Standards and Recommended Practices

Approved SMPTE Recommended Practices

The Society's Executive Committee for Standards Approval approved two SMPTE Recommended Practices: RP 105-1989, Method for Determining the Degree of Jump and Weave in 70-, 35- and 16-mm Motion-Picture Projected Images; and RP 95-1989, Installation of Gain Screens. These and other SMPTE Recommended Practices may be obtained from Society Headquarters for $3.00 each.

Proposed American National Standards

Published here for a trial period and public review are Proposed American National Standards SMPTE 244M, Television Digital Recording — Representation of NTSC Encoded (System M) Video Signal — Active Video Portion; SMPTE 245M, Television Digital Recording — 19-mm Type D-2 Composite Format — Tape Record; SMPTE 246M, Television Digital Recording — 19-mm Type D-2 Composite Format — Magnetic Tape; SMPTE 247M, Television Digital Recording — 19-mm Type D-2 Composite Format — Helical Data and Control Records; and SMPTE 248M, Television Digital Recording — 19-mm Type D-2 Composite Format — Cue Record and Time and Control Code Record.

Proposed SMPTE Engineering Guidelines

Also published for a trial period are Proposed SMPTE Engineering Guidelines EG 20, Tape Transport and Geometry Parameters for 19-mm Type D-2 Composite Format for Television Digital Recording; EG 22, Description and Index of Documents for 19-mm Type D-2 Composite Television Digital Recording; and EG 21, Nomenclature for Television Digital Recording, 19-mm Type D-1 Component and Type D-2 Composite Formats.

Copies of all proposals are available from Society Headquarters for $3.00 each. Comments should be addressed to Sherwin H. Becker, Director of Engineering, at Society Headquarters. The proposals will be submitted to the Executive Committee for Standards Approval if no adverse comments are received by September 1, 1990.

—Sherwin H. Becker, Director of Engineering

SMPTE RECOMMENDED PRACTICE — RP 105-1989

Method for Determining the Degree of Jump and Weave in 70-, 35- and 16-mm Motion-Picture Projected Images

Introduction

Acceptability of undesirable image movement in a projection system depends upon several factors such as the purpose of projection, the critical nature of the image, the ratio of viewing distance to screen image size, and the frequency and direction of the motion. Projection performance can be determined by identifying these parameters and classifying the various degrees of steadiness.

1. Scope

This practice identifies image motion, classifies the practical limits of acceptability of film jump and weave, and recommends a method of measurement for projection of 70-, 35-, and 16-mm motion-picture prints.

2. Definitions

2.1 Jump is the undesirable vertical motion (in normal systems where the film travel is vertical) of the projected image. Called jump because of its rapid motion, it is usually at the same frequency as the motion-picture frame rate (24 frames/s, etc.).

2.2 Weave is the undesirable horizontal motion (in normal systems where the film travel is vertical) of the projected image. Weave is normally at a much slower rate than the frame rate, and usually less noticeable.

2.3 The viewer's impression of either jump or weave is related to the apparent size of the screen image. The apparent size of the screen image may be divided into three classifications:

Large: A large appearing screen image is one which is viewed from a distance of 3.7 screen heights or less (vertical field of vision is 15° or greater).

Medium: A medium appearing screen image is one which is viewed from a distance of 3.7 to 5.7 screen heights (vertical field of vision is 10° to 15°).

Small: A small appearing screen image is one which is viewed from a distance greater than 5.7 screen heights (vertical field of vision is 10° or less).

3. Classification

3.1 For each classification of apparent size of the screen image, the following percentages of jump and weave indicate the practical limit of acceptability in terms of the percentage of the image height:

Classification	Jump	Weave
Large appearing screen image (Review rooms, premier theaters)	0.12%	0.20%
Medium appearing screen image (First-run theaters)	0.20%	0.25%
Small appearing screen image	0.30%	0.30%

3.2 The values specified are achievable when using SMPTE test films. Higher values may be expected from normal release prints which may be produced to less exacting tolerances.

4. Recommended Method of Measurement

The recommended method of measurement is to project a test film made on a registration pin camera, such as the SMPTE 16-PA, as specified in SMPTE Recommended Practice on Specifications for 16-mm Projector Alignment and Screen Image Quality Test Film, RP 82-1985; the SMPTE 35-PA, as specified in SMPTE Recommended Practice on Specifications for 35-mm Projector Alignment and Screen Image Quality Test Film, RP 40-1971 (R1977); or the SMPTE 70-PA, as specified in SMPTE Recommended Practice on Specifications for 70-mm Projector Alignment and Screen Image Quality Test Film, RP 91-1987.

These films have the overall area covered with a checkerboard pattern as follows:

35-PA 170 vertical squares (see table below)

Aspect Ratio	Projected Image Area	One square = Percent Movement
1.37:1	0.602 x 0.825"	0.7%
1.66:1	0.497 x 0.825"	0.8%
1.75:1	0.471 x 0.825"	0.9%
1.85:1	0.446 x 0.825"	0.94%
2.4:1	0.700 x 0.838"	0.6%

200 horizontal squares (1 square = 0.5%)

70-PA 100 vertical squares (1 square = 1.0%)
220 horizontal squares (1 square = 0.46%)

16-PA 100 vertical squares (1 square = 1.0%)
134 horizontal squares (1 square = 0.75%)

Revision of RP 105-1981
Approved December 29, 1989

Project the appropriate test film under normal conditions. For 35-mm projection, jump should be measured with the format which uses the smallest film image height used in the theater, usually 1.85:1, and weave should be measured with the format which uses the largest film image width used in the theater, usually 2.4:1 anamorphic.

