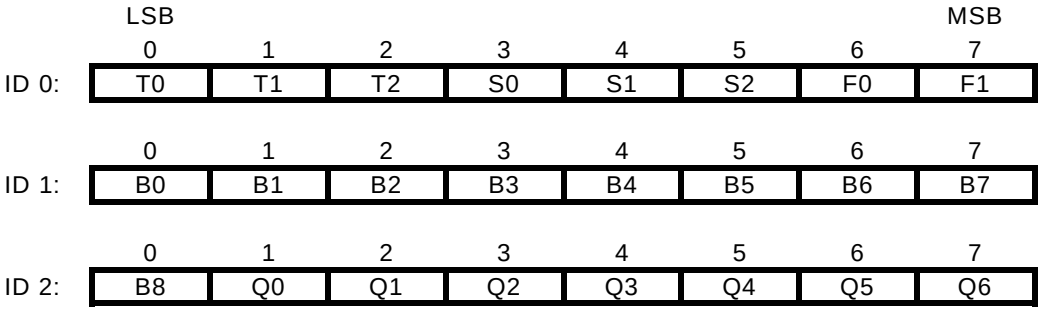


Figure 8 – ID information

The three ID bytes are defined as follows:

ID 0:	T0 ... T2:	Track identification (0 ... 7)
	S0 ... S2:	Segment identification (0 ... 7)
	F0, F1:	Data field identification (0 ... 3)
ID 1:	B0 ... B7:	Block identification (eight bits)
ID 2:	B8:	Block identification (ninth bit)
	Q0 ... Q6:	Data or video standard dependent

6 Randomization

All data bytes and associated outer check bytes (see for example figure 11 of ANSI/SMPTE 278M) shall be randomized before being inserted into the inner code block and before calculation of the inner check bytes. Sync, IDs, inner check bytes, and the run-up patterns of the preamble and postamble are not randomized.

The randomization shall be performed by an exclusive-or (X-OR) operation of the data bytes and associated outer check bytes with the randomizing bytes commencing with the first byte location after the identification (ID) bytes. The result of the ex-oring are the RData bytes.

A randomizing sequence is formed by reading successive bytes from table 1. The sequence may commence at any address location in the table between 000_h and $F0E_h$ and continue sequentially for 208/218 bytes.

The starting address of the randomizing sequence is defined by the ID words. The exact relation between starting address and ID words depends on the recorded video or data standard.

Table 1 – Randomization sequence

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

7 Modulation code

The blocks are subject to an 8–12 modulation coding prior to recording. Eight tables are used to map incoming data bytes to 12-bit words. The tables given in this standard are not valid for the sync which may be a unique sequence as described in ANSI/SMPTE 278M. The modulation tables are numbered A1 to A4 and B1 to B4. The table used depends on parameters Pa, Pb, Pc (see table 2).

For the preset byte of data:

Pa is true (“1") a) if no * is attached in the modulation table to the previous data, **OR** b) if the previous modulation bits are part of a sync.

Pb is true (”1") if the last bit of the previous modulation bits of data or sync equals “0.”

Pc is true (“1") a) if the next modulation bits are not part of a sync, **AND** b) the first two bits of the next byte of data prior to modulation equal ”10" (first bit written left).

Table 2 – Selection of modulation tables

	Pa	Pb	Pc
Modulation table A1	1	1	0
Modulation table A2	1	1	1
Modulation table A3	1	0	0
Modulation table A4	1	0	1
Modulation table B1	0	1	0
Modulation table B2	0	1	1
Modulation table B3	0	0	0
Modulation table B4	0	0	1

For the modulation tables, see clause 11. Recording starts with the left modulation bit leading. The unmodulated data are given in hexadecimal form with the left digit representing the four most significant bits of the byte of unmodulated data.

8 Magnetization

8.1 Polarity

The recorder shall operate in reproduce mode without regard to the polarity of the recorded flux on the helical tracks.

8.2 Record equalization

The record head current should generate the same flux levels at the head gap at both the Nyquist and half-Nyquist frequencies.

8.3 Record level

Record head current 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 equivalent results.

9 Longitudinal tracks

9.1 General

There are three longitudinal tracks as dimensionally specified in clause 10. These tracks carry the index, cue, and control records. This clause describes their electrical parameters.

9.2 Control track

9.2.1 Method of recording

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

9.2.2 Servo reference pulse doublet

The servo reference pulse at the time of recording shall be a series of pulse doublets with a pulse distance of 3.33 ms as shown in figure 9.

9.2.3 Flux polarity

During the time interval A (see figure 9) of the record, the polarity of the recorded flux shall be such that the south poles of the magnetic domains point in the direction of normal tape movement. During time B, the north poles shall be similarly oriented.

9.2.4 Flux level

The recorded current shall maximize the playback signal.

