Standards and Recommended Practices

Approved American National Standards

Five American National Standards were approved by the American National Standards Institute on August 10, 1993: ANSI/SMPTE 244M-1993, Television — System M/NTSC Composite Video Signals — Bit-Parallel Digital Interface; ANSI/SMPTE 245M-1993, Television Digital Recording — 19-mm Type D-2 Composite Format — Tape Record; ANSI/SMPTE 246M-1993, Television Digital Recording — 19-mm Type D-2 Composite Format — Magnetic Tape; ANSI/SMPTE 247M-1993, Television Digital Recording — 19-mm Type D-2 Composite Format — Helical Data and Control Records; and ANSI/SMPTE 248M-1993, Television Digital Recording — 19-mm Type D-2 Composite Format — Cue Record and Time and Control Code Record. SMPTE 244M and SMPTE 247M are available from Society Headquarters for $20.00 each; SMPTE 246M and SMPTE 248M for $10.00 each; and SMPTE 245M for $13.00 each.

Approved SMPTE Engineering Guidelines

The Society recently approved three SMPTE Engineering Guidelines: EG 20-1993, Tape Transport Geometry Parameters for 19-mm Type D-2 Composite Format for Television Digital Recording; EG 21-1993, Nomenclature for Television Digital Recording of 19-mm Type D-1 Component and Type D-2 Composite Formats; and EG 22-1993, Description and Index of Documents for 19-mm Type D-2 Composite Television Digital Recording. EG 20 and EG 21 may be obtained from Headquarters for $13.00 each and EG 22 for $10.00 each.

Proposed SMPTE Recommended Practice

Published here for a trial period and public review is Proposed SMPTE Recommended Practice RP 27.4, Specifications for an Operational Test Pattern for Checking Jitter, Weave, and Travel Ghost in Television Projectors. The proposal will be approved if no adverse comments from publication are received. Comments should be addressed to Sherwin H. Becker, Director of Engineering, at Society Headquarters prior to February 1, 1994. Copies of RP 27.4 are available from Headquarters for $10.00.

— *Sherwin H. Becker,*
Director of Engineering

SMPTE Standards Subscription Service

The Society provides a Standards Subscription Service to assist firms, libraries, and individuals in establishing and maintaining a complete and current file of approved American National Standards, SMPTE Recommended Practices, and SMPTE Engineering Guidelines in the motion-picture, television, and video magnetic recording fields. Through this service, the Society makes automatic distribution to standards subscribers of all new and revised standards, recommended practices, and guidelines that are approved during the calendar year in these fields.

For further information, write to: Standards Subscription Service, Engineering Dept., Society of Motion Picture and Television Engineers, 595 West Hartsdale Ave., White Plains, NY 10607.

SMPTE STANDARD

ANSI/SMPTE 244M-1993

for Television — System M/NTSC Composite Video Signals — Bit-Parallel Digital Interface

1 Scope

1.1 This standard describes a bit-parallel composite video digital interface for systems operating according to the 525-line, 59.94-Hz NTSC standard, as described by SMPTE 170M, sampled at four times color subcarrier frequency. Sampling parameters for the digital representation of encoded video signals, the relationship between sampling phase and color subcarrier, and the digital levels of the video signal are defined.

1.2 This standard has application for use with shielded twisted 12-pair cable of conventional design over distances up to 50 m, without transmission equalization or any special equalization of the receiver. Longer cable lengths may be used, but with rapidly increasing requirement for care in the cable selection and possible receiver equalization or the use of active repeaters or both.

1.3 Digital composite video signals, as defined by this standard, are the signals conveyed by the composite implementation of the serial digital interface. It should be noted that additional information to that described by this standard is also carried by the serial digital interface.

The serial digital interface is the preferred method for the interconnection of composite digital equipments when cable lengths exceed 50 m.

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.

SMPTE 170M, Television — Composite Analog Video Signal — NTSC for Studio Applications

ISO 2110:1989, Information Technology — Data Communication — 25-Pole DTE/DCE Interface Connector and Contact Number Assignments

CCIR Recommendation 471-1, Nomenclature and Description of Colour Bar Signals

3 General specifications

3.1 The analog signal shall be sampled at a rate of four times the color subcarrier frequency along the I and Q axes. The phase reference for the sample clock shall be color subcarrier (f_{sc}). Many systems will derive this phase reference from the burst of the analog signal.

3.2 Color subcarrier phase to horizontal sync timing (SC/H) in the digital domain shall be zero.

3.3 The quantization scale shall be uniformly quantized PCM at 10 bits per sample. Eight bits per sample video data may be carried across the interface by using the eight most significant bits and setting the two least significant bits to zero.

3.4 The bits of the digital words that describe the video signal are transmitted in a parallel arrangement using 10 conductor pairs. An eleventh conductor pair carries a clock signal at $4f_{sc}$ (14.31818 MHz).

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3.5 The interface consists of one transmitter and one receiver in a point-to-point connection.

4 Sampling structure and quantization specifications

4.1 Sampling structure

Figure 1 depicts the line and field structure of the NTSC signal during the vertical blanking interval. Burst locked sinewave, shown in figure 1, is defined as a continuous sinewave at subcarrier frequency, with the same phase as burst.

4.1.1 There are 910 samples in a horizontal line period; 768 samples constitute the digital active video portion of each line. The remaining 142 samples comprise the digital horizontal blanking interval.

Each of the four samples during a color subcarrier period is described by the chrominance signal axis that it falls on. Figure 2 shows the derivation of the sample sequence.

Figure 3 depicts the sample numbering for a nominal NTSC signal. The half-amplitude point of the leading (falling) edge of the analog horizontal sync signal falls between samples 784 and 785.

The first of the 910 samples represents the first sample of the digital active line and is designated sample 0 for the purpose of reference. The 910 samples per line are, therefore, numbered 0 through 909. Samples 0 through 767 inclusive contain the digital active line video data.

4.1.2 The sample at sample 0, line 10, field 1, color frame A is an I axis (+123°) sample. (See figure 4.)

4.2 Quantization specifications

4.2.1 The digital video signal shall be quantized according to table 1.

Table 1 – Signal quantization

	8-bit system	10-bit system
White level	$C8_h$	320_h
Blanking level	$3C_h$	$0F0_h$
Sync tip level	04_h	010_h

Note - The "h" suffix indicates a hexidecimal value.

4.2.2 The amplitude relationship between the digital signal and an equivalent analog signal is shown in figure 5. The signal illustrated is a representation of 100% level, 7.5% setup (100/7.5/100/7.5) color bars.

4.2.3 The characteristics of the data word are based on the assumption that the location of any required (sin x)/x correction is at the point where the digital signal is converted to an analog form.

4.2.4 Data is represented in 8- or 10-bit words.

In an 8-bit system, 254 of the 256 levels (01 through FE) are used to express a quantized value.

In a 10-bit system, 1016 of the 1024 levels (004 through 3FB) are used to express a quantized value.

In an 8-bit system, levels 00 and FF are protected and are not permitted in the data stream.

In a 10-bit system, levels 000, 001, 002, 003 and 3FC, 3FD, 3FE, and 3FF are protected and are not permitted in the data stream.

The protected and permitted data levels are shown in table 2.

Table 2 – Permitted and protected values

8 bits		10 bits
00	Protected	000 001 002 003
01 — FE	Permitted	004 — 3FB
FF	Protected	3FC 3FD 3FE 3FF

4.2.5 Some models of composite digital video equipment allow the use of protected values in the video data. Designers of new equipment should consider the effects of such signals when detecting synchronizing patterns.

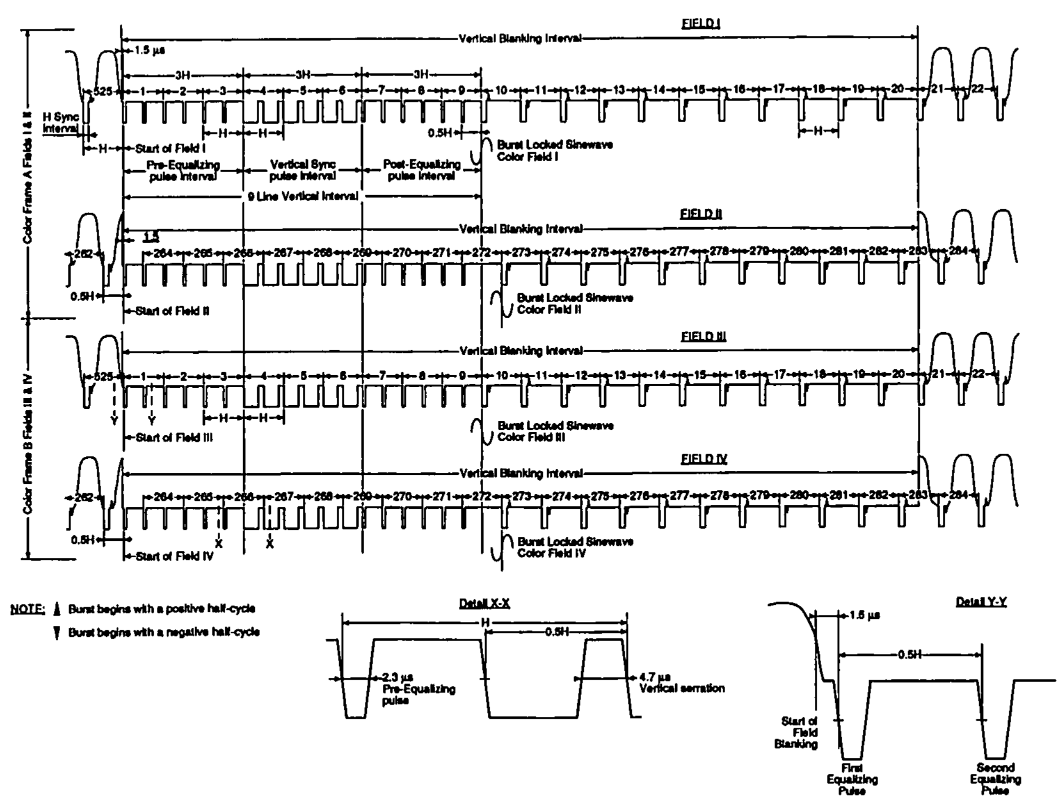
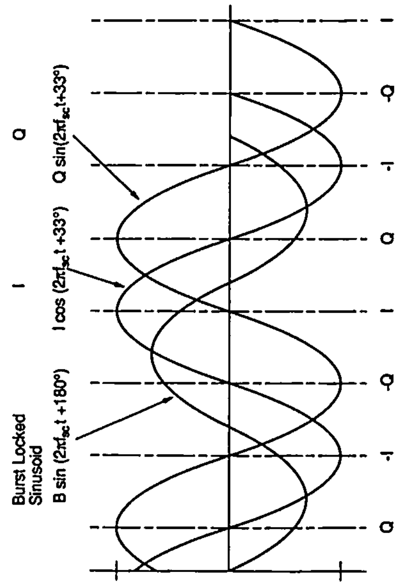


Figure 1 – Vertical blanking interval structure



NOTE – The equation for the chrominance signal is $E = I\cos(2\pi f_{sc}t + 33°) + Q\sin(2\pi f_{sc}t + 33°)$.
The equation for the burst locked sinusoid is $E = B\sin(2\pi f_{sc}t + 180°)$.

Figure 2 – Derivation of sample sequence

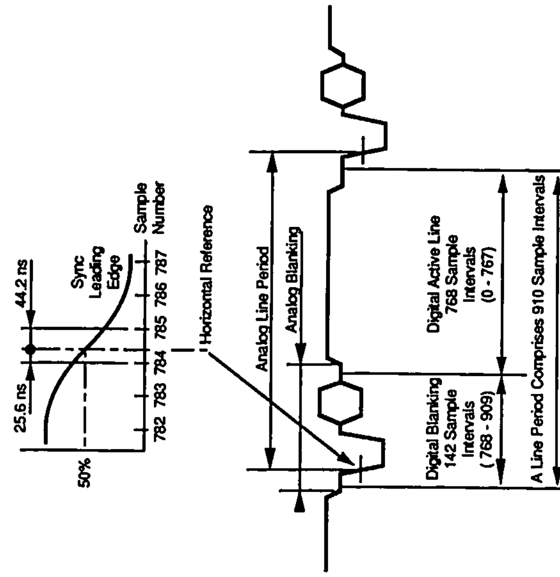


Figure 3 – Sample numbering for horizontal line period of nominal NTSC signal

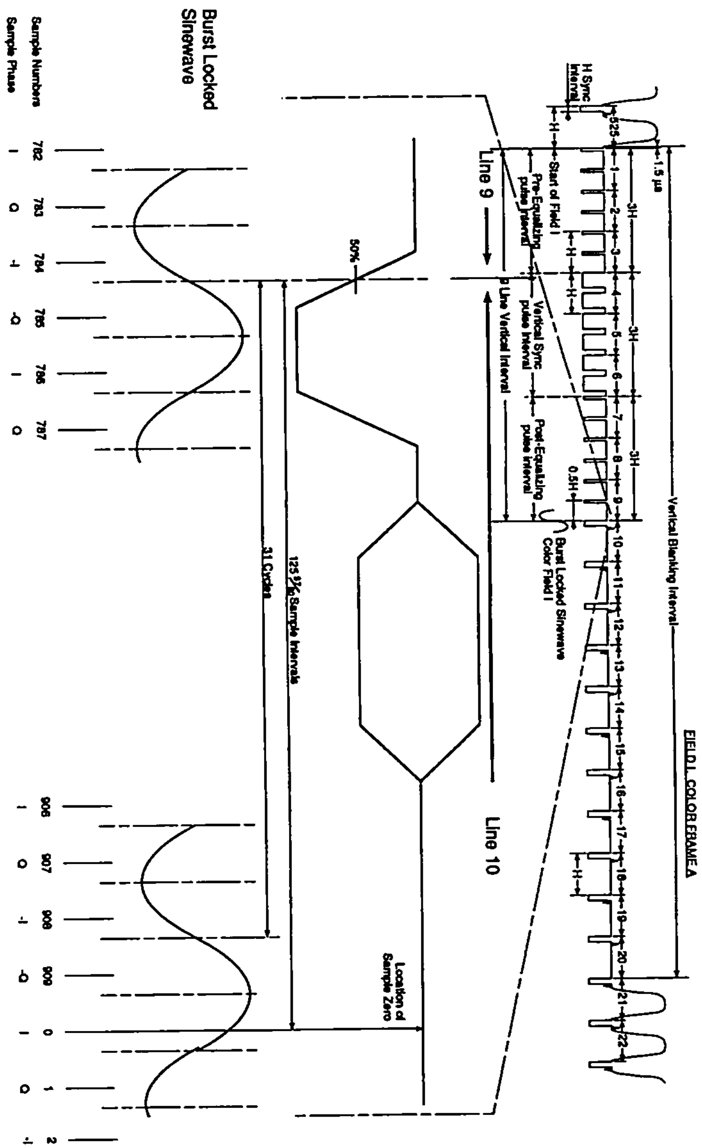


Figure 4 – Derivation of the sample zero sampling phase for line 10, field I, color frame A