Place an appropriate device, such as a microphone stand, near the screen to provide a sharp shadow. Position the shadow to be adjacent to any background square and observe the amount of movement. As an example, using the 35-PA test film, if the vertical movement averages a quarter square and projection is at a 1.85:1 ratio, the jump is 0.94% divided by 4, or 0.235%.

Appendix

(This Appendix is not part of the SMPTE Recommended Practice, but is included for information only.)

A1. This practice assumes that jump is the undesirable vertical motion that functions at frame-rate frequency, while weave is much slower, and perhaps slower than 1/4 of frame-rate frequency. Of course, random motion from splices or film damage might be more noticeable.

A2. For convenience, the table below shows the practical limit of acceptability in terms of fractions of a block on the appropriate test film for each film size and projection format:

Apparent Image Size		35-mm Format 2.4	1.85	1.75	1.66	1.37	70-mm	16-mm
Large	Jump	1/5	1/8	1/8	1/7	1/6	1/8	1/8
	Weave	2/5	2/5	2/5	2/5	2/5	2/5	1/4
Medium	Jump	1/3	1/5	1/5	1/4	1/3	1/5	1/5
	Weave	1/2	1/2	1/2	1/2	1/2	1/2	1/3
Small	Jump	1/3	1/3	3/8	1/2	1/2	1/3	1/2
	Weave	3/5	3/5	3/5	3/5	3/5	2/3	1/2

A3. This practice assumes that other parameters, including equipment maintenance and test film perforation condition, are noted.

SMPTE RECOMMENDED PRACTICE

RP 95-1989

Installation of Gain Screens

1. *Scope*

This practice specifies the optimum installation parameters for gain screens used in motion-picture theaters.

2. *Considerations*

2.1 A gain screen is any screen surface with a gain of 1.1 or more. Gain determination of screens is specified in SMPTE Recommended Practice on Gain Determination of Front Projection Screens, RP 94-1989.

2.2 The effect of the screen gain is reduced when the angle of viewing is increased away from the major reflected rays. (See Appendix A4.)

2.3 When the light projection is perpendicular to the screen surface, the effect of gain diminishes in every direction away from the perpendicular condition to the screen center.

2.4 Specular screens follow the physical law; i.e., the angle of incidence equals the angle of reflection.

3. *Formulas*

3.1 Radius of Screen. The screen shall be curved when installed to a radius of:

$$\frac{\text{Projection distance} + \text{Distance between screen and audience center}}{2}$$

3.2 Degree of Tilt. To have maximum gain aimed at the center of the audience, the screen shall be tilted as follows:

$$\frac{\text{Projection angle to screen center}}{2}$$

Appendix

(This Appendix is not part of the SMPTE Recommended Practice, but is included for information only.)

A1. With gain screens, it is best to locate the audience inside the one-half maximum gain angles; good audience coverage can be attained if the audience boundaries are defined by the angles at which the gain is no less than that necessary to provide the recommended screen luminance (see American National Standard for Motion-Picture Film — Screen Luminance and Viewing Conditions —Indoor Theater Projection, ANSI/SMPTE 196M-1986).

A2. Retroflective or beaded-type screens shall be avoided unless the projector is in the center of the audience.

A3. Higher gain screens (1.5 and higher), and all "silver" screens should be installed in curved form to avoid the objectionable "hot-spot."

A4. Nearly all gain screens have a mirror effect, which causes the angle of projection reaching the sides of the screen to be reflected toward the walls unless the installation is in curved form.

A5. Where the audience seating is wider than the screen width, consideration should be given to a "ray-trace" of reflected light from the gain screen, so that the light properly reaches the side seats across the middle rows. Ray-tracing can be done by hand drawing or by computer and may differ from the formulas given in 3.1 and 3.2 above, especially with shorter focal length lenses, such as the range of 50- to 75-mm focal length for 35-mm anamorphic projection from a rear projection booth.

A6. Use of a curved screen with vertical projection angles greater than 8° requires consideration of curvilinear distortion, and may require adjustment of screen masking.

Revision of RP 95-1980
Approved December 29, 1989

Proposed American National Standard

for television digital recording — representation of NTSC encoded (system M) video signal — active video portion

SMPTE 244M

1. Scope

1.1 This standard specifies the sampling parameters for the digital representation of the active line portion of encoded video signals. It specifies the relationship between the sampling phase and the color subcarrier as well as digital levels of the video signal.

1.2 This standard applies to systems operating according to the 525-line 59.94-Hz NTSC standard as described by CCIR Report 624-3.

2. Referenced Documents

This standard is intended for use in conjunction with the following documents:

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

CCIR Report 624-3, Characteristics of Systems for Monochrome and Colour Television

3. General Specifications

The sampling shall be phase referenced to the burst locked sinewave. The burst locked sinewave is defined as a sinewave with the same frequency and phase as the burst and phase locked to the color burst. Color subcarrier to horizontal sync timing relationship (SC/H) in the digital domain shall be zero degrees.

4. Digital Signal Specifications

4.1 Signal Level and Duration

4.1.1 Quantization Parameters. The digital video signal shall be quantized according to the parameters of Table 1.

4.1.2 Amplitude Relationship. The relationship between the digital signal and an equivalent analog signal is shown in Fig. 1. The signal illustrated is a representation of 100% level, 7.5% set-up (100/7.5/100/7.5) color bars.

4.1.3 Phase Relationship. Fig. 2 defines the timing relationship between video signals in the analog and digital domains. The half-amplitude point of the leading (falling) edge of the analog horizontal sync signal shall be between samples 784 and 785.