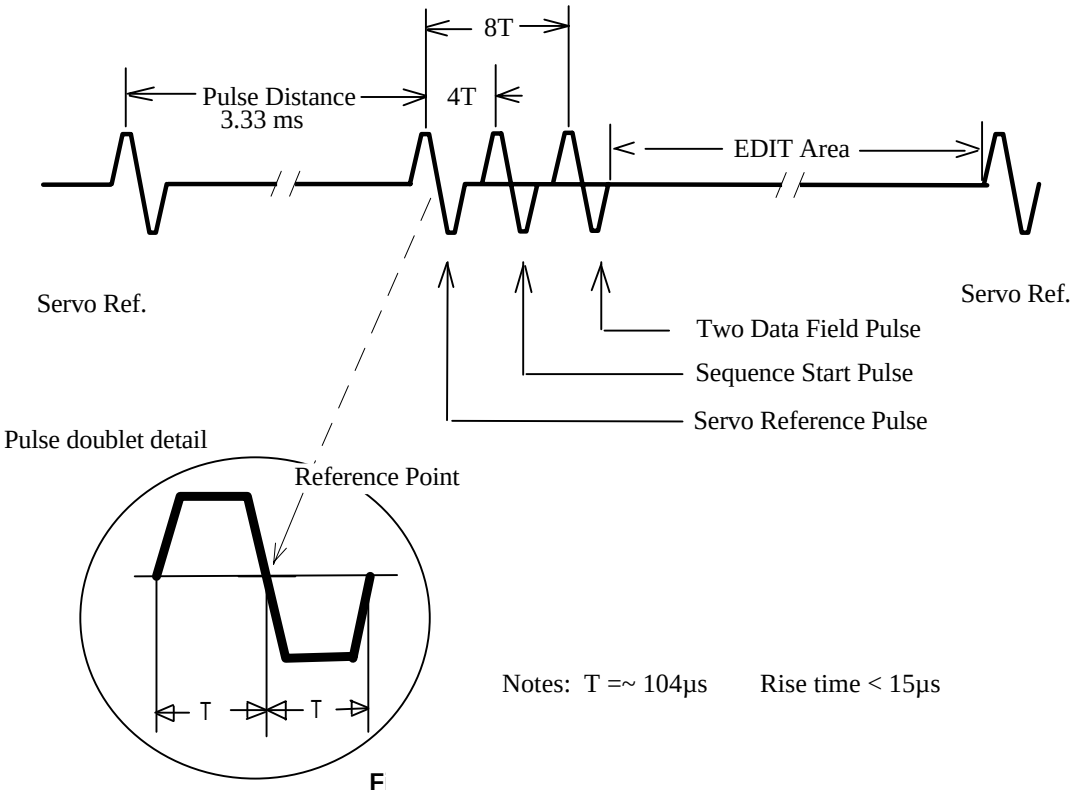


Figure 9 – Control track waveform timing

9.2.5 Pulse doublet width

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 be less than 15 µs and differ by less than 5 µs.

9.2.6 Servo reference pulse doublet timing

The servo reference pulse doublet and the data of the program reference point when recorded shall occur at the same time (see dimension P1 in table 3).

9.2.7 Sequence start pulse

A second pulse doublet shall, when present, indicate the start of specific processing sequences. It shall be located at a distance of 4T after the servo reference pulse doublet.

9.2.8 Two data field pulse doublet

A third pulse doublet shall, when present, indicate the start of even data fields. It shall be located at a distance 8T after the servo reference pulse doublet. That servo reference pulse doublet coincides with the program reference point (see figure 10).

9.2.9 EDIT timing

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

9.3 Cue record

9.3.1 Recorded format

The signal recorded on this track shall be an analog signal which is audio or audio compatible.

9.3.2 Method of recording

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

9.3.3 Timing

Cue information shall be recorded on the tape at a point in reference to the associated data information as defined by dimension P3 of figures 10 and 11 and table 2.

9.3.4 Flux level

The recorded reference audio level shall correspond to an rms magnetic short-circuit flux level of 125 nWb/m ± 5 nWb/m at 1000 Hz. When a tape record is recorded from a constant voltage level applied to the input terminals of the recording system, the short circuit flux level on the record versus frequency shall be linear.

9.4 Index record

9.4.1 Recorded format

The signal recorded on this track shall be a two-level signal.

9.4.2 Method of recording

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

9.4.3 Flux level

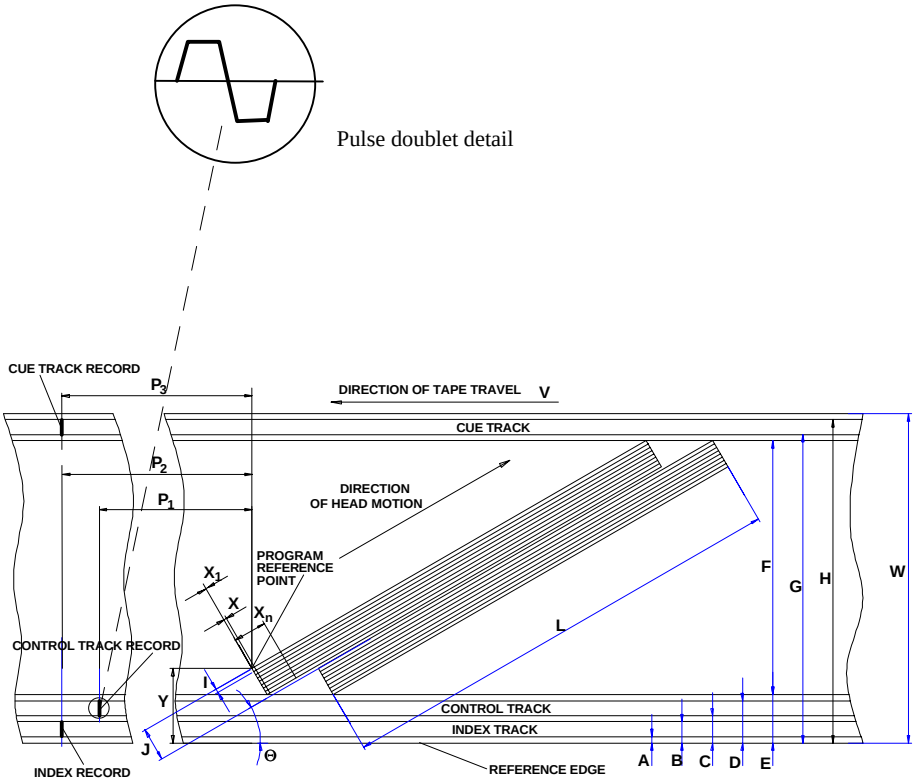
The recorded peak-to-peak flux shall correspond to a magnetic short circuit flux level of 500 nWb/m ± 100 nWb/m.

10 Record location and dimensions

Record location and dimensions shall be in accordance with table 3.

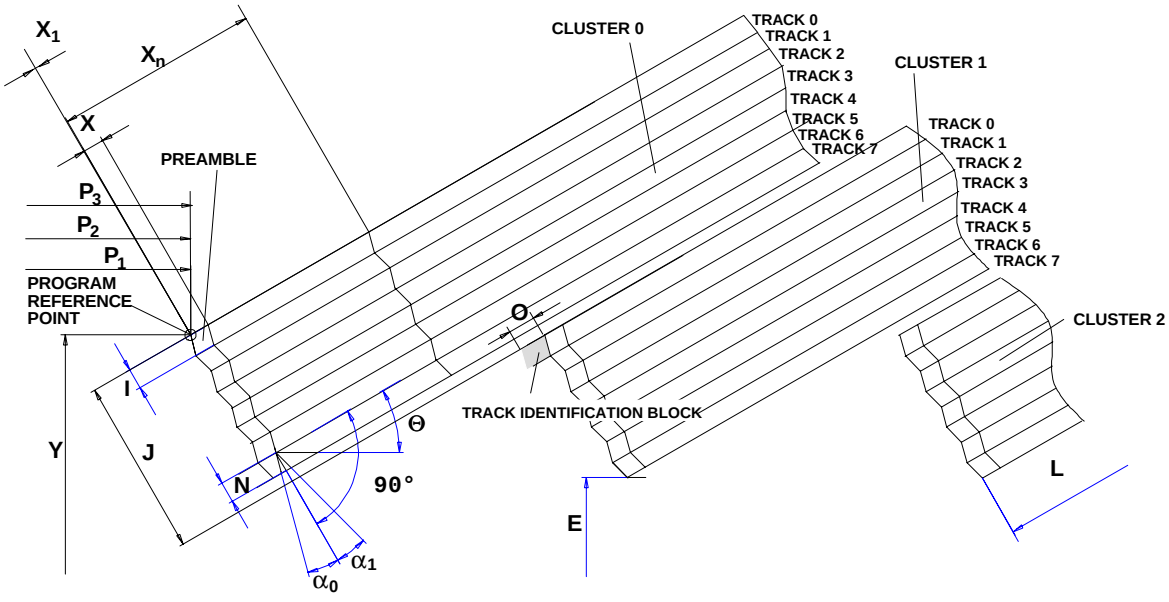
Table 3 – Record location and dimensions