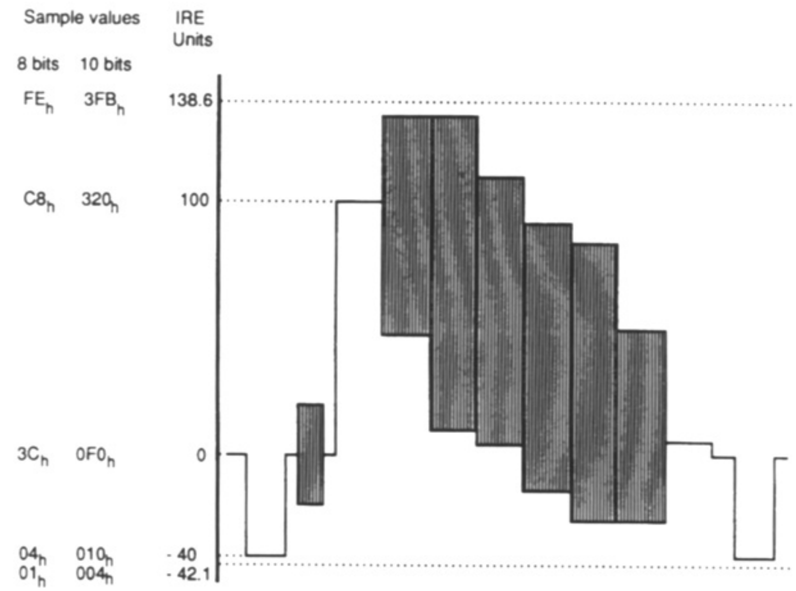


Figure 5 – Relationship between analog signal levels (IRE units) and digital sample values

4.3 Coding parameters

Sampling and quantization parameters are summarized in table 3.

Table 3 – Summary of coding parameters

Input signal	NTSC	
Number of samples/line period	910	
Sampling structure	Orthogonal	
Sampling frequency	$4f_{sc}$	
Sampling phase	I and Q axes (+123° and +33°)	
Form of coding	Uniformly quantized PCM, 8 or 10 bits per sample	
Quantization scale	8-bit system	10-bit system
White level	C8	320
Blanking level	3C	0F0
Sync tip level	04	010

5 Digital raster structure

Figure 6 depicts the digital raster structure and its relationship to the analog raster structure.

5.1 Digital active field

The digital active field duration exceeds that of the analog active field. The digital active field period is positioned to begin before and end after the analog video. Thus, the vertical blanking edges of the analog video are contained within the digital active picture space.

5.2 Digital active line

The digital active line duration exceeds that of the analog active line. The digital active line is positioned to begin before and end after analog video. Thus, the blanking edges of the analog video are contained within the digital active line period.

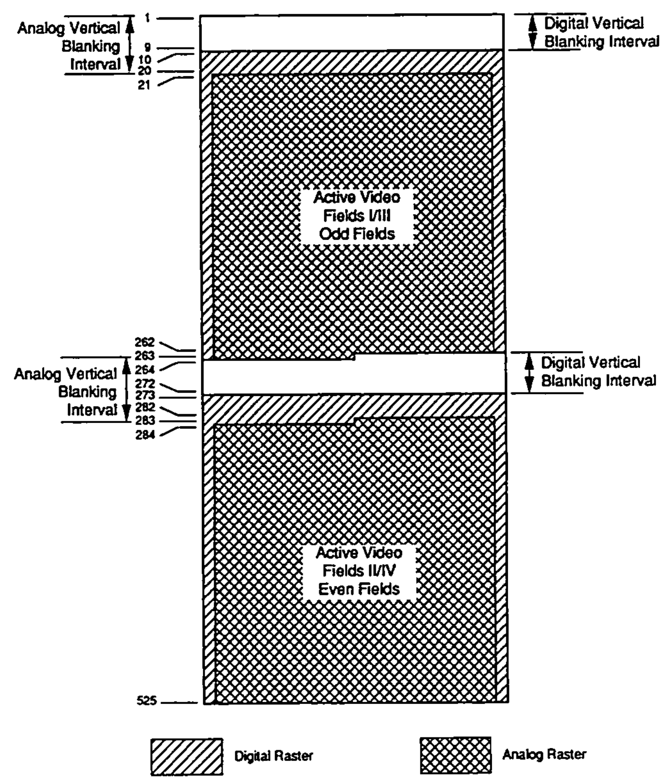


Figure 6 – Relationship between the analog and digital rasters

5.3 Analog blanking for digitally generated NTSC

When NTSC signals are digitally generated, blanking edges and rise times appropriate for the analog waveform must be included as an integral part of the digital signal. The edges and timings shall be in accordance with those defined in SMPTE 170M.

5.4 Digital vertical blanking interval

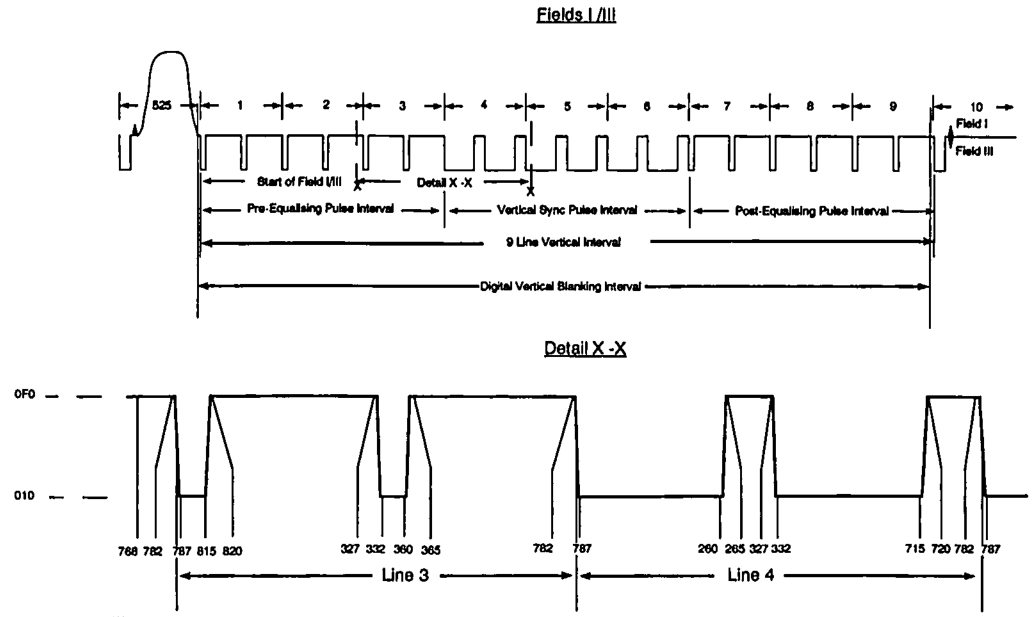
5.4.1 The digital vertical blanking interval extends from line 525, sample 768 to line 9, sample 767 inclusive, for fields I and III and from line 263, sample 313 to line 272, sample 767 inclusive, for fields II and IV.

5.4.2 Digital data within the digital vertical blanking interval shall consist of a digital representation of an analog vertical interval. A 10-bit representation of the signal is preferred, although 8-bit values can be used. Suggested values are shown in table 4.

5.4.3 The location and magnitude of the samples during the digital vertical blanking intervals are shown in figure 7a and figure 7b.

Table 4 – 10- and 8-bit hexadecimal values for the digital vertical blanking interval

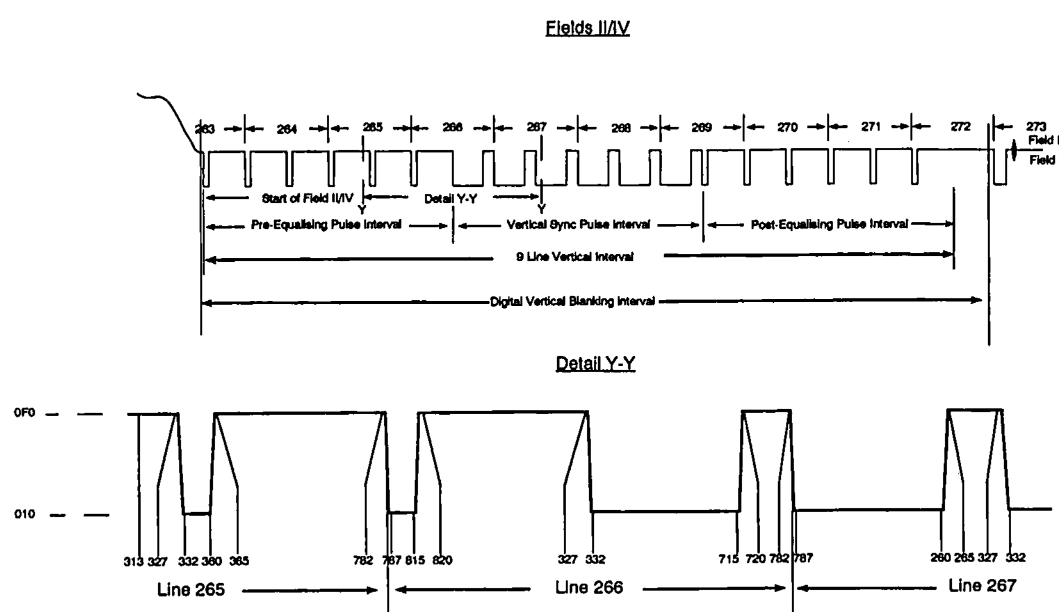
	Fields I/III Sample values			Fields II/IV Sample values	
Word	10 bit	8 bit	Word	10 bit	8 bit
		Equalizing pulse interval values			
768–782	0F0	3C	313–327	0F0	3C
783	0E9	3A	328	0E9	3A
784	0A4	29	329	0A4	29
785	044	11	330	044	11
786	011	04	331	011	04
787–815	010	04	332–360	010	04
816	017	06	361	017	06
817	05C	17	362	05C	17
818	0BC	2F	363	0BC	2F
819	0EF	3C	364	0EF	3C
820–327	0F0	3C	365–782	0F0	3C
328	0E9	3A	783	0E9	3A
329	0A4	29	784	0A4	29
330	044	11	785	044	11
331	011	04	786	011	04
332–360	010	04	787–815	010	04
361	017	06	816	017	06
362	05C	17	817	05C	17
363	0BC	2F	818	0BC	2F
364	0EF	3C	819	0EF	3C
365–782	0F0	3C	820–327	0F0	3C
		Vertical serration values			
782	0F0	3C	327	0F0	3C
783	0E9	3A	328	0E9	3A
784	0A4	29	329	0A4	29
785	044	11	330	044	11
786	011	04	331	011	04
787–260	010	04	332–715	010	04
261	017	06	716	017	06
262	05C	17	717	05C	17
263	0BC	2F	718	0BC	2F
264	0EF	3C	719	0EF	3C
265–327	0F0	3C	720–782	0F0	3C
328	0E9	3A	783	0E9	3A
329	0A4	29	784	0A4	29
330	044	11	785	044	11
331	011	04	786	011	04
332–715	010	04	787–260	010	04
716	017	06	261	017	06
717	05C	17	262	05C	17
718	0BC	2F	263	0BC	2F
719	0EF	3C	264	0EF	3C
720–782	0F0	3C	265–327	0F0	3C



Word Address (Decimal)	768	782	783	784	785	786	787	815	816	817	818	819	820	327	328	329	330	331	332	360	361	362	363	364	365
Sample Magnitude (10-Bit Hex)	0F0	0F0	0E9	0A4	044	011	010	010	017	05C	0BC	0EF	0F0	0F0	0E9	0A4	044	011	010	010	017	05C	0BC	0EF	0F0

Word Address (Decimal)	260	261	262	263	264	265	327	328	329	330	331	332	715	716	717	718	719	720	782	783	784	785	786	787
Sample Magnitude (10-Bit Hex)	010	017	05C	0BC	0EF	0F0	0F0	0E9	0A4	044	011	010	010	017	05C	0BC	0EF	0F0	0F0	0E9	0A4	044	011	010

Figure 7a – Location and magnitude of 10-bit samples during digital vertical blanking interval of fields I and III



Word Address (Decimal)	313	327	328	329	330	331	332	360	361	362	363	364	365	782	783	784	785	786	787	815	816	817	818	819	820
Sample Magnitude (10-Bit Hex)	0F0	0F0	0E9	0A4	044	011	010	010	017	05C	0BC	0EF	0F0	0F0	0E9	0A4	044	011	010	010	017	05C	0BC	0EF	0F0

Word Address (Decimal)	715	716	717	718	719	720	782	783	784	785	786	787	260	261	262	263	264	265	327	328	329	330	331	332
Sample Magnitude (10-Bit Hex)	010	017	05C	0BC	0EF	0F0	0F0	0E9	0A4	044	011	010	010	017	05C	0BC	0EF	0F0	0F0	0E9	044	044	011	010

Figure 7b – Location and magnitude of 10-bit samples during digital vertical blanking interval of fields II and IV

5.4.4 Some models of digital composite video equipment may use values for the samples in the digital vertical blanking interval that differ from those listed in table 4. However, the range of values must conform to the tolerances laid down for the analog signal by SMPTE 170M. Designers of receivers for this interface should consider the effects of such changes when implementing detection circuits.

5.5 Digital horizontal blanking interval

5.5.1 The digital horizontal blanking interval extends from sample 768 to sample 909 inclusive, on all lines outside the digital vertical blanking interval.

5.5.2 Digital data within the digital horizontal blanking interval shall consist of a digital representation of an analog horizontal blanking interval, with a burst of 0 SC/H phase. A 10-bit representation is preferred. Where 8-bit values are used, the sample values are selected to maximize the accuracy of representation of the burst. Suggested values are shown in table 5.

5.5.3 The location and magnitude of the samples during the digital horizontal blanking region are shown in figure 8.

5.5.4 Some models of digital composite video equipment may use values for the samples in the digital horizontal blanking interval that differ from those listed in table 5. However, the range of values must conform to the tolerances laid down for the analog signal by SMPTE 170M and by this standard in respect of 0 SC/H phase. Designers of receivers for this interface should consider the effects of such changes when implementing detection circuits.