4.1.4 Vertical Blanking. Video data will not be present on lines 1 to 9 and 264 to 272. Video or ancillary data may be present on the active video portion of lines 10 to 19 and 273 to 282.

4.1.5 Sin (x)/x Considerations. 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.

4.1.6 Data Signal Format. Data is represented in 8- or 10-bit words. In 8-bit systems, 254 of the 256 levels (01_h through FE_h) are used to express a quantized value. In 10-bit systems, 1016 of the 1024 levels (004_h through $3FB_h$) are used to express a quantized value.

In 8-bit systems, the levels 00_h and FF_h are not permitted in the data stream to protect unique synchronizing patterns, which will contain the values of 00_h and FF_h in a defined sequence. In 10-bit systems, the levels 000_h, 001_h, 002_h, 003_h, $3FC_h$, $3FD_h$, $3FE_h$, and $3FF_h$ are not permitted in the data stream to protect unique synchronizing patterns which will contain the values of 000_h and $3FF_h$ in a defined sequence.

THIS PROPOSAL IS PUBLISHED FOR COMMENT ONLY

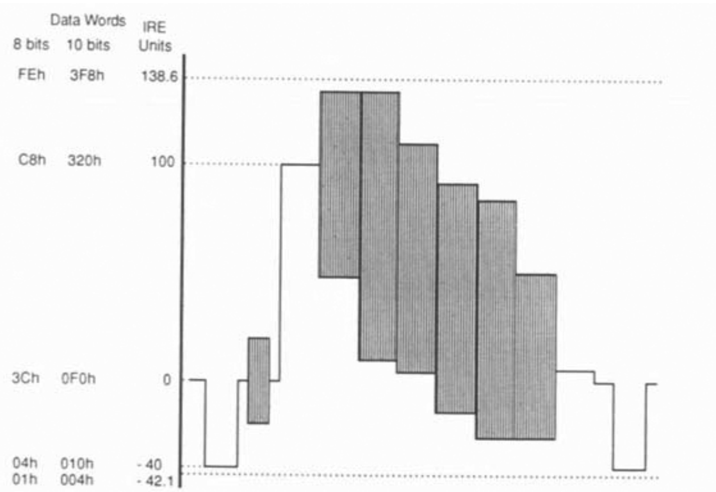


Fig. 1
Relationship Between Analog IRE Units and 8- and 10-Bit Data Word

Table 1
Coding Parameters

Coded signals	NTSC	
No. of samples/full line	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	
Number of samples per digital active line	768	
Relationship of video signal levels and 8- and 10-bit quantization levels ("h" suffix indicates hexadecimal value)		
	8-Bit System	10-Bit-System
Blanking level	$3C_h$	$0F0_h$
White level	$C8_h$	320_h

The protected and valid data levels of video and ancillary data are shown in Table 2.

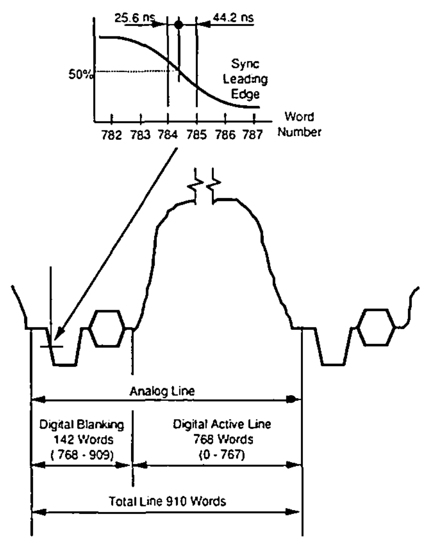


Fig. 2
Horizontal Sync Relationship

Table 2
Valid and Protected Data Levels

8 Bits		10 Bits
00	Protected	000 001 002 003
01 FE	Valid	004 3FB
FF	Protected	3FC 3FD 3FE 3FF

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

4.2 Digital Blanking Relationships. Synchronizing information is required to define the location of the digitized active lines. The following paragraphs define the relationships between the digitized active lines and the synchronizing reference points.

4.2.1 Horizontal Reference Relationship. Fig. 2 shows the relationship between video signals in the digital and analog domain.

768 words represent the active video portion of each line.

The remaining 142 words of a total line are not within the scope of this standard.

The first of these 910 words is designated word 0 for the purpose of reference only and represents the first sample of the active line. The 910 sample words per total line are, therefore, numbered 0 through 909.

Words 0 through 767, inclusive, contain video data. The remaining words are designated 768 through 909.

4.2.2 Sampling Phase Definition. The sample at word zero (0), of line ten (10), field one (1), Frame A, is the sample on the I axis (+123°). Line ten (10) is defined by Fig. 3.

4.2.3 Four-Field Color Sequence. Four-field color sequence information must be conveyed along with the encoded active video in order to identify color frame.