Dimensions		Specifications	Tolerances	Units
A	Index track lower edge	0.200	± 0.100	mm
B	Index track upper edge	0.700	± 0.100	mm
C	Control track lower edge	1.000	± 0.100	mm
D	Control track upper edge	1.500	+ 0.050 – 0.100	mm
E	Program area lower edge	1.761	Derived	mm
F	Program area width	16.098	Derived	mm
G	Cue track lower edge	18.200	± 0.100	mm
H	Cue track upper edge	18.900	± 0.100	mm
I	Helical track pitch	0.021	Basic	mm
J	Helical cluster pitch	0.1759	Basic	mm
L	Helical cluster length	150.08	± 0.300	mm
M	Number of blocks per track	270	Basic	
N	Record head track width	0.023	± 0.002	mm
O	Length of TID pattern	0.700	± 0.200	mm
P1	Control track pulse	0	± 0.060	mm
P2	Index code information	99.500	± 0.300	mm
P3	Cue information	99.500	± 0.500	mm
V	Tape speed	497.419	± 0.05%	mm/s
W	Tape width	19.010	± 0.015	mm
X	Block length	0.55587	Basic	mm
X1	Location of start of block 1	0	± 0.200	mm
Xn	Location of start of block n	n*0.55587	± 0.300	mm
Y	Program reference point	1.930	Basic	mm
Z0	Tolerance zone track 0	0.006	Basic	mm
Z	Tolerance zone other tracks	0.010	Basic	mm
Θ	Dynamic track angle	6.09033	Basic	degree
α0	Azimuth angle (track 0)	14.93	± 0.17	degree
α1	Azimuth angle (track 1)	15.07	± 0.17	degree



NOTE – Tape viewed from magnetic coating side.

Figure 10 – Location and dimensions of recorded tracks

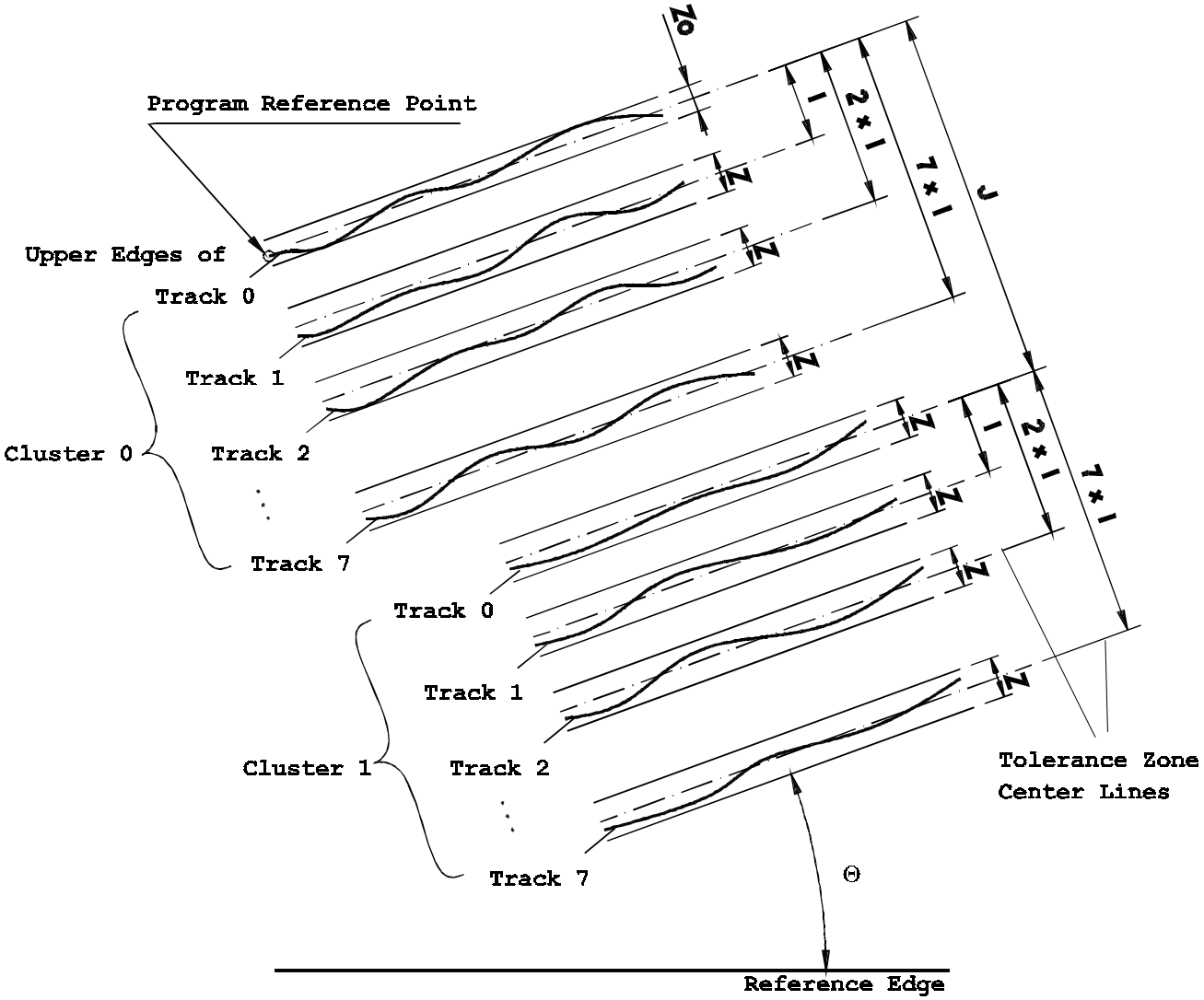


NOTES

1 The program reference point is defined by the intersection of the upper edge of track 0 of cluster 0 of the even-numbered data fields with a line parallel at distance Y to the reference edge.