NOTE – There are two sets of values listed in the table for both the 10-bit and 8-bit sample values. The first value is designated as being 0° and represents the sample values that are used when the phase of the burst is positive. The second value is designated as being 180° and represents the sample values that are used when the phase of the burst is negative.

6 Electrical characteristics

6.1 Signal conventions

6.1.1 The signals shall be transmitted via balanced signal pairs. Although the use of ECL technology is not mandated, the line driver and receiver shall be ECL compatible to permit the use of standard ECL parts for either or both ends. In this standard, "standard ECL" refers to the 10,000 series of ECL logic.

6.1.2 The signalling sense of the voltage appearing across the interconnection cable is positive binary and defined as follows: The DATA terminal of the generator shall be positive (+) with respect to the RETURN terminal for a binary 1 (HIGH or H or ON) state. The DATA terminal of the generator shall be negative (-) with respect to the RETURN terminal for a binary 0 (LOW or L or OFF) state. (See figure 9.)

6.1.3 The data lines are designated DATA 0 through DATA 9. DATA 9 is the most significant bit.

6.2 Transmitter characteristics

6.2.1 The transmitter shall have a balanced output with a maximum impedance of 110 ohms.

6.2.2 The common mode voltage of the line driver shall be -1.3 V ± 15% with reference to the ground terminals.

6.2.3 The generated signal shall lie between 0.8 V and 2.0 V peak-to-peak, measured across a 110-ohm resistor connected to the output terminals without any transmission line.

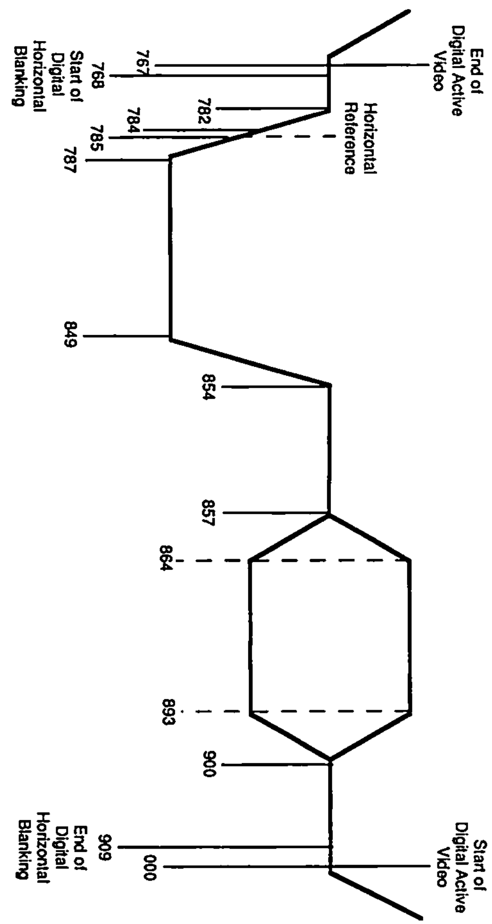
6.2.4 Rise and fall times shall be no longer than 5 ns and differ by not more than 2 ns, as measured between the 20% and 80% amplitude points, across a 110-ohm resistor connected to the output terminals without any transmission line.

6.3 Receiver characteristics

6.3.1 The cable shall be terminated by 110 ohms ± 10 ohms.

Table 5 – 10- and 8-bit hexadecimal values for the digital horizontal blanking interval

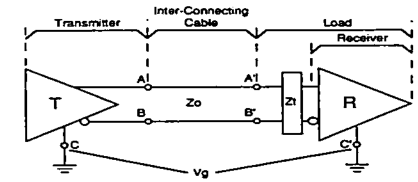
	10-bit sample values		8-bit sample values			10-bit sample values		8-bit sample values	
Word	0°	180É	0°	180°	Word	0°	180°	0°	180°
768–782	0F0	0F0	3C	3C	874	12D	0B3	4B	2D
783	0E9	0E9	3A	3A	875	092	14E	25	53
784	0A4	0A4	29	29	876	0B3	12D	2D	4B
785	044	044	11	11	877	14E	092	53	25
786	011	011	4	4	878	12D	0B3	4B	2D
787–849	010	010	4	4	879	092	14E	25	53
850	017	017	6	6	880	0B3	12D	2D	4B
851	05C	05C	17	17	881	14E	092	53	25
852	0BC	0BC	2F	2F	882	12D	0B3	4B	2D
853	0EF	0EF	3C	3C	883	092	14E	25	53
854–856	0F0	0F0	3C	3C	884	0B3	12D	2D	4B
857	0F0	0F0	3C	3C	885	14E	092	53	25
858	0F4	0EC	3D	3B	886	12D	0B3	4B	2D
859	0DC	104	37	41	887	092	14E	25	53
860	0D6	10A	36	42	888	0B3	12D	2D	4B
861	12C	0B4	4B	2D	889	14E	092	53	25
862	123	0BD	49	2F	890	12D	OB3	4B	2D
863	096	14A	25	53	891	092	14E	25	53
864	0B3	12D	2D	4B	892	0B3	12D	2D	4B
865	14E	092	53	25	893	14E	092	53	25
866	12D	0B3	4B	2D	894	129	0B7	4A	2E
867	092	14E	25	53	895	0A6	13A	2A	4E
868	0B3	12D	2D	4B	896	0CD	113	33	45
869	14E	092	53	25	897	112	0CE	44	34
870	12D	0B3	4B	2D	898	0FA	0E6	3F	39
871	092	14E	25	53	899	0EC	0F4	3B	3D
872	0B3	12D	2D	4B	900–909	0F0	0F0	3C	3C
873	14E	092	53	25					



Word No.	768	782	783	784	785	786	787	849	850	851	852	853	854	857	858	859	860	861	862	863	864	865	866	867	868	869	870	871	872
Burst Phase 0°	0F0	0F0	0E9	0A4	044	011	010	010	017	05C	0BC	0EF	0F0	0F0	0F4	0DC	0D6	12C	123	096	0B3	14E	12D	092	0B3	14E	12D	092	0B3
Burst Phase 180°	0F0	0F0	0E9	0A4	044	011	010	010	017	05C	0BC	0EF	0F0	0F0	0EC	104	10A	0B4	0BD	14A	12D	092	0B3	14E	12D	092	0B3	14E	12D

Word No.	873	874	875	876	877	878	879	880	881	882	883	884	885	886	887	888	889	890	891	892	893	894	895	896	897	898	899	900	909
Burst Phase 0°	14E	12D	092	0B3	14E	12D	092	0B3	14E	12D	092	0B3	14E	12D	092	0B3	14E	12D	092	0B3	14E	129	0A6	0CD	112	0FA	0EC	0F0	0F0
Burst Phase 180°	092	0B3	14E	12D	092	0B3	14E	12D	092	0B3	14E	12D	092	0B3	14E	12D	092	0B3	14E	12D	092	0B7	13A	113	0CE	0E6	0F4	0F0	0F0

Figure 8 – Location and magnitude of 10-bit samples during digital horizontal blanking interval



A, A' = Data line
B, B' = Return line
Zt = Cable termination
A, B = Transmitter interface points
A', B' = Load interface points
C = Transmitter circuit ground
C' = Load circuit ground
Vg = Ground potential difference
Zo = Cable characteristic impedance

Figure 9 – Balanced interface circuit

6.3.2 The line receiver must properly sense the binary data when connected directly to a line driver operating at the extreme voltage limits permitted by 6.2.3.

6.3.3 The receiver shall require a differential input voltage of no more than 185 mV to correctly attain the intended binary state.

6.3.4 The receiver shall operate correctly in the presence of common mode noise having a maximum amplitude of ± 0.5 V.

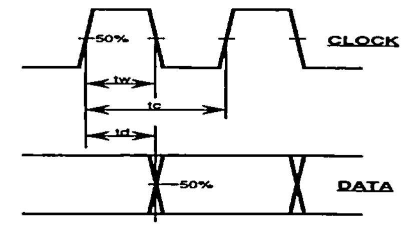
6.3.5 The receiver shall operate with a different delay between the received clock and any received data signals of up to 15 ns.

6.4 Clock signal

6.4.1 The clock signal is a $4f_{sc}$ square wave as shown in figure 10. The clock pulse width (Tw) is 35 ns ± 5 ns.

6.4.2 The peak-to-peak jitter between rising edges of the clock shall be within 5 ns of the average time of the rising edge computed over at least one television field.

6.4.3 The positive transition of the clock signal nominally occurs between the data transitions.



tw = 35 ns ± 5 ns

tc = $1/4f_{sc}$ (approximately 69.8 ns)

td = 35 ns ± 5 ns

Figure 10 – Digital interface clock waveform

7 Mechanical characteristics

7.1 General

This clause defines the mechanical specifications for the interface of digital video systems used in environments where the physical distance between the devices is limited and the general physical environment can be termed interior.

The majority of applications of this interface involve cable lengths of less than 50 m. For these lengths, cables with reasonable uniformity between pairs will, generally, give satisfactory results. For cable lengths greater than 50 m, cable specifications and termination characteristics become more critical and it is likely that equalization will be required.

7.2 Interconnecting cable

7.2.1 The interface is designed to operate with a nominal signal-pair impedance of 110 ohms.

7.2.2 The cable shall contain 12 pairs of conductors of which 11 pairs shall be used as signal lines. The remaining pair shall be used as system ground.

7.2.3 It is recommended that the cable be constructed to minimize the effects of crosstalk between signal lines, the susceptibility of the signal lines to external noise, and the transmission of interface signals to the external environment.

7.2.4 The cable shall have an outer shield, to minimize radiation, carried through the cable assembly. This shield shall be terminated via the chassis ground pin and the connector body at each end.

7.2.5 The cable shall be constructed to minimize the differential time delay between any two of the conductor pairs.

7.3 Connectors

7.3.1 The connectors shall have the mechanical characteristics conforming to the industry standard 25-pin subminiature type D, as described below. Additional information may be found in ISO 2110. (This interface will require that the connectors be inserted many times. ECL voltage and current levels are relatively low. Thus, the materials in the connector should be appropriate to the application.)

7.3.2 Cable connectors employ pin contacts and equipment connectors employ socket contacts (see figure 11).

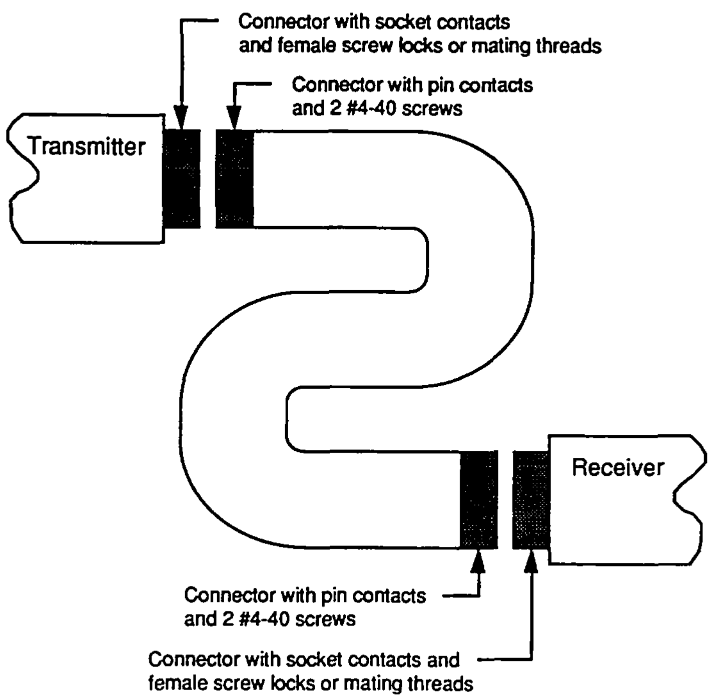


Figure 11 – Cable connector configuration

7.3.3 Cable connectors shall be provided with No. 4-40 mounting screws and equipment connectors shall be provided with female screw locks or mating threads. For further information, see annex A.

7.4 Connector contact assignments shall be in accord with table 6.

Table 6 – Connector contact assignments

Contact	Signal line	Contact	Signal line
1	CLOCK	14	CLOCK RETURN
2	SYSTEM GROUND	15	SYSTEM GROUND
3	DATA 9 (MSB)	16	DATA 9 RETURN
4	DATA 8	17	DATA 8 RETURN
5	DATA 7	18	DATA 7 RETURN
6	DATA 6	19	DATA 6 RETURN
7	DATA 5	20	DATA 5 RETURN
8	DATA 4	21	DATA 4 RETURN
9	DATA 3	22	DATA 3 RETURN
10	DATA 2	23	DATA 2 RETURN
11	DATA 1	24	DATA 1 RETURN
12	DATA 0 (LSB)	25	DATA 0 RETURN
13	CABLE SHIELD		

Annex A (informative)
Additional data

A.1 Connector characteristics

The interface employs a 25-pin subminiature type D connector with the connectors on the transmitter and receiver using socket contacts and the connectors on both ends of the cable using pin contacts.

Connectors are locked together by two No. 4-40 screws on the cable connectors, which mate with female screw locks mounted on the equipment connectors. Detailed dimensions are given in ISO 2110.

The relative position of the connector and the female screw lock are defined in figure A.1. The recommended minimum connector spacing is defined in figure A.2. It is recommended that the cable connectors employ a conductive backshell to maintain the shielding of the signal conductors. Care should be taken to select designs that are appropriate for use with the screw latching specified.

A.2 Cable shield pin

The cable shield (pin 13) is for the purpose of controlling electromagnetic radiation from the cable. It is recommended that pin 13 provide high-frequency continuity to the chassis ground at both ends and, in addition, provide DC continuity to the chassis ground at the transmit end.

A.3 Connector orientation

For either vertical or horizontal mounting, contact 1 should be uppermost.