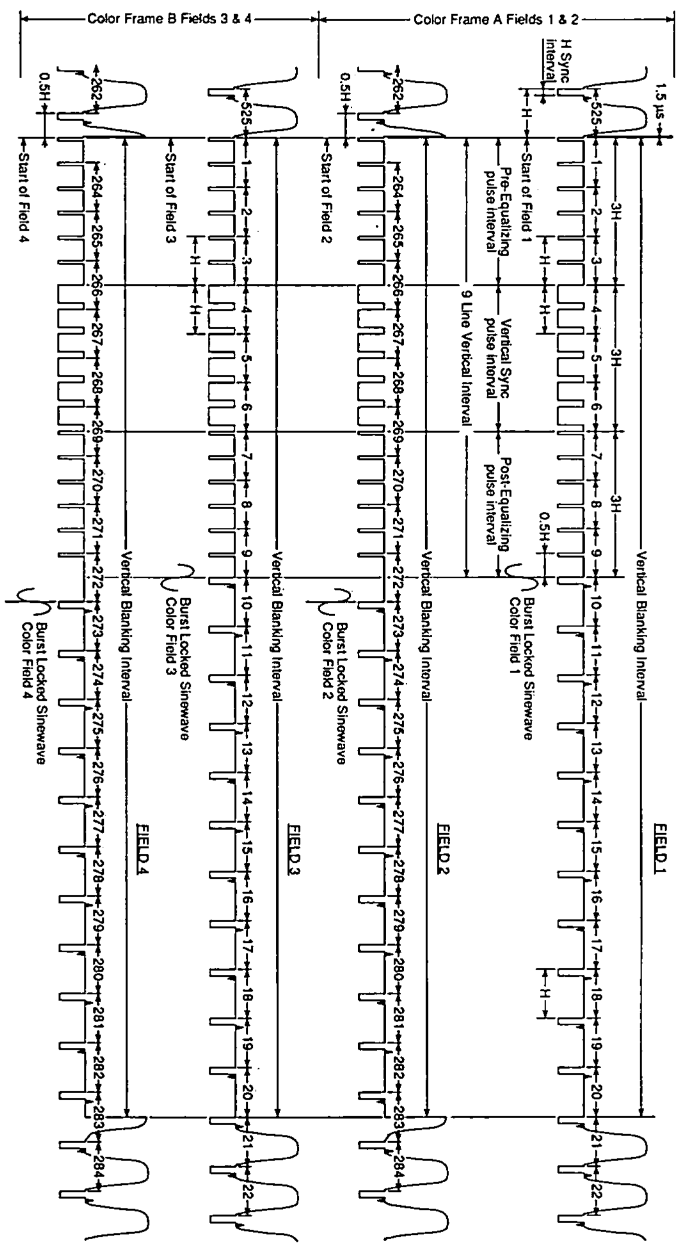


Fig. 3
Composite Vertical Blanking Interval

Note: ▲ Burst begins with a positive half-cycle.
▼ Burst begins with a negative half-cycle.

Proposed American National 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 SMPTE 244M.

2. Referenced Documents

This standard is intended for use in conjunction with the following documents:

SMPTE 244M, Television Digital Recording — Representation of NTSC Encoded (System M) Video Signal—Active Video Portion

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

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

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

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

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

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:

Time of 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 to 1.5 N

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

3.4.1 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. 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 Fig. 3. This constraint may be a physical deformation or an equivalent mathematical transformation. The program reference point lies on a line perpendicular to the reference edge through the center point of the reference edge.

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

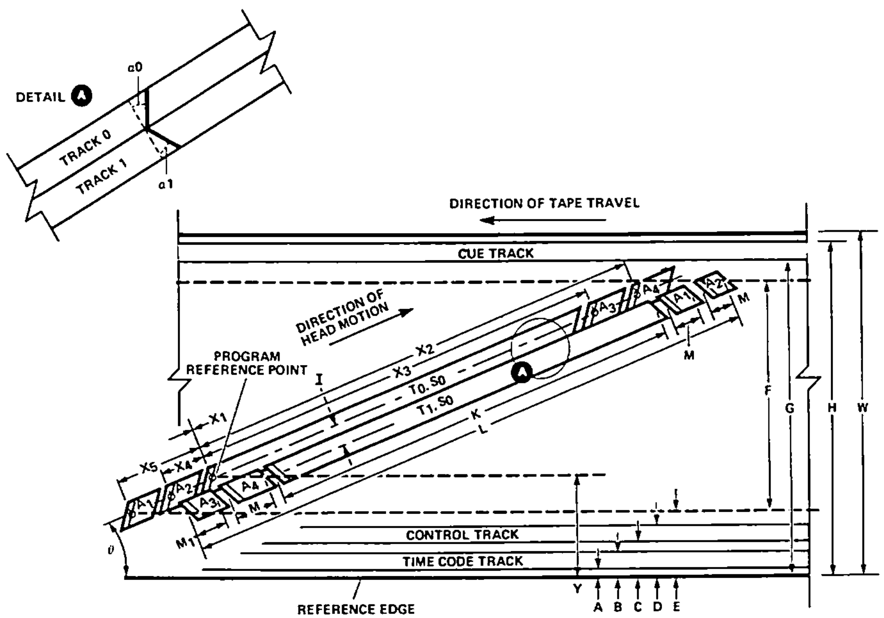


Fig. 1
Location and Dimensions of Recorded Tracks
(Tape Viewed from Magnetic Coating Side)

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 segment number (typical).
3. Dimensions X_1-X_5 are determined by the program reference point as defined in Fig. 2.

Table 1
Record Location and Dimensions for 525/60 Standard

	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	1.5	± 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	Nom
K	Video sector length	132.49	Derived
L	Helical track total length	150.78	Derived
M_1	Audio sector A1 track 0 and A3 track 1	4.13	Derived
M	All other audio sectors	4.01	Derived
P_1	Control pulse distance	107.66	± 0.3
P_2	Cue/time code distance	108.41	± 0.3
W	Tape width	19.01	± 0.015
X_1	Location of video sector	0	± 0.1
X_2	Location of start of audio sector A_4	137.57	± 0.1
X_3	Location of start of audio sector A_3	133.03	± 0.1
X_4	Location of start of audio sector A_2	4.54	± 0.1
X_5	Location of start of audio sector A_1	9.08	± 0.1
Y	Program reference point	2.80	Basic
θ	Track angle	6.1296°	
a0	Track 0 azimuth angle	+14.97° ± 0.17°	
a1	Track 1 azimuth angle	—15.03° ± 0.17°	

Note: Above measurements shall be made under the conditions specified in 3.2.