2 For easier identification of the track-to-head relation, track 0 of cluster 1 of the even-numbered data fields is extended by a track identification (TID) pattern.

Figure 11 – Detail of recorded tracks of field 0



NOTE – The upper edge of the tracks shall be within the borders of the tolerance zones Z0 and Z.

Figure 12 – Location and dimensions of tolerance zones of helical track record

11 Modulation tables

Table 4 – Modulation tables

Data	Modulation codes			
HEX	Table A1 BIN	Table A2 BIN	Table A3 BIN	Table A4 BIN
00	011100011100	011100011100	100011100011	100011100011
01	111100011100	111100011100	000011100011	000011100011
02	001100011100	001100011100	110011100011	110011100011
03	110011100011	110011100011	001100011100	001100011100
04	011000011100	011000011100	100111100011	100111100011
05	111000011100	111000011100	000111100011	000111100011
06	011111100011	011111100011	100000011100	100000011100
07	111111100011	111111100011	000000011100	000000011100
08	011110011100	011110011100	100001100011	100001100011
09	111110011100	111110011100	000001100011	000001100011
0A	001110011100	001110011100	110001100011	110001100011
0B	110001100011	110001100011	001110011100	001110011100
0C	011001100011	011001100011	100110011100	100110011100
0D	111001100011	111001100011	000110011100	000110011100
0E	001111100011	001111100011	110000011100	110000011100
0F	110000011100	110000011100	001111100011	001111100011
10	011100111100	011100111100	100011000011	100011000011
11	111100111100	111100111100	000011000011	000011000011
12	001100111100	001100111100	110011000011	110011000011
13	110011000011	110011000011	001100111100	001100111100
14	011000111100	011000111100	100111000011	100111000011
15	111000111100	111000111100	000111000011	000111000011
16	011111000011	011111000011	100000111100	100000111100
17	111111000011	111111000011	000000111100	000000111100
18	011100000011	011100000011	100011111100	100011111100
19	111100000011	111100000011	000011111100	000011111100
1A	001100000011	001100000011	110011111100	110011111100
1B	110011111100	110011111100	001100000011	001100000011
1C	011000000011	011000000011	100111111100	100111111100
1D	111000000011	111000000011	000111111100	000111111100
1E	001111000011	001111000011	110000111100	110000111100
1F	110000111100	110000111100	001111000011	001111000011
20	011100001100	011100001100	100011110011	100011110011
21	111100001100	111100001100	000011110011	000011110011
22	001100001100	001100001100	110011110011	110011110011
23	110011110011	110011110011	001100001100	001100001100
24	011000001100	011000001100	100111110011	100111110011
25	111000001100	111000001100	000111110011	000111110011
26	011111110011	011111110011	100000001100	100000001100
27	111111110011	111111110011	000000001100	000000001100
28	011110001100	011110001100	100001110011	100001110011
29	111110001100	111110001100	000001110011	000001110011

(continued)

Table 4 (continued)

Data	Modulation codes			
	Table A1	Table A2	Table A3	Table A4
HEX	BIN	BIN	BIN	BIN
2A	001110001100	001110001100	110001110011	110001110011
2B	110001110011	110001110011	001110001100	001110001100
2C	011001110011	011001110011	100110001100	100110001100
2D	111001110011	111001110011	000110001100	000110001100
2E	001111110011	001111110011	110000001100	110000001100
2F	110000001100	110000001100	001111110011	001111110011
30	011100110011	011100110011	100011001100	100011001100
31	111100110011	111100110011	000011001100	000011001100
32	001100110011	001100110011	110011001100	110011001100
33	110011001100	110011001100	001100110011	001100110011
34	011000110011	011000110011	100111001100	100111001100
35	111000110011	111000110011	000111001100	000111001100
36	011111001100	011111001100	100000110011	100000110011
37	111111001100	111111001100	000000110011	000000110011
38	011110000011	011110000011	100001111100	100001111100
39	111110000011	111110000011	000001111100	000001111100
3A	001110000011	001110000011	110001111100	110001111100
3B	110001111100	110001111100	001110000011	001110000011
3C	011001111100	011001111100	100110000011	100110000011
3D	111001111100	111001111100	000110000011	000110000011
3E	001111001100	001111001100	110000110011	110000110011
3F	110000110011	110000110011	001111001100	001111001100
40	011100011000	011100011000	100011100111	100011100111
41	111100011000	111100011000	000011100111	000011100111
42	001100011000	001100011000	110011100111	110011100111
43	110011100111	110011100111	001100011000	001100011000
44	011000011000	011000011000	100111100111	100111100111
45	111000011000	111000011000	000111100111	000111100111
46	011111100111	011111100111	100000011000	100000011000
47	111111100111	111111100111	000000011000	000000011000
48	011110011000	011110011000	100001100111	100001100111
49	111110011000	111110011000	000001100111	000001100111
4A	001110011000	001110011000	110001100111	110001100111
4B	110001100111	110001100111	001110011000	001110011000
4C	011001100111	011001100111	100110011000	100110011000
4D	111001100111	111001100111	000110011000	000110011000
4E	001111100111	001111100111	110000011000	110000011000
4F	110000011000	110000011000	001111100111	001111100111
50	011100111000	011100111000	100011000111	100011000111
51	111100111000	111100111000	000011000111	000011000111
52	001100111000	001100111000	110011000111	110011000111
53	110011000111	110011000111	001100111000	001100111000
54	011000111000	011000111000	100111000111	100111000111
55	111000111000	111000111000	000111000111	000111000111

(continued)

Table 4 (continued)