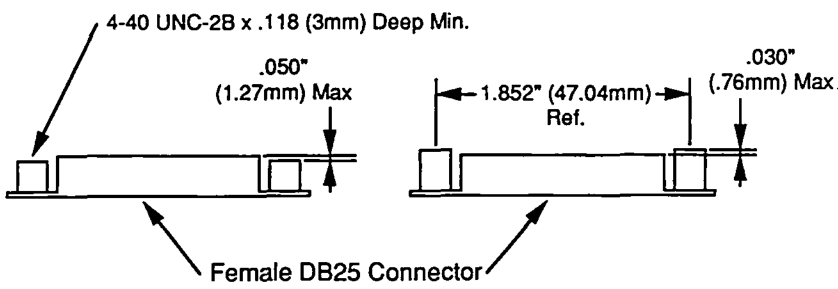


Figure A.1 – Female screw lock mounting detail

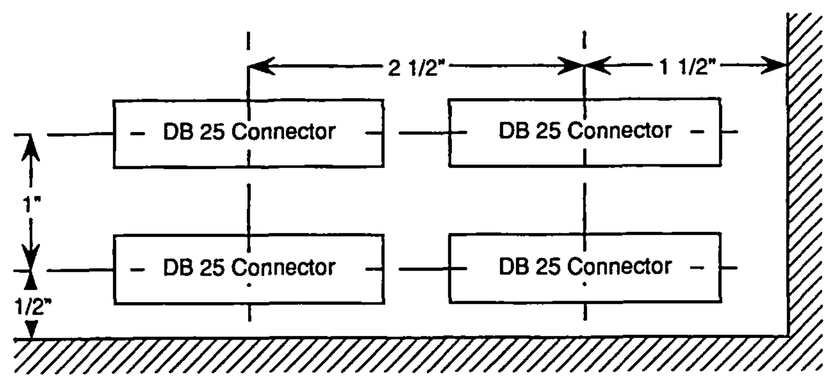


Figure A.2 – Minimum connector spacing

SMPTE STANDARD

for Television Digital Recording — 19-mm Type D-2 Composite Format — Tape Record

1 Scope

This standard specifies the dimensions and location of the audio, video, ancillary data, cue track, time code, and control-track records for 19-mm type D-2 helical-scan composite digital cassette television tape recorders operating on the 525/60 television system encoded according to ANSI/SMPTE 244M.

2 General specifications

2.1 Dimensions are in the metric system.

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

– Temperature	20°C ± 1°C
– Relative humidity	(50 ± 2)%
– Barometric pressure	96 kPa ± 10 kPa
– Tape tension	0.70 N ± 0.05 N

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

– Time of conditioning: Not less than 24 hours

– Environmental: Stabilized to the conditions specified in 2.2

– Tape tension: Wound on a reel at a tension of 0.6 N to 1.5 N

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

2.4.1 All dimensions in the table and figures shall be measured from an equivalent reference edge. The tape reference edge is a line through three points on the edge of tape constrained to lie in one straight line. This constraint may be a physical deformation or an equivalent mathematical transformation. The first and third points shall be separated by a measurement distance (MD) of 210 mm. The second point shall be located a distance 0.2 MD from the first point and 0.8 MD from the third point as shown in figure 3. The program reference point lies on a line perpendicular to the reference edge through the second point on the reference edge.

2.4.2 Measuring techniques are shown in annex A.

2.4.3 As indicated in figure 1, this standard anticipates the use of overlap recording by helical tape record heads of width greater than the track pitch.

3 Tape speed

The basic value for tape speed is 131.700 mm/s. The tape speed tolerance is ± 0.2%.

4 Record location and dimensions

4.1 Record location and dimensions for continuous recording shall be as specified in figures 1 and 2 and table 1.

4.2 In recording, sector locations on each helical track shall be contained within the tolerance specified in table 1 and figure 3.

4.3 The width and height tolerances of the heads used for recording shall be chosen so as to ensure

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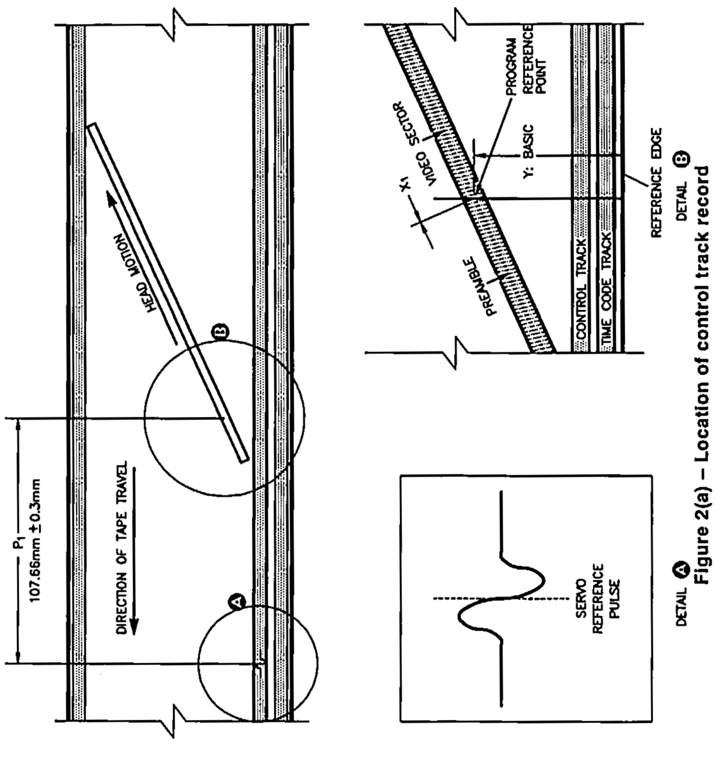


Figure 2(a) – Location of control track record

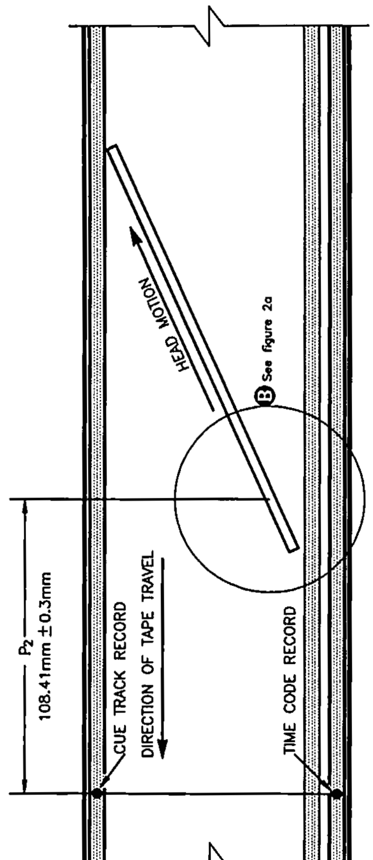
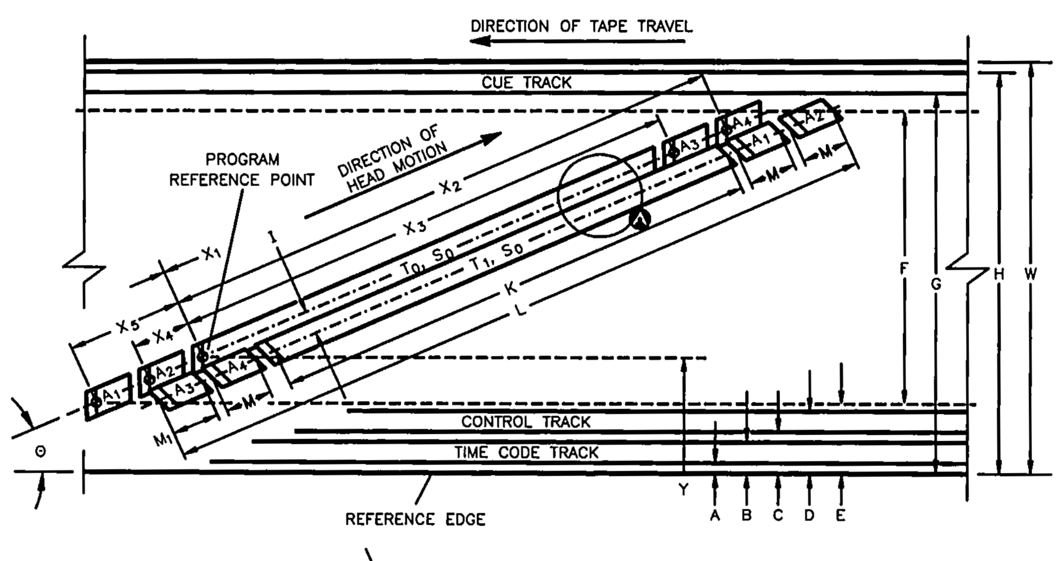
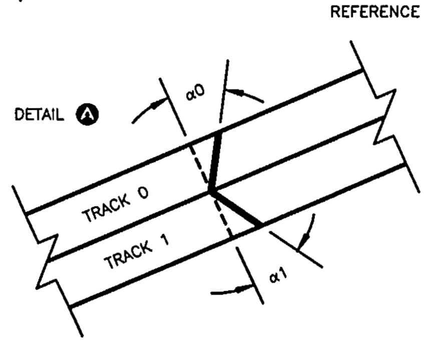


Figure 2(b) – Location of cue/time code record





NOTES
1 A_1, A_2, A_3, and A_4 are audio sectors.
2 T_0 and T_1 are track numbers. S_0 is a segment number (typical).
3 Tape viewed from magnetic coating side.
4 Dimensions X_1–X_5 are determined by the program reference point as defined in figure 2(a), in 6.3, and at the end of the preambles of the corresponding video and audio sectors specified in ANSI/SMPTE 247M.

Figure 1 – Location and dimensions of recorded tracks

Table 1 – Record location and dimensions

	Dimensions	Millimeters Nominal	Tolerance
A	Time code track lower edge	0.2	± 0.1
B	Time code track upper edge	0.7	± 0.1
C	Control track lower edge	1.0	± 0.1
D	Control track upper edge	1.50	± 0.05
E	Program area lower edge	1.807	Derived
F	Program area width	16.1	Derived
G	Cue track lower edge	18.2	± 0.1
H	Cue track upper edge	18.9	± 0.1
I	Helical track pitch	0.0391	± 0.0030
K	Video sector length	132.49	Derived
L	Helical track total length	150.78	Derived
M_1	Audio sector A_1 track 0 and A_3 track 1	4.13	Derived
M	All other audio sectors	4.01	Derived
P_1	Control pulse distance	107.66	± 0.30
P_2	Cue/time code distance	108.41	± 0.30
W	Tape width	19.010	± 0.015
X_1	Location of video sector	0	± 0.10
X_2	Location of start of audio sector A_4	137.57	± 0.10
X_3	Location of start of audio sector A_3	133.03	± 0.10
X_4	Location of start of audio sector A_2	4.54	± 0.10
X_5	Location of start of audio sector A_1	9.08	± 0.10
Y	Program reference point	2.80	Basic
θ	Track angle	6.1296°	
α0	Track 0 azimuth angle	+14.97° ± 0.17°	
α1	Track 1 azimuth angle	−15.03° ± 0.17°	

NOTE – Above dimensions shall apply under the conditions specified in 2.2.

zero guard band between recorded tracks. If a guard band is present it shall not exceed 4 µm nor contain any previously recorded information. The minimum track width after recording is 35 µm measured across the track in a line perpendicular to the centerline of the tracks.

5 Helical track record curvature

5.1 The centerlines of any four consecutive tracks shall be contained within the pattern of the four tolerance zones established in figure 3.

5.2 Each zone is defined by two parallel lines which are inclined at an angle of 6.1296° basic with respect to the tape reference edge.

5.3 The centerlines of all zones shall be spaced 0.0391 mm basic apart. The width of the first zone shall be 0.008 mm basic. The width of zones 2 through 4 shall be 0.012 mm basic. These zones are established to contain track angle errors, track straightness errors, and track pitch errors. (See annex A.)

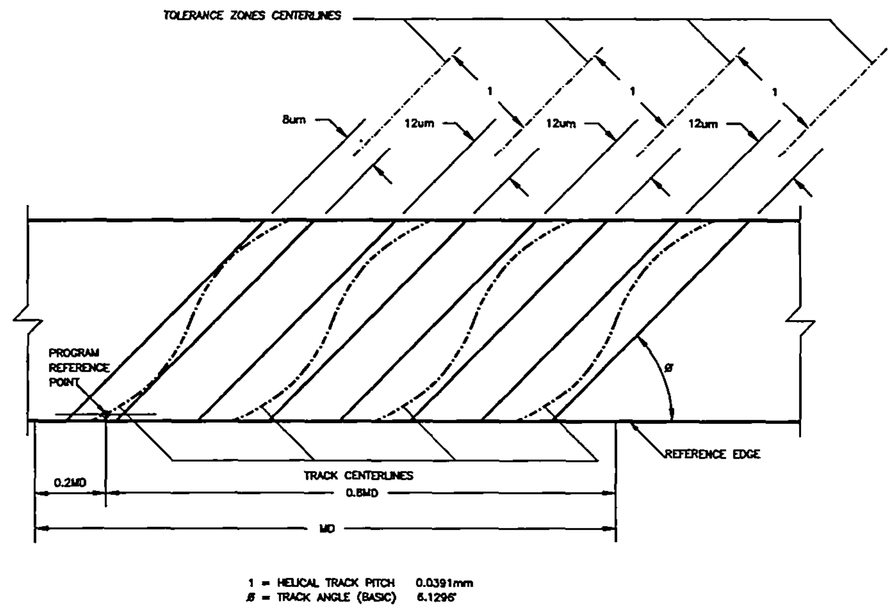


Figure 3 – Location and dimensions of tolerance zones of helical track record

6 Relative positions of recorded signals

6.1 Audio, video, and ancillary data, tracking control, time code, and cue track, with information intended to be time coincident, shall be positioned as shown in figures 1 and 2.

6.2 The spatial relationship between the cue track record, time code record, control track record, and helical tracks is specified in figures 1 and 2.

6.3 The program reference point is determined by the intersection of a line parallel to the reference edge of the tape at the distance Y and the centerline of each track in each video field (segment 0, track 0). The end of the preamble and the video sector shall be recorded at the program reference point and the tolerance is the dimension X_1. The locations are shown in figures 1 and 2. Dimensions X_1 and Y are given in table 1. The relationship between sectors and contents of each sector is specified in ANSI/SMPTE 247M.

7. Gap azimuth

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

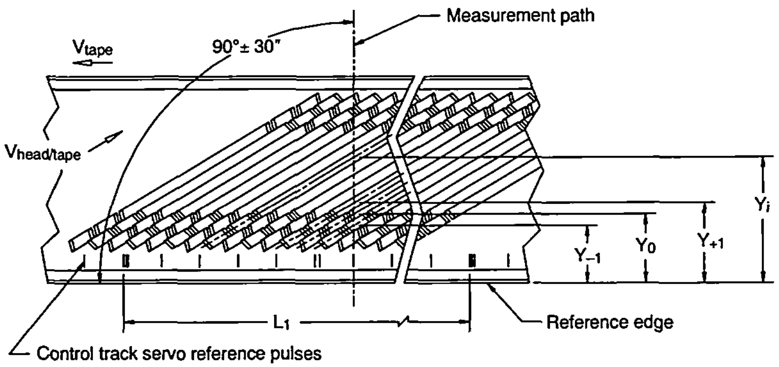
7.2 The azimuth of the head gaps used for the helical track recording shall be inclined at angles α0 and α1, as specified in table 1, perpendicular to the helical track record. The azimuth of the first track of every field (segment 0, track 0) shall be oriented in the clockwise direction with respect to the line perpendicular to the track direction when viewed from the side of the tape containing the magnetic record.