4. Tape Speed

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

5. Record Location and Dimensions

5.1 Record location and dimensions for continuous recording shall be as specified in Figs. 1 and 2 and Table 1.

5.2 In recording, sector locations on each helical track shall be contained within the tolerance specified in Table 1 and Fig. 3.

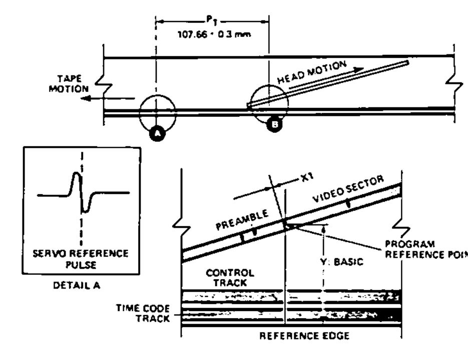


Fig. 2(a)
Location of Control Track Record

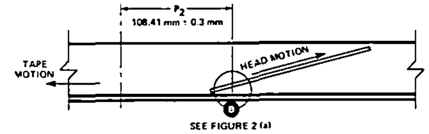


Fig. 2(b)
Location of Cue/Time Code Record

5.3 The record head width and height tolerances shall be chosen so as to ensure a zero guard band between recorded tracks and a minimum track width after overlap recording of 35 μm measured across the track in a line perpendicular to the centerline of the tracks.

6. Helical Track Record Curvature

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

6.2 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.

6.3 The centerlines of all zones shall be spaced 0.0391 mm basic apart. The width of the first zone shall be 0.01 mm basic. The width of zones 2 through 4 shall be 0.015 mm basic. These zones are established to contain track angle errors, track straightness errors, and track pitch errors. (See Appendix.)

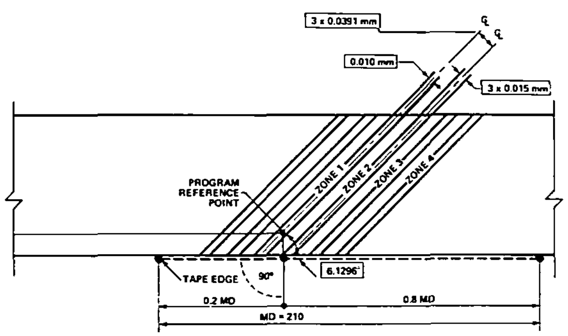


Fig. 3
Location and Dimensions of Tolerance Zones of Helical Track Record

Note: The centerline of any 4 consecutive tracks shall be contained within each zone given.

7. Relative Positions of Recorded Signals

7.1 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 Figs. 1 and 2.

7.2 The spatial relationship between the cue track record, time code record, control track record, and helical tracks are specified in Figs. 1 and 2.

7.3 The program reference point is defined as a point at the intersection of a line that is 2.80 mm above the reference edge of the tape, Dimension Y in Table 1, and the track centerline as shown in Figs. 1 and 2. The relationship between sectors and contents of each sector is specified by SMPTE 247M.

8. Gap Azimuth

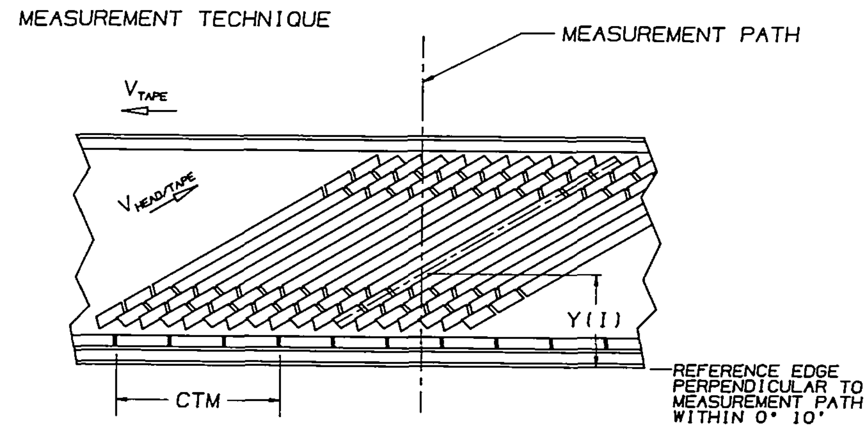
8.1 The cue, control track, and time code head gaps used to produce longitudinal track records shall be perpendicular to the track record.

8.2 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 magnetic coating side of the tape.

Appendix

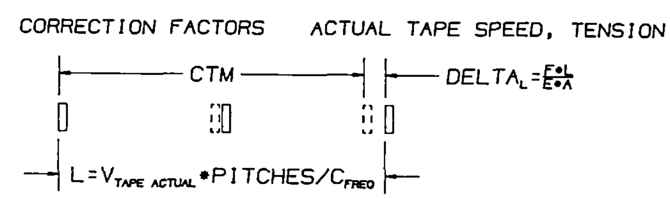
(This Appendix is not part of the American National Standard, but is included for information only.)