Data	Modulation codes			
	Table A1	Table A2	Table A3	Table A4
HEX	BIN	BIN	BIN	BIN
56	011111000111	011111000111	100000111000	100000111000
57	111111000111	111111000111	000000111000	000000111000
58	011100000111	011100000111	100011111000	100011111000
59	111100000111	111100000111	000011111000	000011111000
5A	001100000111	001100000111	110011111000	110011111000
5B	110011111000	110011111000	001100000111	001100000111
5C	011000000111	011000000111	100111111000	100111111000
5D	111000000111	111000000111	000111111000	000111111000
5E	001111000111	001111000111	110000111000	110000111000
5F	110000111000	110000111000	001111000111	001111000111
60	011100011111	011100011111	100011100000	100011100000
61	111100011111	111100011111	000011100000	000011100000
62	001100011111	001100011111	110011100000	110011100000
63	110011100000	110011100000	001100011111	001100011111
64	011000011111	011000011111	100111100000	100111100000
65	111000011111	111000011111	000111100000	000111100000
66	011111100000	011111100000	100000011111	100000011111
67	111111100000	111111100000	000000011111	000000011111
68	011110011111	011110011111	100001100000	100001100000
69	111110011111	111110011111	000001100000	000001100000
6A	001110011111	001110011111	110001100000	110001100000
6B	110001100000	110001100000	001110011111	001110011111
6C	011001100000	011001100000	100110011111	100110011111
6D	111001100000	111001100000	000110011111	000110011111
6E	001111100000	001111100000	110000011111	110000011111
6F	110000011111	110000011111	001111100000	001111100000
70	011100111111	011100111111	100011000000	100011000000
71	111100111111	111100111111	000011000000	000011000000
72	001100111111	001100111111	110011000000	110011000000
73	110011000000	110011000000	001100111111	001100111111
74	011000111111	011000111111	100111000000	100111000000
75	111000111111	111000111111	000111000000	000111000000
76	011111000000	011111000000	100000111111	100000111111
77	111111000000	111111000000	000000111111	000000111111
78	011110000111	011110000111	100001111000	100001111000
79	111110000111	111110000111	000001111000	000001111000
7A	001110000111	001110000111	110001111000	110001111000
7B	110001111000	110001111000	001110000111	001110000111
7C	011001111000	011001111000	100110000111	100110000111
7D	111001111000	111001111000	000110000111	000110000111
7E	001111000000	001111000000	110000111111	110000111111
7F	110000111111	110000111111	001111000000	001111000000
80 *	011100011110	011100011100	100011100001	100011100011
81 *	111100011110	111100011100	000011100001	000011100011

(continued)

Table 4 (continued)

Data	Modulation codes			
HEX	Table A1 BIN	Table A2 BIN	Table A3 BIN	Table A4 BIN
82 *	001100011110	001100011100	110011100001	110011100011
83 *	110011100001	110011100011	001100011110	001100011100
84 *	011000011110	011000011100	100111100001	100111100011
85 *	111000011110	111000011100	000111100001	000111100011
86 *	011111100001	011111100011	100000011110	100000011100
87 *	111111100001	111111100011	000000011110	000000011100
88 *	011110011110	011110011100	100001100001	100001100011
89 *	111110011110	111110011100	000001100001	000001100011
8A *	001110011110	001110011100	110001100001	110001100011
8B *	110001100001	110001100011	001110011110	001110011100
8C *	011001100001	011001100011	100110011110	100110011100
8D *	111001100001	111001100011	000110011110	000110011100
8E *	001111100001	001111100011	110000011110	110000011100
8F *	110000011110	110000011100	001111100001	001111100011
90 *	011100111110	011100111100	100011000001	100011000011
91 *	111100111110	111100111100	000011000001	000011000011
92 *	001100111110	001100111100	110011000001	110011000011
93 *	110011000001	110011000011	001100111110	001100111100
94 *	011000111110	011000111100	100111000001	100111000011
95 *	111000111110	111000111100	000111000001	000111000011
96 *	011111000001	011111000011	100000111110	100000111100
97 *	111111000001	111111000011	000000111110	000000111100
98 *	011100000001	011100000011	100011111110	100011111100
99 *	111100000001	111100000011	000011111110	000011111100
9A *	001100000001	001100000011	110011111110	110011111100
9B *	110011111110	110011111100	001100000001	001100000011
9C *	011000000001	011000000011	100111111110	100111111100
9D *	111000000001	111000000011	000111111110	000111111100
9E *	001111000001	001111000011	110000111110	110000111100
9F *	110000111110	110000111100	001111000001	001111000011
A0 *	011100001110	011100001100	100011110001	100011110011
A1 *	111100001110	111100001100	000011110001	000011110011
A2 *	001100001110	001100001100	110011110001	110011110011
A3 *	110011110001	110011110011	001100001110	001100001100
A4 *	011000001110	011000001100	100111110001	100111110011
A5 *	111000001110	111000001100	000111110001	000111110011
A6 *	011111110001	011111110011	100000001110	100000001100
A7 *	111111110001	111111110011	000000001110	000000001100
A8 *	011110001110	011110001100	100001110001	100001110011
A9 *	111110001110	111110001100	000001110001	000001110011
AA *	001110001110	001110001100	110001110001	110001110011
AB *	110001110001	110001110011	001110001110	001110001100
AC *	011001110001	011001110011	100110001110	100110001100

(continued)

Table 4 (continued)

Data	Modulation codes			
	Table A1	Table A2	Table A3	Table A4
HEX	BIN	BIN	BIN	BIN
AD *	111001110001	111001110011	000110001110	000110001100
AE *	001111110001	001111110011	110000001110	110000001100
AF *	110000001110	110000001100	001111110001	001111110011
B0 *	011100110001	011100110011	100011001110	100011001100
B1 *	111100110001	111100110011	000011001110	000011001100
B2 *	001100110001	001100110011	110011001110	110011001100
B3 *	110011001110	110011001100	001100110001	001100110011
B4 *	011000110001	011000110011	100111001110	100111001100
B5 *	111000110001	111000110011	000111001110	000111001100
B6 *	011111001110	011111001100	100000110001	100000110011
B7 *	111111001110	111111001100	000000110001	000000110011
B8 *	011110000001	011110000011	100001111110	100001111100
B9 *	111110000001	111110000011	000001111110	000001111100
BA *	001110000001	001110000011	110001111110	110001111100
BB *	110001111110	110001111100	001110000001	001110000011
BC *	011001111110	011001111100	100110000001	100110000011
BD *	111001111110	111001111100	000110000001	000110000011
BE *	001111001110	001111001100	110000110001	110000110011
BF *	110000110001	110000110011	001111001110	001111001100
C0 *	011100011001	011100011000	100011100110	100011100111
C1 *	111100011001	111100011000	000011100110	000011100111
C2 *	001100011001	001100011000	110011100110	110011100111
C3 *	110011100110	110011100111	001100011001	001100011000
C4 *	011000011001	011000011000	100111100110	100111100111
C5 *	111000011001	111000011000	000111100110	000111100111
C6 *	011111100110	011111100111	100000011001	100000011000
C7 *	111111100110	111111100111	000000011001	000000011000
C8 *	011110011001	011110011000	100001100110	100001100111
C9 *	111110011001	111110011000	000001100110	000001100111
CA *	001110011001	001110011000	110001100110	110001100111
CB *	110001100110	110001100111	001110011001	001110011000
CC *	011001100110	011001100111	100110011001	100110011000
CD *	111001100110	111001100111	000110011001	000110011000
CE *	001111100110	001111100111	110000011001	110000011000
CF *	110000011001	110000011000	001111100110	001111100111
D0 *	011100111001	011100111000	100011000110	100011000111
D1 *	111100111001	111100111000	000011000110	000011000111
D2 *	001100111001	001100111000	110011000110	110011000111
D3 *	110011000110	110011000111	001100111001	001100111000
D4 *	011000111001	011000111000	100111000110	100111000111
D5 *	111000111001	111000111000	000111000110	000111000111
D6 *	011111000110	011111000111	100000111001	100000111000
D7 *	111111000110	111111000111	000000111001	000000111000