Annex A (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 of the distance between a minimum of 201 control track servo reference pulses (200 control track pitches minimum) (see L_1, figure A.1). All measurements are made under the environmental conditions described in clause 2.2 except that the measurements are made without tape tension (see figure A.1). The tape is then mathematically stretched to account for tape tension (see figure A.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 figure A.3).

Track location error includes track angle errors, track straightness errors, and track pitch errors. The starting point for calculations and measurements is, for example, the program reference point. The values for each fourth track are the errors for tolerance zone one; shifting one track, the second tolerance zone can be measured and so on. It is not necessary to measure all tracks; a suitable number is 20 samples per zone. A plot of the track location error against the track number shall be computed (see figure A.4). The peak-to-peak value shall lie within the tolerance zones according to clause 5.3.



NOTES
1 i is the track number (i = 0 for the track containing the program reference point).
2 Y_i is the actual track position (measured from the reference edge of the tape).
3 L_1 is the distance of n control track pitches (n = 200 minimum).

Figure A.1 – Measurement of ferrofluid tape development

The measured distance, L_1, must be corrected for tape tension. The corrected tape length, L_2 (for n control track pitches), is:

$L_2 = L_1 \times (1+T/(A \times E))$

where

T is the tape tension (0.7 N)
A is the tape cross section area (0.013 mm × 19.01 mm)
E is Young's modulus (10 000 N/mm^2).

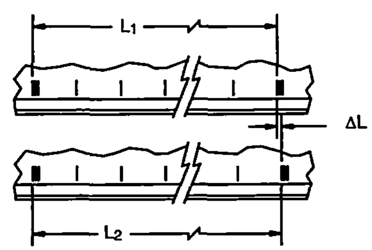


Figure A.2 – Correction for tape tension

The corrected longitudinal track pitch, L_3, is:

$L_3 = L_2/(n \times q)$

where

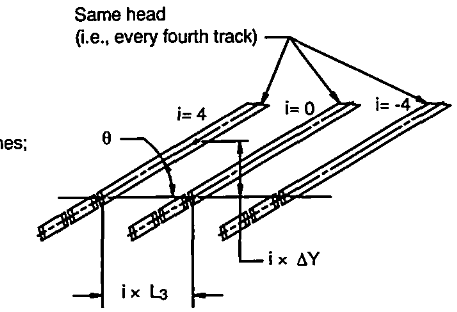
L2 is the corrected tape length for n control track pitches;
q is the number of tracks per control track pitch (2).

The cross track pitch, ΔY, is:

$\Delta Y = L_3 \times \tan(\theta)$

where

L_3 is the corrected track length;
θ is the theoretical track angle (6.1296°).



The theoretical track position, Y_{it}, to any track i is:

$Y_{it} = Y+(i \times \Delta Y)$

where

Y is the distance to the program reference point (2.80 mm);
i is the track number (i = 0 for the track containing the program reference point);
ΔY is the cross tape track pitch.

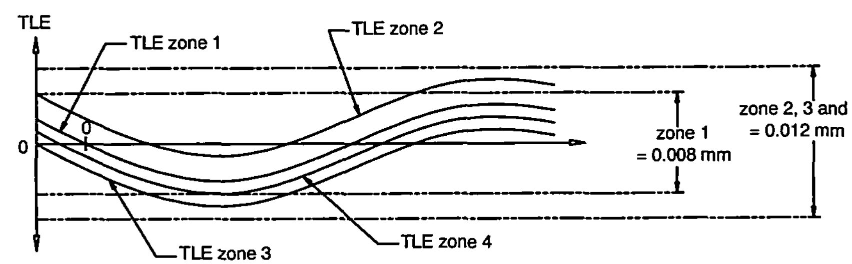
The track location error, TLE, is calculated as:

$TLE = Y_i - Y_{it}$

where

Y_i is the actual track position of track i;
Y_{it} is the theoretical track position of track i.

Figure A.3 – Calculation of track location error



NOTES
1 For tolerance zone 1: i = ... –4, 0, +4, +8 ....
2 For tolerance zone 2: i = ... –5, –1, +3, +7 ....
3 For tolerance zone 3: i = ... –6, –2, +2, +6 ....
4 For tolerance zone 4: i = ... –7, –3, +1, +5 ....

Figure A.4 – Example plot of track location error versus track number

Annex B (informative)
Bibliography

ANSI/SMPTE 244M-1993, Television — System M/NTSC Composite Video Signals — Bit-Parallel Digital Interface

ANSI/SMPTE 246M-1993, Television Digital Recording — 19-mm Type D-2 Composite Format — Magnetic Tape

ANSI/SMPTE 247M-1993, Television Digital Recording — 19-mm Type D-2 Composite Format — Helical Data and Control Records

ANSI/SMPTE 248M-1993, Television Digital Recording — 19-mm Type D-2 Composite Format — Cue Record and Time and Control Code Record

SMPTE EG 20-1993, Tape Transport Geometry Parameters for 19-mm Type D-2 Composite Format for Television Digital Recording

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

SMPTE STANDARD

for Television Digital Recording — 19-mm Type D-2 Composite Format — Magnetic Tape

1 Scope

This standard specifies the principal properties of the magnetic tape used for the 19-mm type D-2 composite digital television format.

2 Measurement environment

2.1 Dimensions are in the metric system.

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

- Temperature 20°C ± 1°C
- Relative humidity (50 ± 2)%
- Barometric pressure 96 kPa ± 10 kPa

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

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

3 Television tape specifications

3.1 Base

The base material shall be polyester or equivalent.

3.2 Width

The tape width shall be 19.010 mm ± 0.015 mm.

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

3.3 Delta width

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

3.3.1 Measurement of delta width shall be over a tape length of 230 mm with a tension of 0.7 N.

3.4 Reference edge straightness

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

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

3.5 Tape thickness

Tape shall have a thickness between 11 µm and 13 µm.

3.6 Transmissivity

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

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3.7 Offset yield strength

Offset yield strength shall be greater than 15 N.

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

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

3.8 Magnetic coating

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

3.8.1 The coating coercivity shall be a class 1500 oersted (120,000 A/m), as measured by a 50- or 60-Hz BH meter or vibrating sample magnetometer (VSM).

3.8.2 The magnetic particles shall be longitudinally oriented.

Annex A (informative)
Bibliography

ANSI/SMPTE 244M-1993, Television — System M/NTSC Composite Video Signals — Bit-Parallel Digital Interface

ANSI/SMPTE 245M-1993, Television Digital Recording — 19-mm Type D-2 Composite Format — Tape Record

ANSI/SMPTE 247M-1993, Television Digital Recording — 19-mm Type D-2 Composite Format — Helical Data and Control Records

ANSI/SMPTE 248M-1993, Television Digital Recording — 19-mm Type D-2 Composite Format — Cue Record and Time and Control Code Record

SMPTE EG 20-1993, Tape Transport Geometry Parameters for 19-mm Type D-2 Composite Format for Television Digital Recording

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

CCIR Report 624-4 (MOD F), Characteristics of Television Systems

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 ANSI/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, Digital Audio Engineering — Serial Transmission Format for Two-Channel Linearly Represented Digital Audio Data

CCIR Report 624-4 (MOD F), Characteristics of 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.

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.

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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.

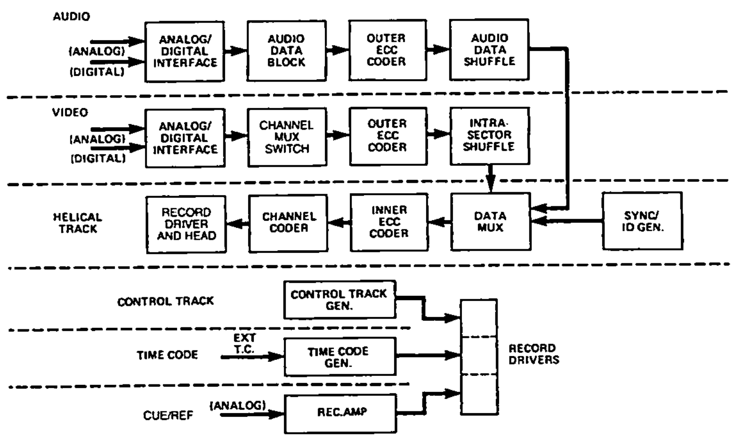


Figure 1 – Block diagram – Record

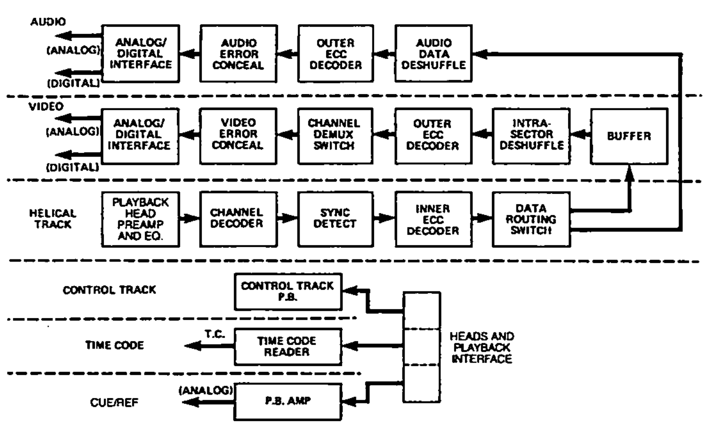
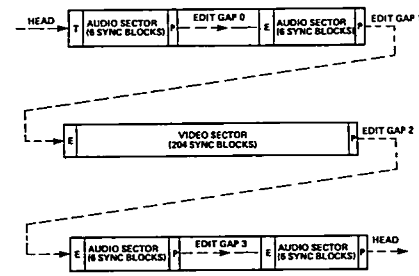


Figure 2 – Block diagram – Reproduce



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

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.)

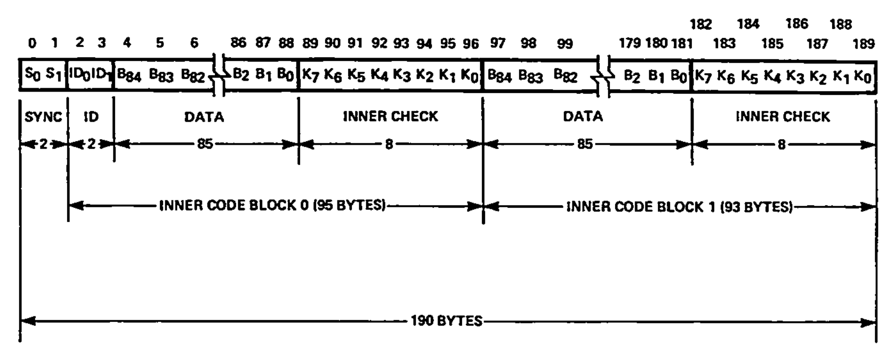


Figure 4 – Sync block format

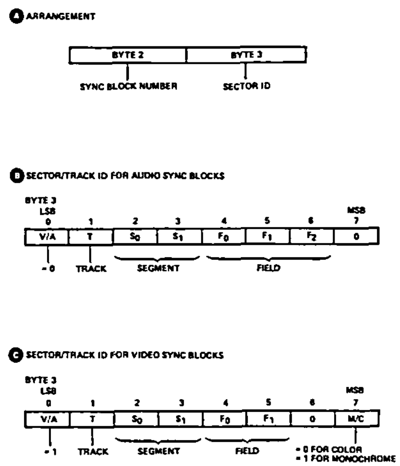


Figure 5 – Sync block identification format

(c) The field address F_0, F_1 (bits 4 and 5 of the sector ID for video sync blocks) shall identify the 4-field color sequence as defined in CCIR 624-3 (MOD F), 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.

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).

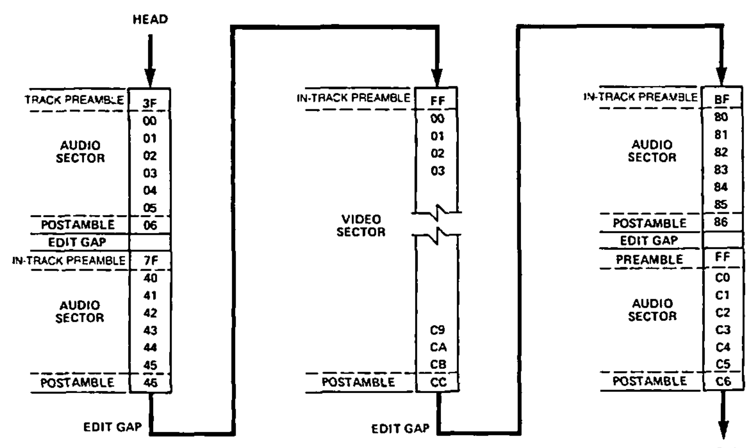
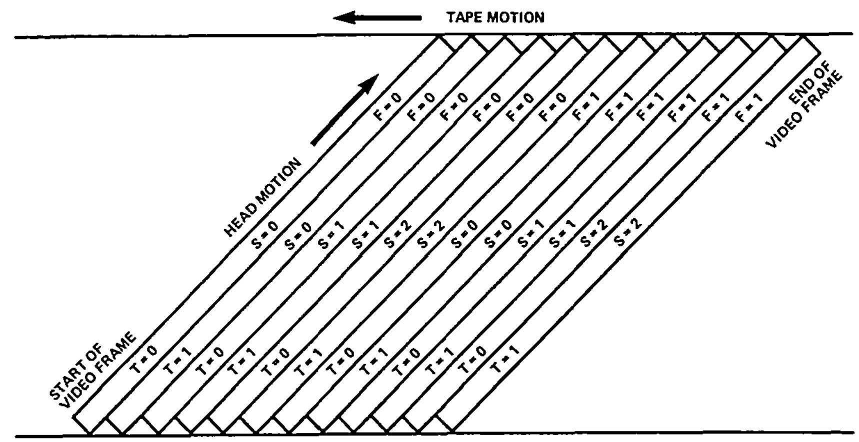


Figure 6 – Sync block ID number



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

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 clocl: 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 2 —	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).