Cross Tape Track Measurement Technique



Y(I) MUST USE SAME HEAD FOR EACH MEASUREMENT (i.e. EVERY 4th TRACK)

CTM = CONTROL TRACK PULSES (UNTENSIONED TAPE)



F = TENSION (.7 N)

E = YOUNG'S MODULUS (8000 N/mm^2)

A = CROSS SECTIONAL AREA (.013 x 19 mm^2)

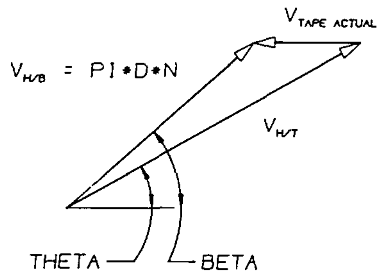
C_{FREQ} = CONTROL TRACK FREQUENCY (180/1.001 Hz)

L = CORRECTED DISTANCE

$$V_{TAPE\ ACTUAL} = CTM * C_{FREQ} / ((1 - F/(E * A)) * PITCHES)$$

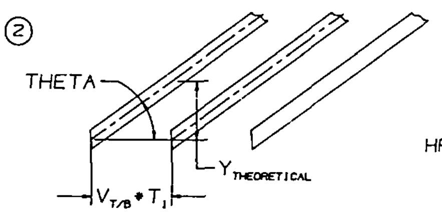
MODEL

(1)



$V_{H/B}$ = VELOCITY OF HEAD wrt BAND
$V_{TAPE\ ACTUAL}$ = ACTUAL VELOCITY of TAPE
$V_{H/T}$ = VELOCITY of HEAD wrt TAPE
D = EFFECTIVE SCANNER DIAMETER
N = SCANNER SPEED $(\frac{REV}{S})$
THETA = TRACK ANGLE
BETA = SCANNER HELIX ANGLE

(2)



T_1 = TIME BETWEEN HEAD PASSES

$$= \frac{1}{N * HPPR}$$

HPPR = HEAD PASSES per REVOLUTION

FROM (1)

$$TAN\ (THETA) = \frac{PI \bullet D \bullet N \bullet SIN(BETA)}{PI \bullet D \bullet N \bullet COS(BETA) + V_{TAPE\ ACTUAL}}$$

FROM (2)

$$TAN\ (THETA) = \frac{Y_{THEORETICAL}}{V_{TAPE\ ACTUAL} \bullet T_1}$$

THEREFORE:

$$Y_{THEORETICAL} = \frac{PI \bullet D \bullet N \bullet SIN(BETA)}{PI \bullet D \bullet N \bullet COS(BETA) + V_{TAPE\ ACTUAL}} \bullet V_{TAPE\ ACTUAL} \bullet T_1$$

$$TRACK\ LOCATION\ ERROR = Y(I) - Y(I)_{THEORETICAL}$$

Proposed American National Standard

for television digital recording —

19-mm type D-2 composite format — magnetic tape

SMPTE 246M

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. Referenced Documents

This standard is intended for use in conjunction with the following documents:

SMPTE 244M, Television Digital Recording — Representation of NTSC Encoded (System M) Video Signal — Active Video Portion

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

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

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

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

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

CCIR Report 624-3, Characteristics of Systems for Monochrome and Colour Television

3. Measurement Environment

3.1 Dimensions are in the metric system.

3.2 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

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 to 1.5 N

4. Television Tape Specifications

4.1 Base. The base material shall be polyester or equivalent.

4.2 Width. The tape width shall be 19.010 ± 0.015 mm.

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

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

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

4.4 Reference Edge Straightness. The reference edge straightness maximum deviation is 6 μm p-p.

4.4.1 Edge straightness fluctuation is measured at the edge of a moving tape guided by three guides having contact 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.

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

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

4.7 Offset Yield Strength. Offset yield strength shall be greater than 15 N.

4.7.1 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.

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

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

4.8.1 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).

4.8.2 The magnetic particles shall be longitudinally oriented.

Proposed American National Standard

for television digital recording —

19-mm type D-2 composite format — helical data and control records

SMPTE 247M

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, Sec. 4 of this document 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 SMPTE 245M.

1.2 The standard applies to recorders operating in the 525-line television system with a frame frequency of 29.97 Hz nominal and in accord with SMPTE 244M. One video channel and four independent audio channels are recorded. Audio channels operate in accord with ANSI S4.40-1985 at a nominal 48 kHz sampling frequency.

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

2. Referenced Documents

This standard is intended for use in conjunction with the following documents:

ANSI S4.40-1985, Digital Audio Engineering — Serial Transmission Format for Linearly Represented Digital Audio Data

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

SMPTE 244M, Television Digital Recording — Representation of NTSC Encoded (System M) Video Signal — Active Video Portion

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

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

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

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

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

CCIR Report 624-3, Characteristics of Systems for Monochrome and Colour Television

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

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. Fig. 3 shows the arrangement of video and audio sectors on the tape.

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

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

Sync blocks containing sync pattern and identification pattern, followed by a fixed length data block with error control.

Postamble containing sync pattern and identification pattern.

3.2 Labelling Conventions for Audio and Video Data. In this standard, the least significant bit is shown on the left and is the first recorded to tape.

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

Byte values are expressed in hexadecimal notation unless otherwise noted.