(continued)

Table 4 (continued)

Data	Modulation codes			
HEX	Table A1 BIN	Table A2 BIN	Table A3 BIN	Table A4 BIN
D8 *	011100000110	011100000111	100011111001	100011111000
D9 *	111100000110	111100000111	000011111001	000011111000
DA *	001100000110	001100000111	110011111001	110011111000
DB *	110011111001	110011111000	001100000110	001100000111
DC *	011000000110	011000000111	100111111001	100111111000
DD *	111000000110	111000000111	000111111001	000111111000
DE *	001111000110	001111000111	110000111001	110000111000
DF *	110000111001	110000111000	001111000110	001111000111
E0	011100001111	011100001111	100011110000	100011110000
E1	111100001111	111100001111	000011110000	000011110000
E2	001100001111	001100001111	110011110000	110011110000
E3	110011110000	110011110000	001100001111	001100001111
E4	011000001111	011000001111	100111110000	100111110000
E5	111000001111	111000001111	000111110000	000111110000
E6	011111110000	011111110000	100000001111	100000001111
E7	111111110000	111111110000	000000001111	000000001111
E8	011110001111	011110001111	100001110000	100001110000
E9	111110001111	111110001111	000001110000	000001110000
EA	001110001111	001110001111	110001110000	110001110000
EB	110001110000	110001110000	001110001111	001110001111
EC	011001110000	011001110000	100110001111	100110001111
ED	111001110000	111001110000	000110001111	000110001111
EE	001111110000	001111110000	110000001111	110000001111
EF	110000001111	110000001111	001111110000	001111110000
F0	011100110000	011100110000	100011001111	100011001111
F1	111100110000	111100110000	000011001111	000011001111
F2	001100110000	001100110000	110011001111	110011001111
F3	110011001111	110011001111	001100110000	001100110000
F4	011000110000	011000110000	100111001111	100111001111
F5	111000110000	111000110000	000111001111	000111001111
F6	011111001111	011111001111	100000110000	100000110000
F7	111111001111	111111001111	000000110000	000000110000
F8 *	011110000110	011110000111	100001111001	100001111000
F9 *	111110000110	111110000111	000001111001	000001111000
FA *	001110000110	001110000111	110001111001	110001111000
FB *	110001111001	110001111000	001110000110	001110000111
FC *	011001111001	011001111000	100110000110	100110000111
FD *	111001111001	111001111000	000110000110	000110000111
FE	001111001111	001111001111	110000110000	110000110000
FF	110000110000	110000110000	001111001111	001111001111

(continued)

Table 4 (continued)

Data	Modulation codes			
HEX	Table B1 BIN	Table B2 BIN	Table B3 BIN	Table B4 BIN
00	011100011100	011100011100	100011100011	100011100011
01	000011100011	000011100011	111100011100	111100011100
02	001100011100	001100011100	110011100011	110011100011
03	000011100011	000011100011	111100011100	111100011100
04	011000011100	011000011100	100111100011	100111100011
05	000111100011	000111100011	111000011100	111000011100
06	011111100011	011111100011	100000011100	100000011100
07	000111100011	000111100011	111000011100	111000011100
08	011110011100	011110011100	100001100011	100001100011
09	000001100011	000001100011	111110011100	111110011100
0A	001110011100	001110011100	110001100011	110001100011
0B	000001100011	000001100011	111110011100	111110011100
0C	011001100011	011001100011	100110011100	100110011100
0D	000110011100	000110011100	111001100011	111001100011
0E	001111100011	001111100011	110000011100	110000011100
0F	000110011100	000110011100	111001100011	111001100011
10	011100111100	011100111100	100011000011	100011000011
11	000011000011	000011000011	111100111100	111100111100
12	001100111100	001100111100	110011000011	110011000011
13	000011000011	000011000011	111100111100	111100111100
14	011000111100	011000111100	100111000011	100111000011
15	000111000011	000111000011	111000111100	111000111100
16	011111000011	011111000011	100000111100	100000111100
17	000111000011	000111000011	111000111100	111000111100
18	011100000011	011100000011	100011111100	100011111100
19	000011111100	000011111100	111100000011	111100000011
1A	001100000011	001100000011	110011111100	110011111100
1B	000011111100	000011111100	111100000011	111100000011
1C	011000000011	011000000011	100111111100	100111111100
1D	000111111100	000111111100	111000000011	111000000011
1E	001111000011	001111000011	110000111100	110000111100
1F	000111111100	000111111100	111000000011	111000000011
20	011100001100	011100001100	100011110011	100011110011
21	000011110011	000011110011	111100001100	111100001100
22	001100001100	001100001100	110011110011	110011110011
23	000011110011	000011110011	111100001100	111100001100
24	011000001100	011000001100	100111110011	100111110011
25	000111110011	000111110011	111000001100	111000001100
26	011111110011	011111110011	100000001100	100000001100
27	000111110011	000111110011	111000001100	111000001100
28	011110001100	011110001100	100001110011	100001110011
29	000001110011	000001110011	111110001100	111110001100
2A	001110001100	001110001100	110001110011	110001110011
2B	000001110011	000001110011	111110001100	111110001100

(continued)

Table 4 (continued)