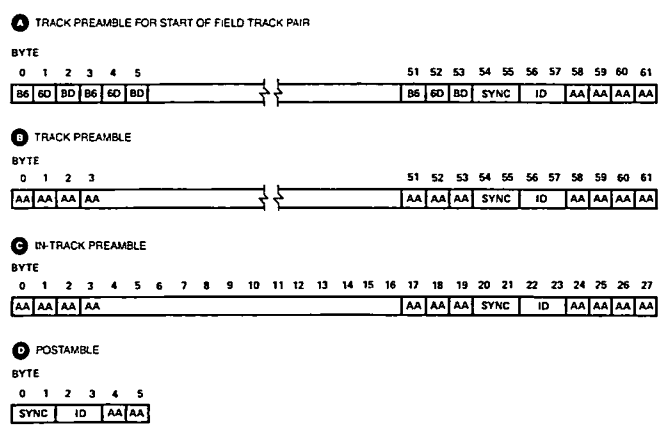


Figure 8 – Sector preamble and postamble

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.

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 ANSI/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.

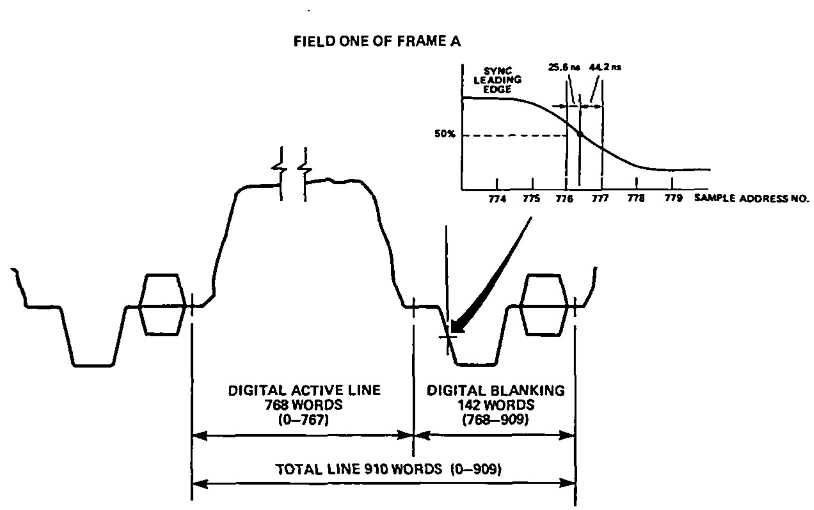
Under this condition sample number 785 occurs 44.2 ns (57° of color subcarrier) after the 50-percent point of the leading edge of the horizontal sync pulse.

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 CCIR 624-4 (MOD F), 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 CCIR 624-4 (MOD F) (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;



NOTE — Zero-degree ScH.

Figure 9 – Horizontal sync relationship

- 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.

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.

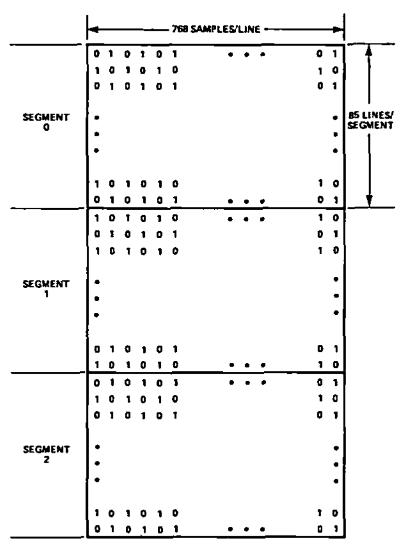


Figure 10 – Channel distribution of samples

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:

$L = 0, 1, \ldots, 84$

Let h be the horizontal sample location within line L:

$h = 0, 1, \ldots, 767$

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

$ih = int(h/2), \; ih = 0, 1, \ldots, 383$

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

Let Oblock be the outer block number within line L:

$Oblock = 0.1, \ldots, 5$

Let Obyt be the sample number within outer block Oblock:

$Obyt = 0, 1, \ldots, 63$

(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:

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

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
and
$Col = L + 85 \bullet Oblock$

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

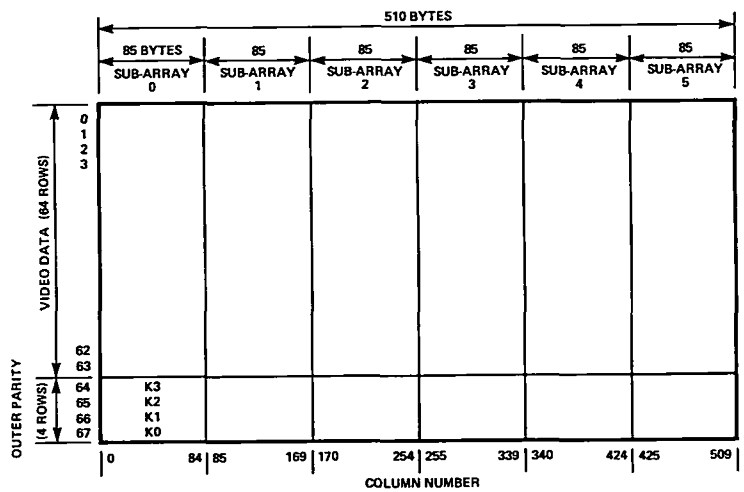


Figure 11 — Video sector array

times 85 bytes), and 68 rows (64 video data plus 4 outer check bytes). Figure 11 illustrates the 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 in 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.

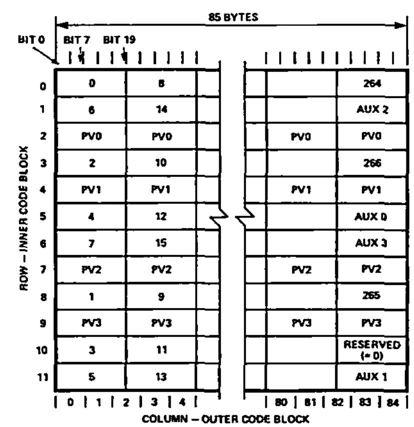
Source data is defined as follows:

(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.

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.

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

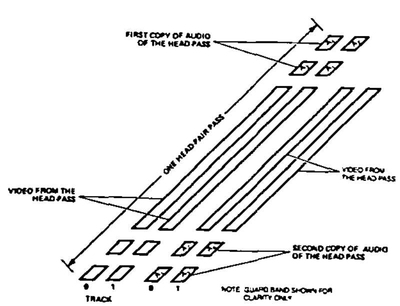
Bits 2, 3, and 4 of this byte are recorded in an auxiliary word.

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



NOTE – Guard band shown for clarity only.

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.

Table 3 – Audio data word mode

	Bit				
Word mode	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.

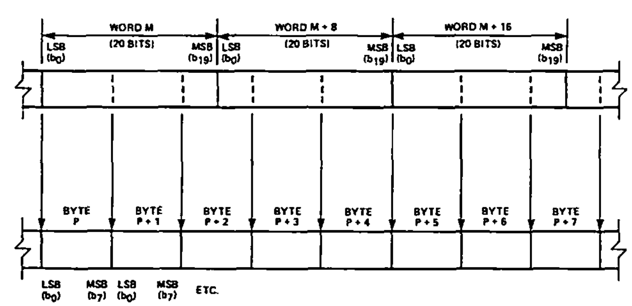


Figure 14 – Allocation of audio words to bytes

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

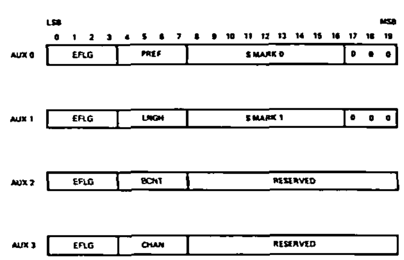
(d) Sample number 266 is unoccupied for one block in every 5 fields. Its value should be equated to that of sample number 265. Audio segment zero of every 5th field shall contain 266 samples. All other segments shall contain 267.

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.

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

Bits 0–3 → 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

Mode	CHAN 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: LSB 0 1 2 3 4 5 6 7 MSB — Channel status (AES/EBU byte 0)

Bits 0–2 → 0 1 2 PREF

Bit 0: Preemphasis bit 0
Bit 1: Preemphasis bit 1
Bit 2: Preemphasis bit 2
Bit 3: 0

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

Bit: LSB 0 1 2 3 MSB — LNGH

Bit 0: Not used = 0
Bit 1: LNGH 1 (LSB)
Bit 2: LNGH 2
Bit 3: LNGH 3 (MSB)

Mode	Bits 3	2	1	Audio length	Ancillary bits 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.

3.10.4.4 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 0 1 2 3 4 5 6 7 8 MSB — 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	0

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.

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: in 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 $x_4D(x)$ by G(x), where D(x) is the polynomial given by:

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

Equation of full code is given by

$B_7x^{11} + B_6x^{10} + B_5x^9 + \ldots + B_1x^5 + B_0x^4 + K_3x^3 + K_2x^2 + K_1x + K_0$

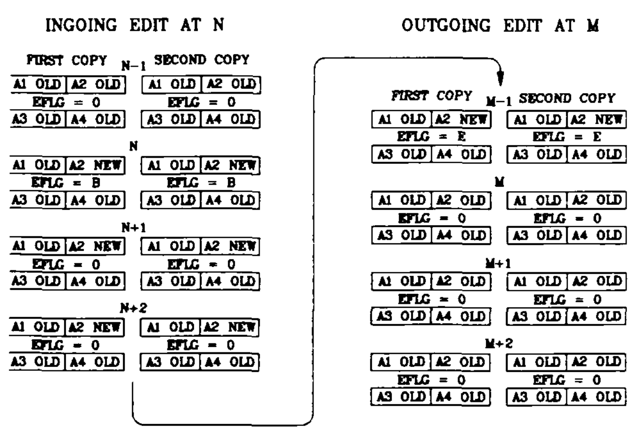


Figure 16 – Audio edit (channel A2 only)

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 A_1, A_2, A_3, and A_4 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.

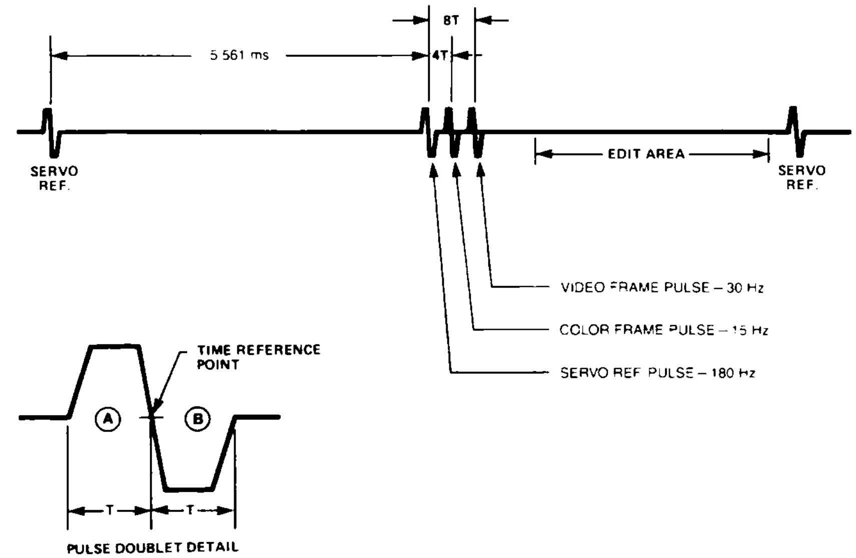
4.1.5 Servo reference pulse doublets shall be separated by a pitch equivalent to a pair of helical tracks.

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 CCIR 624-4 (MOD F), 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.



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

Figure 17 – Control waveform-timing

Annex A (informative)
Bibliography

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

ANSI/SMPTE 244M-1993, Television — System M/NTSC Composite Video Signals — Bit-Parallel Digital Interface

ANSI/SMPTE 245M-1993, Television Digital Recording — 19-mm Type D-2 Composite Format — Tape Record

ANSI/SMPTE 246M-1993, Television Digital Recording — 19-mm Type D-2 Composite Format — Magnetic Tape

ANSI-SMPTE 248M-1993, Television Digital Recording — 19-mm Type D-2 Composite Format — Cue Record and Time and Control Record

SMPTE EG 20-1993, Tape Transport Geometry Parameters for 19-mm Type D-2 Composite Format for Television Digital Recording

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

CCITT Vol III, Fascicle III.4, Transmission of Sound — Programme and Television Signals, Recommendation J.17, Pre-emphasis

SMPTE STANDARD

for Television Digital Recording — 19-mm Type D-2 Composite Format — Cue Record and Time and Control Code Record

1 Scope

This standard specifies the content, format, and modulation method of the longitudinal records contained in the cue track and the time-code track in 19-mm type D-2 helical-scan cassette video recorders. Track dimensions and locations are specified in ANSI/SMPTE 245M. The document applies to recorders operating in the 525-line television system with a frame frequency of 29.97 Hz.

2 Normative references

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

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

ANSI/SMPTE 245M-1993, Television Digital Recording — 19-mm Type D-2 Composite Format — Tape Record

3 General specifications

3.1 Dimensions are in the metric system.

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

- Temperature 20°C ± 1°C
- Relative humidity (50 ± 2)%
- Barometric pressure 96 kPa ± 10 kPa
- Tape tension 0.7 N ± 0.05 N

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

- Storage conditioning: Not less than 24 hours

- Environmental: Stabilized to the conditions specified in 3.2

- Tape tension: Wound on a reel at a tension of 0.6 N to 1.5 N

3.4 Relative timing

3.4.1 The relationship between the start of address of the time code and the program reference point of a track with an even-field address (count) for the video data is defined by figure 2(b) of ANSI/SMPTE 245M.

The start of address of the time code as recorded on the tape is defined by dimension P_2, figure 2(b), of ANSI/SMPTE 245M. This corresponds to the timing of the program reference point for all odd-numbered fields.

3.4.2 The time and control code information shall refer to the video frame during which it is recorded.

3.4.3 Cue information shall be recorded on the tape at a point referenced to the associated video information as defined by dimension P_2, figure 2(b), of ANSI/SMPTE 245M (i.e., cue may be up to 90 TV lines early).

3.4.4 Control track servo pulse record timing is described in clause 4.1.5 of ANSI/SMPTE 247M.

American National Standard

Approved August 10, 1993

4 Tape speed

The basic value for tape speed is 131.700 mm/s. The tape speed tolerance is ± 0.2%.

5 Cue record

5.1 Method of recording

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

5.2 Flux level

The recorded reference audio level shall correspond to an rms magnetic short circuit flux level of 80 nWb/m ± 5 nWb/m of track width at 1000 Hz.

5.3 Recorded flux characteristics

When a tape record is recorded from a constant voltage level applied to the input terminals of the recording system, the short circuit flux level on the record versus frequency shall be given by the following equation:

$$L\phi(f) = 10 \log \left\{ \frac{1}{1 + \left(\frac{f}{fh}\right)^2} \right\} \text{dB}$$

where $L\phi$ is the relative flux level; f is the frequency at which the response is calculated; and Fh is the upper transition frequency, 10.8 kHz. (This corresponds to a time constant of 15 microseconds.)