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

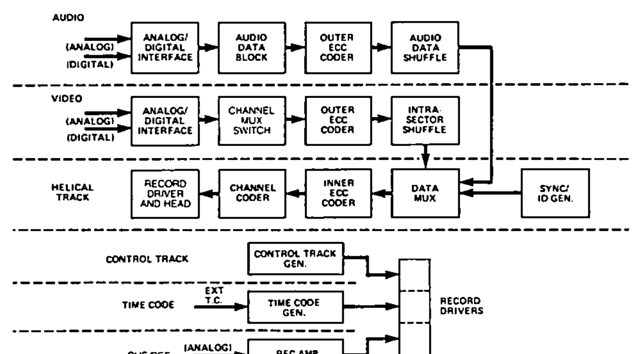

Fig. 1
Block Diagram — Record

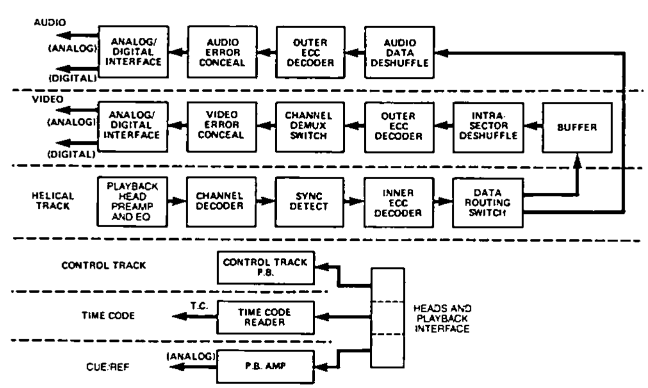

Fig. 2
Block Diagram — Reproduce

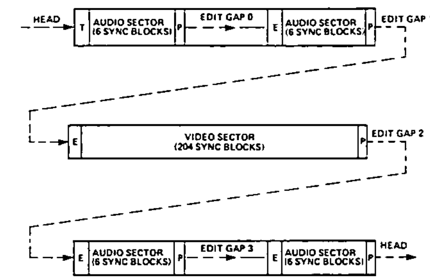

Fig. 3
Sector Arrangement on Helical Track

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

Fig. 4 shows the sync block format.

3.3.1 Sync Pattern

(a) Length: 16 bits (2 bytes)

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

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

(c) Protection: None

3.3.2 Identification Pattern. The first byte of the identification pattern identifies a particular sync block of a helical track. The second byte of the identification pattern identifies a particular track. Fig. 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. Fig. 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.

(c) The field address F_0, F_1 (bits 4 and 5 of the sector ID for video sync blocks) shall identify the

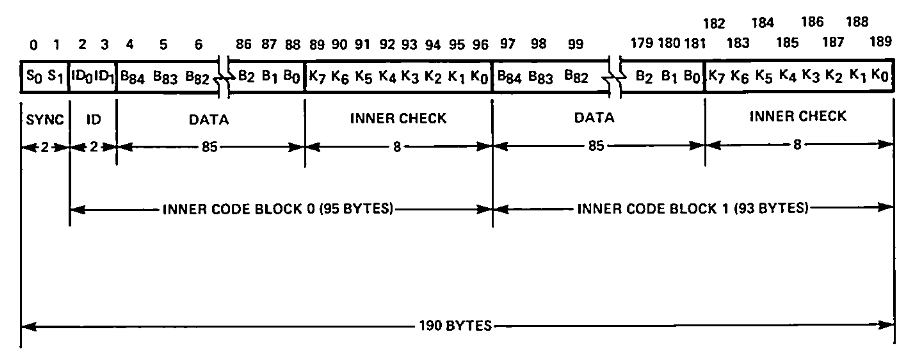

Fig. 4
Sync Block Format

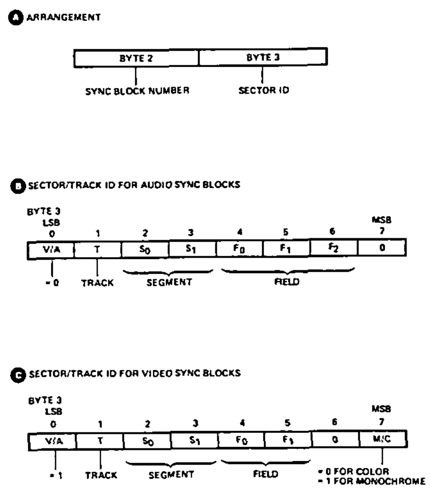

Fig. 5
Sync Block Identification Format

4-field color sequence as defined in CCIR 624-3, Fig. 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.

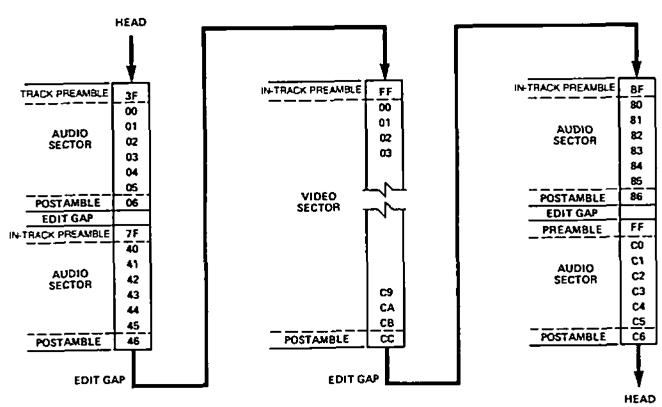

Fig. 6
Sync Block ID Number

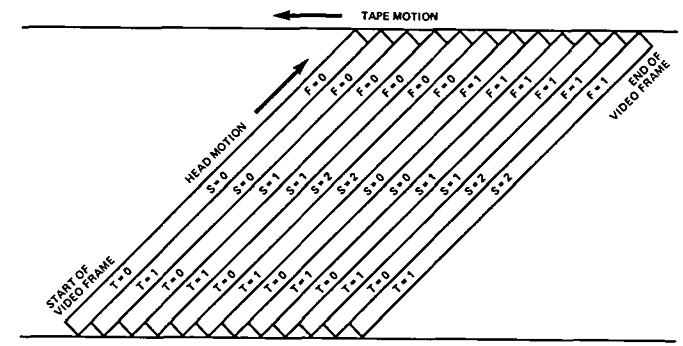

Fig. 7
Track, Segment and Field Numbers

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

(b) Arrangement: See Fig. 4.