Data	Modulation codes			
	Table B1	Table B2	Table B3	Table B4
HEX	BIN	BIN	BIN	BIN
2C	011001110011	011001110011	100110001100	100110001100
2D	000110001100	000110001100	111001110011	111001110011
2E	001111110011	001111110011	110000001100	110000001100
2F	000110001100	000110001100	111001110011	111001110011
30	011100110011	011100110011	100011001100	100011001100
31	000011001100	000011001100	111100110011	111100110011
32	001100110011	001100110011	110011001100	110011001100
33	000011001100	000011001100	111100110011	111100110011
34	011000110011	011000110011	100111001100	100111001100
35	000111001100	000111001100	111000110011	111000110011
36	011111001100	011111001100	100000110011	100000110011
37	000111001100	000111001100	111000110011	111000110011
38	011110000011	011110000011	100001111100	100001111100
39	000001111100	000001111100	111110000011	111110000011
3A	001110000011	001110000011	110001111100	110001111100
3B	000001111100	000001111100	111110000011	111110000011
3C	011001111100	011001111100	100110000011	100110000011
3D	000110000011	000110000011	111001111100	111001111100
3E	001111001100	001111001100	110000110011	110000110011
3F	000110000011	000110000011	111001111100	111001111100
40	011100011000	011100011000	100011100111	100011100111
41	000011100111	000011100111	111100011000	111100011000
42	001100011000	001100011000	110011100111	110011100111
43	000011100111	000011100111	111100011000	111100011000
44	011000011000	011000011000	100111100111	100111100111
45	000111100111	000111100111	111000011000	111000011000
46	011111100111	011111100111	100000011000	100000011000
47	000111100111	000111100111	111000011000	111000011000
48	011110011000	011110011000	100001100111	100001100111
49	000001100111	000001100111	111110011000	111110011000
4A	001110011000	001110011000	110001100111	110001100111
4B	000001100111	000001100111	111110011000	111110011000
4C	011001100111	011001100111	100110011000	100110011000
4D	000110011000	000110011000	111001100111	111001100111
4E	001111100111	001111100111	110000011000	110000011000
4F	000110011000	000110011000	111001100111	111001100111
50	011100111000	011100111000	100011000111	100011000111
51	000011000111	000011000111	111100111000	111100111000
52	001100111000	001100111000	110011000111	110011000111
53	000011000111	000011000111	111100111000	111100111000
54	011000111000	011000111000	100111000111	100111000111
55	000111000111	000111000111	111000111000	111000111000
56	011111000111	011111000111	100000111000	100000111000
57	000111000111	000111000111	111000111000	111000111000

(continued)

Table 4 (continued)

Data	Modulation codes			
	Table B1	Table B2	Table B3	Table B4
HEX	BIN	BIN	BIN	BIN
58	011100000111	011100000111	100011111000	100011111000
59	000011111000	000011111000	111100000111	111100000111
5A	001100000111	001100000111	110011111000	110011111000
5B	000011111000	000011111000	111100000111	111100000111
5C	011000000111	011000000111	100111111000	100111111000
5D	000111111000	000111111000	111000000111	111000000111
5E	001111000111	001111000111	110000111000	110000111000
5F	000111111000	000111111000	111000000111	111000000111
60	011100011111	011100011111	100011100000	100011100000
61	000011100000	000011100000	111100011111	111100011111
62	001100011111	001100011111	110011100000	110011100000
63	000011100000	000011100000	111100011111	111100011111
64	011000011111	011000011111	100111100000	100111100000
65	000111100000	000111100000	111000011111	111000011111
66	011111100000	011111100000	100000011111	100000011111
67	000111100000	000111100000	111000011111	111000011111
68	011110011111	011110011111	100001100000	100001100000
69	000001100000	000001100000	111110011111	111110011111
6A	001110011111	001110011111	110001100000	110001100000
6B	000001100000	000001100000	111110011111	111110011111
6C	011001100000	011001100000	100110011111	100110011111
6D	000110011111	000110011111	111001100000	111001100000
6E	001111100000	001111100000	110000011111	110000011111
6F	000110011111	000110011111	111001100000	111001100000
70	011100111111	011100111111	100011000000	100011000000
71	000011000000	000011000000	111100111111	111100111111
72	001100111111	001100111111	110011000000	110011000000
73	000011000000	000011000000	111100111111	111100111111
74	011000111111	011000111111	100111000000	100111000000
75	000111000000	000111000000	111000111111	111000111111
76	011111000000	011111000000	100000111111	100000111111
77	000111000000	000111000000	111000111111	111000111111
78	011110000111	011110000111	100001111000	100001111000
79	000001111000	000001111000	111110000111	111110000111
7A	001110000111	001110000111	110001111000	110001111000
7B	000001111000	000001111000	111110000111	111110000111
7C	011001111000	011001111000	100110000111	100110000111
7D	000110000111	000110000111	111001111000	111001111000
7E	001111000000	001111000000	110000111111	110000111111
7F	000110000111	000110000111	111001111000	111001111000
80 *	011100011110	011100011100	100011100001	100011100011
81 *	000011100001	000011100011	111100011110	111100011100
82 *	001100011110	001100011100	110011100001	110011100011
83 *	000011100001	000011100011	111100011110	111100011100

(continued)

Table 4 (continued)

Data	Modulation codes			
HEX	Table B1 BIN	Table B2 BIN	Table B3 BIN	Table B4 BIN
84 *	011000011110	011000011100	100111100001	100111100011
85 *	000111100001	000111100011	111000011110	111000011100
86 *	011111100001	011111100011	100000011110	100000011100
87 *	000111100001	000111100011	111000011110	111000011100
88 *	011110011110	011110011100	100001100001	100001100011
89 *	000001100001	000001100011	111110011110	111110011100
8A *	001110011110	001110011100	110001100001	110001100011
8B *	000001100001	000001100011	111110011110	111110011100
8C *	011001100001	011001100011	100110011110	100110011100
8D *	000110011110	000110011100	111001100001	111001100011
8E *	001111100001	001111100011	110000011110	110000011100
8F *	000110011110	000110011100	111001100001	111001100011
90 *	011100111110	011100111100	100011000001	100011000011
91 *	000011000001	000011000011	111100111110	111100111100
92 *	001100111110	001100111100	110011000001	110011000011
93 *	000011000001	000011000011	111100111110	111100111100
94 *	011000111110	011000111100	100111000001	100111000011
95 *	000111000001	000111000011	111000111110	111000111100
96 *	011111000001	011111000011	100000111110	100000111100
97 *	000111000001	000111000011	111000111110	111000111100
98 *	011100000001	011100000011	100011111110	100011111100
99 *	000011111110	000011111100	111100000001	111100000011
9A *	001100000001	001100000011	110011111110	110011111100
9B *	000011111110	000011111100	111100000001	111100000011
9C *	011000000001	011000000011	100111111110	100111111100
9D *	000111111110	000111111100	111000000001	111000000011
9E *	001111000001	001111000011	110000111110	110000111100
9F *	000111111110	000111111100	111000000001	111000000011
A0 *	011100001110	011100001100	100011110001	100011110011
A1 *	000011110001	000011110011	111100001110	111100001100
A2 *	001100001110	001100001100	110011110001	110011110011
A3 *	000011110001	000011110011	111100001110	111100001100
A4 *	011000001110	011000001100	100111110001	100111110011
A5 *	000111110001	000111110011	111000001110	111000001100
A6 *	011111110001	011111110011	100000001110	100000001100
A7 *	000111110001	000111110011	111000001110	111000001100
A8 *	011110001110	011110001100	100001110001	100001110011
A9 *	000001110001	000001110011	111110001110	111110001100
AA *	001110001110	001110001100	110001110001	110001110011
AB *	000001110001	000001110011	111110001110	111110001100
AC *	011001110001	011001110011	100110001110	100110001100
AD *	000110001110	000110001100	111001110001	111001110011
AE *	001111110001	001111110011	110000001110	110000001100