6 Time and control code record

6.1 Method of recording

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

6.2 Flux level

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

6.3 Recorded flux characteristics

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

6.4 Signal

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

Annex A (informative)
Bibliography

SMPTE 226M-1993, Television Digital Component and Composite Recording — 19-mm Type D-1 and D-2 — Tape Cassettes

ANSI/SMPTE 246M-1993, Television Digital Recording — 19-mm Type D-2 Composite Format — Magnetic Tape

ANSI/SMPTE 247M-1993, Television Digital Recording — 19-mm Type D-2 Composite Format — Helical Data and Control Records

SMPTE EG 20-1993, Tape Transport Geometry Parameters for 19-mm Type D-2 Composite Format for Television Digital Recording

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

CCIR Report 624-4 (MOD F), Characteristics of Television Systems

SMPTE ENGINEERING GUIDELINE

Tape Transport Geometry Parameters for 19-mm Type D-2 Composite Format for Television Digital Recording

1 Scope

This guideline describes two feasible examples of mechanical design and test conditions for achieving the record dimensions specified in ANSI/SMPTE 245M. The parameters are for reference purposes only.

2 General specifications

2.1 Dimensions are in the metric system.

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

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

3 Scanner specifications

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

3.2 Two possible design examples are shown in table 1 and table 2, and figure 1 and figure 2.

3.3 The longitudinal head locations and tape wrap for design 1 are shown in figure 3.

3.4 The longitudinal head locations and tape wrap for design 2 are shown in figure 4.

Approved November 12, 1990

Table 1 – Pole tip relationships

Parameters		Design 1	Design 2
Relevant figures		Figure 1	Figure 2
Minimum number of pole tips		4	4
Angular relationship (degrees)	H1 - H2	4.22	3.56
	H3 - H4	4.22	3.56
	H1 - H3	180.00	180.00
Vertical displacement (mm)	H1 - H2	0.0373	0.0376
	H3 - H4	0.0373	0.0376
Maximum tip projection (μm)		50	50

Table 2 – Scanner design parameters

Parameters	Design 1	Design 2
Scanner rotation speed (rps)	90/1.001*	90/1.001*
Number of tracks per rotation	4	4
Actual drum diameter		
Upper (mm)	96.444 ± 0.005	96.444 ± 0.005
Lower (mm)	96.434 ± 0.005	96.434 ± 0.005
Center span tension (N)	0.7 ± 0.1	0.7 ± 0.1
Helix angle (degrees)	6.1592	6.1592
Effective wrap angle (degrees)	178.2	178.2
Scanner circumferential speed (m/sec)	27.3	27.3
Overwrap leading (degrees)	5	5
trailing (degrees)	4.8	4.8
Record head track width	41-45 μm	42 μm typ

*1.001 = 60/59.94

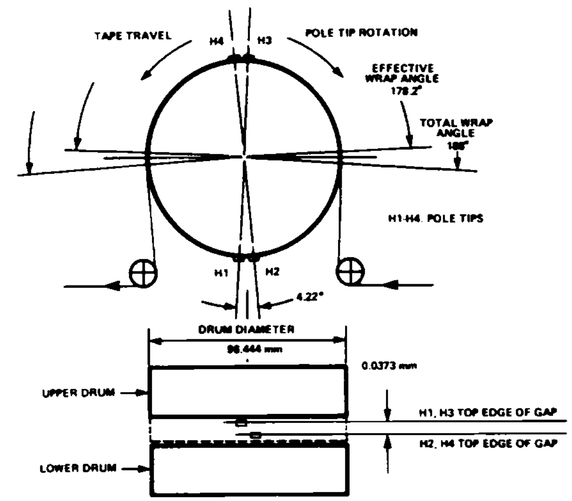


Figure 1 – Scanner configuration for design 1

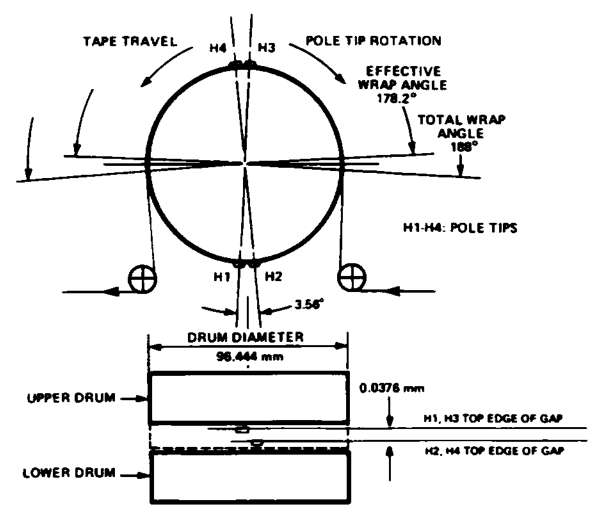


Figure 2 – Scanner configuration for design 2

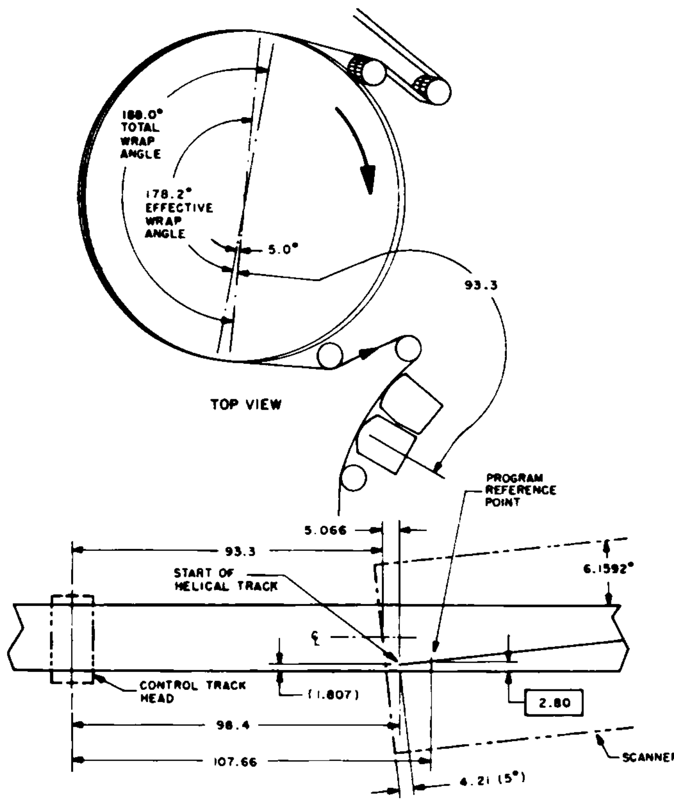


Figure 3 – Longitudinal head locations and tape wrap for design 1

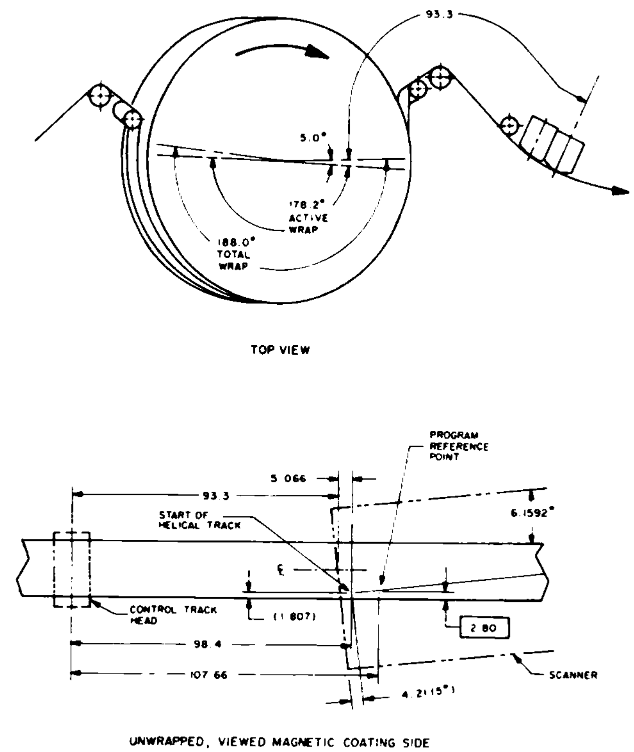


Figure 4 – Longitudinal head locations and tape wrap for design 2

Annex A (informative)
Bibliography

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

ANSI/SMPTE 244M-1993, Television — System M/NTSC Composite Video Signals — Bit-Parallel Digital Interface

ANSI/SMPTE 245M-1993, Television Digital Recording — 19-mm Type D-2 Composite Format — Tape Record

ANSI/SMPTE 246M-1993, Television Digital Recording — 19-mm Type D-2 Composite Format — Magnetic Tape

ANSI/SMPTE 247M-1993, Television Digital Recording — 19-mm Type D-2 Composite Format — Helical Data and Control Records

ANSI/SMPTE 248M-1993, Television Digital Recording — 19-mm Type D-2 Composite Format — Cue Record and Time and Control Code Record

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

SMPTE ENGINEERING GUIDELINE

EG 21-1993

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

1 Scope

This guideline explains terms as used in the documents defining the D-1 and D-2 digital television recording formats.

2 General definitions

2.1 D-1 format recorder: A 19-mm cassette-based digital recorder for component video and other television signals in accordance with SMPTE 227M.

2.2 D-2 format recorder: A 19-mm cassette-based digital recorder for composite video and other television signals in accordance with ANSI/SMPTE 247M.

2.3 program areas: That part of the tape on which is digitally recorded the program video and audio signals.

2.4 program area track pattern: The arrangement of video and audio sectors on helical-scan tracks within the program area.

3 Track pattern allocation — Video and audio segments

3.1 video segment: A video segment contains the digital video data originating from one contiguous portion of a television field. It is recorded within several video sectors, which are located in adjacent video tracks.

3.2 audio segment: An audio segment contains the digital audio data associated with one or more video segments. These data are written into several audio sectors. Audio sectors from different audio channels are interleaved and written on adjacent helical tracks at the ends of video sectors.

4 Electrical signal allocation

4.1 video and audio sectors: A sector is a structured sequence of data which incorporates the video or audio data and appropriate synchronizing and identification patterns, so that the video or audio data can be recovered from tape and identified for subsequent processing.

4.1.1 preamble: A preamble consists of a runup sequence, a sync pattern, an identification pattern, and some fill data.

4.1.1.1 runup sequence: A runup sequence consists of a sequential bit pattern chosen to facilitate the locking of data-extraction circuits.

4.1.1.2 sync pattern: A sync pattern consists of two consecutive bytes whose bit pattern is chosen to be a robust indication of the start of a sync block.

4.1.1.3 identification pattern: An identification pattern consists of two to four consecutive bytes providing a unique address of the position of a sync block within two to four frames of recorded data. It may be coded to remove direct current and provide error protection.

4.1.1.4 fill data: Fill data consists of a few bytes of a fixed pattern which is designed to provide a minimum separation on tape between the runup, sync pattern, and the first sync block. Fill data may also be recorded in the edit gap between sectors in a track.

Approved November 12, 1990

4.1.2 sync block: A sync block consists of a sync pattern followed by an identification pattern followed by two inner code blocks.

4.1.2.1 inner code block: An inner code block consists of a number of bytes of video data, audio data, or outer code check data, followed by a number of inner code check data. A D-2 inner code block may include an identification pattern.

4.1.3 postamble: A postamble consists of a sync pattern followed by an identification pattern and, possibly, some fill data.

5 Subsets of binary data

Usually, for convenience in parallel digital processing, binary information is processed in groups of bits referred to in the literature as words or bytes. These terms have generally understood meanings but are not unambiguously defined. For the purpose of this terminology, the following definitions are assumed:

5.1 bit: A contraction of binary and digit to define a unit of information.

5.2 bit-parallel: Refers to a set of concurrent data bits present on a like number of data lines used to carry information. Bit-parallel data bits may be acted upon concurrently as a group (word) or independently as individual data bits.

5.3 byte: A byte consists of eight bits of binary information. It may have an identity other than being a convenient processing unit (for example, see video data word), but generally this is not implicit.

5.4 video data word: A video data word is a byte in which the eight bits represent the possible 256 quantum levels of a video sample.

5.5 audio data word: An audio data word consists of 16 to 20 bits. In the most basic operating mode 16 bits represent the possible 2^{16} quantum levels of an audio sample and four bits are used for auxiliary signals. Other modes are defined in which either one, two, three, or four of the auxiliary signal bits are allocated to extend the dynamic range of the audio sample quantization. For convenience, the 20-bit word may be processed in five words of four bits each.

5.6 bit rate: The rate at which encoded information is transmitted from one part of a system to another, expressed in bits per second.

5.6.1 In component digital video with a luminance sampling frequency of 13.5 MHz and a color difference sampling frequency of 6.75 MHz for each of the two color-difference channels and 8-bit PCM encoding of each sample, the bit rate is 216 million bits per second.

5.6.2 In composite digital video with a sampling frequency of 14.32 MHz ($4f_{SC}$) and 8-bit PCM encoding of each sample, the bit rate is approximately 114 million bits per second.

5.7 bus: A signal line or a set of signal lines used by an interface to which multiple devices are connected and over which messages are carried.

5.8 unidirectional bus: A bus used by any individual device for one-way transmission only; that is, either input only or output only.

5.9 positive binary: The condition where the most positive of the two possible signal levels is a logical 1.

5.10 clock: A source of accurately timed pulses used for synchronization in a digital computer or as a time base in a transmission system.

A synchronous clock in this application means that the clock pulses are synchronous in frequency and phase to the video horizontal rate for a component signal or the chrominance subcarrier frequency for a composite signal.

5.11 data lines: Refers to the interconnecting signal lines of the interface system. A single data line is defined as a pair of signal lines due to the balanced electrical specification of the system. The signal wires that make up a data line are usually twisted together for crosstalk considerations in conventional cable technology.

5.12 data rate: The rate at which data is transferred from one part of the system to another expressed in bits, bytes, or words per second.

5.13 ECL: Refers to emitter coupled logic. This logic is a nonsaturating form of digital logic which eliminates transistor storage time, permitting very high speed operation. Standard ECL in this application means an integrated circuit device of the ECL 10,000 series or equivalent.

5.14 interface system: The device-independent mechanical, electrical, and functional elements of an interface necessary to effect communication among a set of devices. Cables, connector, driver and receiver circuits, signal line descriptions, timing and control conventions, and functional logic circuits are typical interface system elements.