(continued)

Table 4 (continued)

Data	Modulation codes			
HEX	Table B1 BIN	Table B2 BIN	Table B3 BIN	Table B4 BIN
AF *	000110001110	000110001100	111001110001	111001110011
B0 *	011100110001	011100110011	100011001110	100011001100
B1 *	000011001110	000011001100	111100110001	111100110011
B2 *	001100110001	001100110011	110011001110	110011001100
B3 *	000011001110	000011001100	111100110001	111100110011
B4 *	011000110001	011000110011	100111001110	100111001100
B5 *	000111001110	000111001100	111000110001	111000110011
B6 *	011111001110	011111001100	100000110001	100000110011
B7 *	000111001110	000111001100	111000110001	111000110011
B8 *	011110000001	011110000011	100001111110	100001111100
B9 *	000001111110	000001111100	111110000001	111110000011
BA *	001110000001	001110000011	110001111110	110001111100
BB *	000001111110	000001111100	111110000001	111110000011
BC *	011001111110	011001111100	100110000001	100110000011
BD *	000110000001	000110000011	111001111110	111001111100
BE *	001111001110	001111001100	110000110001	110000110011
BF *	000110000001	000110000011	111001111110	111001111100
C0 *	011100011001	011100011000	100011100110	100011100111
C1 *	000011100110	000011100111	111100011001	111100011000
C2 *	001100011001	001100011000	110011100110	110011100111
C3 *	000011100110	000011100111	111100011001	111100011000
C4 *	011000011001	011000011000	100111100110	100111100111
C5 *	000111100110	000111100111	111000011001	111000011000
C6 *	011111100110	011111100111	100000011001	100000011000
C7 *	000111100110	000111100111	111000011001	111000011000
C8 *	011110011001	011110011000	100001100110	100001100111
C9 *	000001100110	000001100111	111110011001	111110011000
CA *	001110011001	001110011000	110001100110	110001100111
CB *	000001100110	000001100111	111110011001	111110011000
CC *	011001100110	011001100111	100110011001	100110011000
CD *	000110011001	000110011000	111001100110	111001100111
CE *	001111100110	001111100111	110000011001	110000011000
CF *	000110011001	000110011000	111001100110	111001100111
D0 *	011100111001	011100111000	100011000110	100011000111
D1 *	000011000110	000011000111	111100111001	111100111000
D2 *	001100111001	001100111000	110011000110	110011000111
D3 *	000011000110	000011000111	111100111001	111100111000
D4 *	011000111001	011000111000	100111000110	100111000111
D5 *	000111000110	000111000111	111000111001	111000111000
D6 *	011111000110	011111000111	100000111001	100000111000
D7 *	000111000110	000111000111	111000111001	111000111000
D8 *	011100000110	011100000111	100011111001	100011111000
D9 *	000011111001	000011111000	111100000110	111100000111

(continued)

Table 4 (concluded)

Data	Modulation codes			
HEX	Table B1 BIN	Table B2 BIN	Table B3 BIN	Table B4 BIN
DA *	001100000110	001100000111	110011111001	110011111000
DB *	000011111001	000011111000	111100000110	111100000111
DC *	011000000110	011000000111	100111111001	100111111000
DD *	000111111001	000111111000	111000000110	111000000111
DE *	001111000110	001111000111	110000111001	110000111000
DF *	000111111001	000111111000	111000000110	111000000111
E0	011100001111	011100001111	100011110000	100011110000
E1	000011110000	000011110000	111100001111	111100001111
E2	001100001111	001100001111	110011110000	110011110000
E3	000011110000	000011110000	111100001111	111100001111
E4	011000001111	011000001111	100111110000	100111110000
E5	000111110000	000111110000	111000001111	111000001111
E6	011111110000	011111110000	100000001111	100000001111
E7	000111110000	000111110000	111000001111	111000001111
E8	011110001111	011110001111	100001110000	100001110000
E9	000001110000	000001110000	111110001111	111110001111
EA	001110001111	001110001111	110001110000	110001110000
EB	000001110000	000001110000	111110001111	111110001111
EC	011001110000	011001110000	100110001111	100110001111
ED	000110001111	000110001111	111001110000	111001110000
EE	001111110000	001111110000	110000001111	110000001111
EF	000110001111	000110001111	111001110000	111001110000
F0	011100110000	011100110000	100011001111	100011001111
F1	000011001111	000011001111	111100110000	111100110000
F2	001100110000	001100110000	110011001111	110011001111
F3	000011001111	000011001111	111100110000	111100110000
F4	011000110000	011000110000	100111001111	100111001111
F5	000111001111	000111001111	111000110000	111000110000
F6	011111001111	011111001111	100000110000	100000110000
F7	000111001111	000111001111	111000110000	111000110000
F8 *	011110000110	011110000111	100001111001	100001111000
F9 *	000001111001	000001111000	111110000110	111110000111
FA *	001110000110	001110000111	110001111001	110001111000
FB *	000001111001	000001111000	111110000110	111110000111
FC *	011001111001	011001111000	100110000110	100110000111
FD *	000110000110	000110000111	111001111001	111001111000
FE	001111001111	001111001111	110000110000	110000110000
FF *	000110000110	000110000111	111001111001	111001111000

Annex A (informative)
Bibliography

SMPTE 226M, Television Digital Recording — 19-mm Tape Cassettes

EG 21-1993, Nomenclature for Television Digital Recording of 19-mm Type D-1 Component and Type D-2 Composite Formats