5.15 LSB: Least significant bit of a data word.

5.16 MSB: Most significant bit of a data word.

5.17 parallel interface: Pertains to a transmission system wherein all bits of a particular character are sent simultaneously.

5.18 serial interface: Pertains to a transmission system wherein all bits are sent in serial (series) order.

5.19 system: A set of interconnected elements constituted to achieve a given objective by performing a specified function.

6 Error protection strategy

6.1 Various methods are used to reduce the effect of data errors on the objective and subjective quality of the replayed video or audio. The appropriate combination of methods to achieve an optimum result is generally known as the error protection strategy.

6.1.1 error correction: The use of mathematically related check data, recorded with the video and audio data, to determine the precise value and location and, hence, enable correction of data errors.

6.1.2 error concealment: To replace the error sample with the interpolation of adjacent audio or video samples as an estimate of the value of data words previously detected to be in error, but which cannot be corrected.

6.1.3 source precoding: The mapping of video data words so that, for the most probable distribution of data errors, there is a reduction in the peak error produced in a video sample. Source precoding is used in the type D-1 format. Source precoding is not used in the type D-2 format.

7 Error protection — Data organization

7.1 Error correction for both video data and audio data is of the product block type in which each data word is included in the computation of two sets of check data known as outer code check data and inner code check data, respectively.

Additionally, the video and audio data are redistributed from their naturally occurring sequences in order to reduce the effect of burst errors.

Outer code check data are the first to be computed. Inner code check data are the second to be computed, and are applied to the outer code check data as well as to the video and audio data.

7.2 data sector array: For the application of product block error correction, the video data words to be recorded in a video sector are considered as a rectangular array with rows and columns.

7.2.1 outer code check data — outer code block: Outer code check data consists of a number of bytes computed from a column of the video data array and regarded as being appended.

7.2.2 inner code check data — inner code block: Inner code check data consists of a number of bytes computed from a row of the array (or a row of the outer code check data) and appended to that subset. The resulting bytes are known as an inner code block.

7.2.3 product block: The array defined by a number of inner code blocks or the corresponding outer code blocks is known as a product block. There are a number of such product blocks in each sector.

7.3 Video and audio data redistribution

7.3.1 interleaving: The systematic reordering of data so that originally adjacent bytes of data in an error correcting code are separated on tape, thus reducing the effect of bursts of data errors on the error correcting capability. The separation is known as the interleave distance.

7.3.2 shuffling: The systematic reordering of video or audio data words to increase the probability that uncorrectable samples are surrounded by error-free data words, for the application of error concealment.

8 Coding and modulation

8.1 channel coding: The process by which binary information obtained from the digital logic circuits, used in the processing of video and audio data, is converted to a waveform suitable for recording onto a magnetic medium.

8.2 randomization: The reduction of correlation in a serial bit sequence so that it statistically approximates a random sequence.

8.3 scrambling: Alternate term for randomization.

8.4 mapping: The recoding of data by computation or look-up table, so that there is a defined one-to-one relationship between each original code word and the derived code word.

8.5 composite video signal (analog): The color-picture signal, encoded in the NTSC standard, including blanking and all synchronizing signals.

8.6 composite encoded signal (digital): A digital representation of a composite video signal.

8.7 digitize: To sample, quantize, and code an analog signal.

8.8 PCM (pulse-code modulation): A format for representing information as a set of digital words. As used herein, the process involves the conversion of a signal from analog to digital form by means of sampling, quantizing, and coding. The peak-to-peak amplitude range of the analog signal is divided into a finite number of discrete values each having its own value code.

8.9 linear PCM: Pertaining to quantizing intervals that are equal throughout the range of the system.

8.10 quantization: The division of a continuous range of values into a finite number of distinct values.

8.11 sampling: The process of obtaining a series of discrete, instantaneous values of a signal at regular or intermittent intervals.

8.12 SCH: An abbreviation for the timing relationship between the color subcarrier burst and horizontal sync pulses of a composite color video signal. Zero SCH occurs when the positive going zero-crossings of a subcarrier with the same phase as the color burst are nominally coincident with the 50% point on the leading edges of the even horizontal sync pulses in color field 1, as shown in CCIR 624-4 (MOD F), figure 5(c).

9 Mechanical terms

9.1 basic dimension: A basic dimension is a fundamental dimension to which no tolerance is applicable.

9.2 derived dimension: A derived dimension is obtained from other fundamental dimensions by computation and is given for .^formation purposes only.

9.3 reference dimension: A dimension usually without tolerance, used for informational purposes. It may be a dimension resulting from other values.

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

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

9.6 effective diameter: The effective diameter is the diameter at the surface of tape wrapped around the drum which includes the drum diameter and the air film between drum and tape.

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

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

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

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

9.11 center span tension: A calculated value of the tape tension at a point midway between the tape entrance and exit guides of the scanner in the recording system.

10 Editing definitions

10.1 edit gap: The space between adjacent sectors, to which edit transitions must be confined, between the end of the sector postamble and the start of the sector preamble.

10.2 cue track: The longitudinal track reserved for the recording of audio frequency signals which are to be used for editing reference purposes.

Annex A (informative)
Bibliography

ANSI/IEEE 100-1988, Dictionary of Electrical and Electronics Terms

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

ANSI/SMPTE 247M-1993, Television Digital Recording — 19-mm Type D-2 Composite Format — Helical Data and Control Records

CCIR Recommendation 601-2, Encoding Parameters of Digital Television for Studios

CCIR Report 624-4 (MOD F), Characteristics of Television Systems

SMPTE ENGINEERING GUIDELINE

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

1 Scope

This guideline contains the index for the referenced documents describing the 19-mm type D-2 composite television recording format.

2 General description

This format uses 19-mm class 1500 tape as described in SMPTE ANSI/246M. The tape is contained in one of three sizes of cassette as defined in SMPTE 226M. The physical layout of tracks on tape is defined in ANSI/SMPTE 245M. The content of the helical record which contain video and audio data, and of the longitudinal control track record is defined in ANSI/SMPTE 247M. The content of the longitudinal cue track record and of the longitudinal time and control code record is defined in ANSI/SMPTE 248M.

SMPTE EG 20 presents two examples of a mechanical design for a scanner which could record a helical track as defined in ANSI/SMPTE 245M.

3 Index to documents

Approved November 12, 1990

List of Illustrations

List of Tables

Annex A (informative)
Bibliography

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

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

ANSI/SMPTE 244M-1993, Television — System M/NTSC Composite Video Signals — Bit-Parallel Digital Interface

ANSI/SMPTE 245M-1993, Television Digital Recording — 19-mm Type D-2 Composite Format — Tape Record

ANSI/SMPTE 246M-1993, Television Digital Recording — 19-mm Type D-2 Composite Format — Magnetic Tape

ANSI/SMPTE 247M-1993, Television Digital Recording — 19-mm Type D-2 Composite Format — Helical Data and Control Records

ANSI/SMPTE 248M-1993, Television Digital Recording — 19-mm Type D-2 Composite Format — Cue Record and Time and Control Code Record

SMPTE EG 20-1993, Tape Transport Geometry Parameters for 19-mm Type D-2 Composite Format for Television Digital Recording

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

CCIR Report 624-4 (MOD F), Characteristics of Television Systems

PROPOSED SMPTE RECOMMENDED PRACTICE

RP 27.4
Revision of RP 27.4-1985

Specifications for an Operational Test Pattern for Checking Jitter, Weave and Travel Ghost in Television Projectors

1 Scope

This practice specifies the format, dimensions, and optical densities for a test pattern transparency to be used as an operational tool for measurement of television film projector image stability.

2 Purpose

2.1 Specifications

This practice specifies a test film to facilitate day-to-day operational checking of travel ghost, weave, and jitter in 35- and 16-mm television projectors.

2.1.1 Jitter steps

The steps at the top and bottom of the pattern are used for measuring picture jitter vertically.

2.1.2 Weave steps

The steps at the right and left of the pattern are used for measuring picture weave horizontally.

2.1.3 Central window

The central window or rectangular area in the center of the pattern shall be used for measurement of jitter and weave with a grating pattern or a line selector on an oscilloscope.

3 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this practice. 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 IT2.19-1990, Photography — Density Measurements — Geometric Conditions for Transmission Density

ANSI/SMPTE 7-1988, Motion-Picture Film (16-mm) — Camera Aperture Image and Usage

ANSI/SMPTE 59-1991, Motion-Picture Film (35-mm) — Camera Aperture Images and Usage

ANSI/SMPTE 96-1992, Television — 35- and 16-mm Motion-Picture Film and 2x2-in Slides — Scanned Area and Photographic Image Area for 4:3 Aspect Ratio

ANSI/SMPTE 109-1992, Motion-Picture Film (16-mm) — Perforated 1R and 2R

ANSI/SMPTE 139-1986 (R1991), Motion-Picture Film (35-mm) — Perforated KS

4 Format

4.1 Pattern

A reproduction of the test pattern is shown in figure 1.

4.2 Window configuration

The windows shall be staggered so that any trailing or travel ghosts due to the projector shutter opening early or late can be seen above or below the windows.

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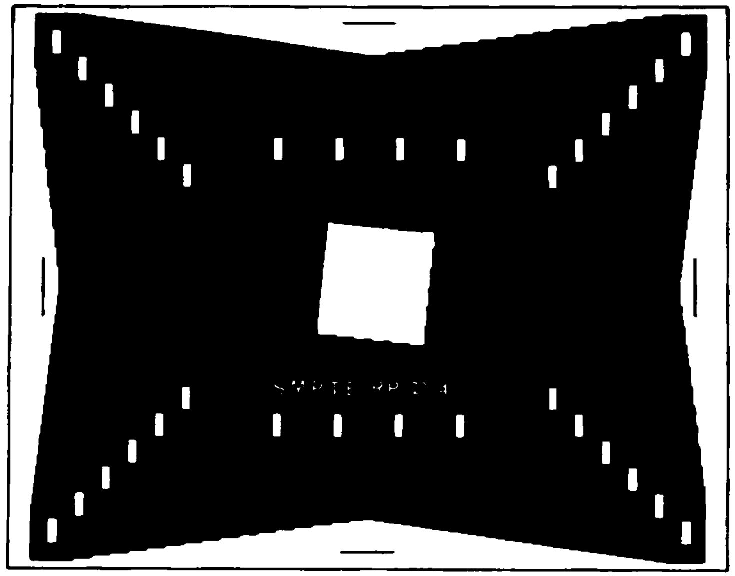

Figure 1 – Reproduction of test pattern

4.3 Pattern identification

The identification number of this practice shall appear on the projected image in the area specified in the figures.

5 Dimensions

5.1 Test pattern

The dimensions of the test pattern shall be as shown in figure 2 and table 1 in percentages of frame height and reproduced with a tolerance of ± 2% of the frame height.

5.1.1 Tolerances

The camera shall be capable of producing an image positioned in relation to the perforations within ± 0.025% of picture height for 35-mm and ± 0.05% of picture height for 16-mm film.

5.2 Test film

The test film shall be a camera original film photographed on high-definition, positive motion-picture stock made in accordance with ANSI/SMPTE 139 and ANSI/SMPTE 109.

5.2.1 The camera shall be capable of producing an image in accordance with style A dimensions specified in ANSI/SMPTE 59 and ANSI/SMPTE 7.

5.3 Projected and transmitted areas

The projected image area is represented by the outside dimensions of the jitter and weave steps. The television transmitted area is represented by the lines inside the jitter and weave steps. The area shall be in accordance with ANSI/SMPTE 96.

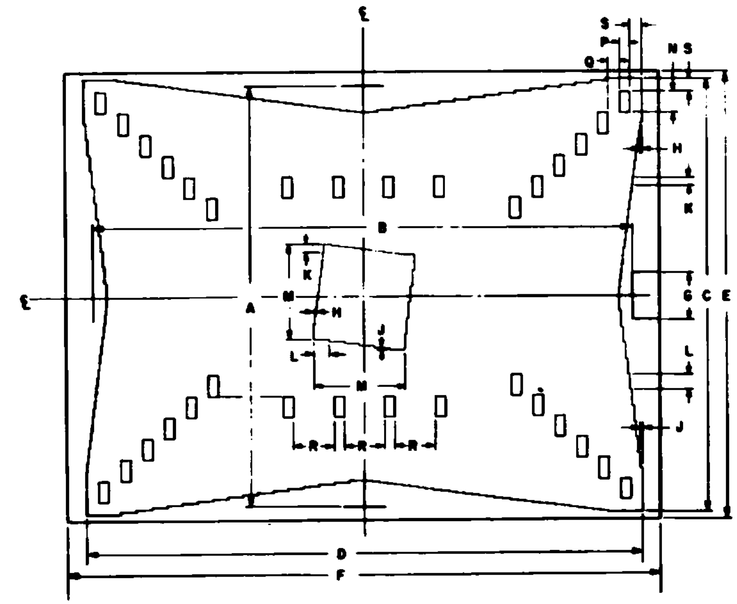

Figure 2 – Dimensional drawing of test pattern

Table 1 – Specifications

	Dimensions	Percent	Inches 35-mm	Inches 16-mm	Millimeters 35-mm	Millimeters 16-mm
A	Scanned area height	100.00	0.594	0.276	15.09	7.01
B	Scanned area width	133.3333	0.792	0.368	20.12	9.35
C	Television projector image height		0.612	0.285	15.54	7.24
D	Television projector image width		0.816	0.380	20.73	9.65
E	Camera image height		0.631	0.295	16.03	7.49
F	Camera image width		0.868	0.404	22.05	10.26
G	Line length	11.25	0.067	0.031	1.70	0.79
H	Half-step width	0.25	0.0015	0.0007	0.038	0.018
J	Full-step width	0.50	0.003	0.0014	0.08	0.036
K	Half-step length	1.875	0.011	0.005	0.28	0.13
L	Full-step length	3.75	0.022	0.010	0.56	0.25
M	Central window height and width	22.50	0.134	0.062	3.40	1.57
N	Window height	5.00	0.030	0.014	0.76	0.36
P	Window width	2.50	0.015	0.007	0.38	0.18
Q	Window spacing in diagonal row	3.00	0.018	0.008	0.46	0.20
R	Window spacing in horizontal row	10.00	0.059	0.028	1.50	0.71
S	Location of corner windows	3.00	0.018	0.008	0.46	0.20

6 Optical densities

6.1 Optical densities

All optical densities shall be measured in accordance with ANSI IT2.19.

6.2 Background

The background shall have a density greater than 1.9.

6.3 Windows and surround area

The density of the windows and surround area shall be nominally clear.

NOTES

1 The emulsion position shall correspond to the one normally used for the specific format.

2 Test material conforming to this practice is available from the Society of Motion Picture and Television Engineers.