(c) Interleaving: None.

(d) Protection: (Inner ECC code).

Type: Reed Solomon
Galois Field: GF(256)
Field generator polynominal:

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

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

Order of Use: Left-most term is most significant.

Code Generator Polynominal GF(256):
$G(x) = (x + 1)(x + a)(x + a^2)(x + a^3)(x + a^4)(x + a^5)(x + a^6)(x \pm a^7)$, 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:
$D(x) = ID_0x^{86} + ID_1x^{85} + B_{84}x^{84} + \ldots + B_2x^2 + B_1x + B_0$

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

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

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

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

When a sector is edited, the appropriate preamble, including run-up sequence, shall be recorded.

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

(a) Length: 62 bytes

(b) Arrangement: See Fig. 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 Fig. 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 Fig. 8C

(c) Run-up pattern: AA_H

LSB							MSB
0	1	0	1	0	1	0	1

(d) Protection: None

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

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

(a) Length: 6 bytes

(b) Arrangement: See Fig. 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 Miller-squared code which is defined by the following coding 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.

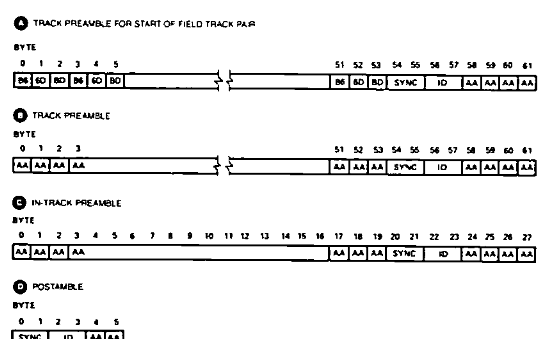

Fig. 8
Sector Preamble and Postamble

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

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

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

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

3.9 Video Processing

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

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

3.9.2.1 Recorded Samples of the Television Line. 768 samples per line are recorded, centered about the active picture. Fig. 9 shows the relationship between video signals in the analog and digital domains together with the address numbers of the digitized samples for zero degrees 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 624-3, is the I sample.

3.9.2.2 Recorded Lines of the Television Frame. 255 consecutive lines from each field 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 624-3 (Fig. 5c):

From field I of color frame A the first recorded line is number 10.

From field II of color frame A the first recorded line is number 272 (line 9 of field II).

From field III of color frame B the first recorded line is number 534 (line 9 of field III).

From field IV of color frame B the first recorded line is number 796 (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.

Fig. 10 shows the distribution of samples.

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

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

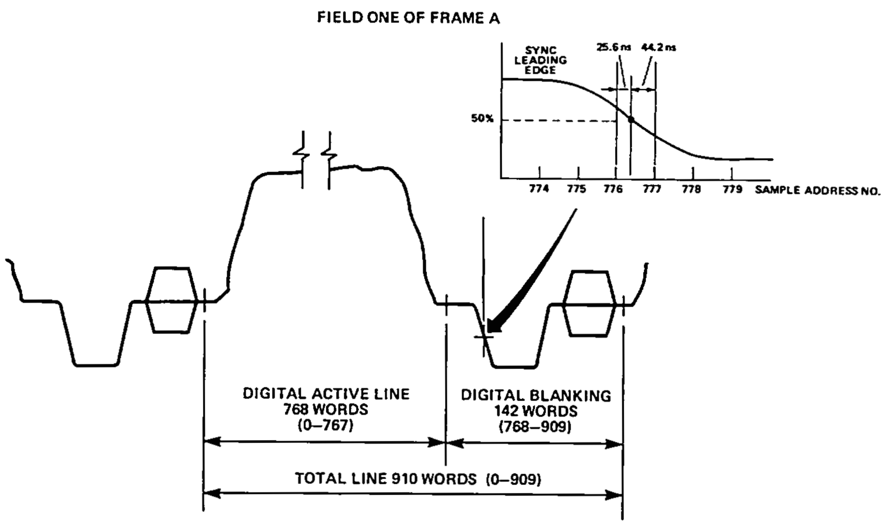

Fig. 9
Horizontal Sync Relationship

Note: Zero degrees SCH.

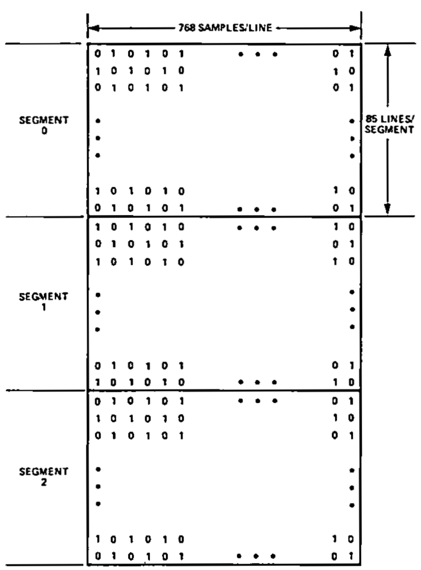

Fig. 10
Channel Distribution of Samples

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:

$ih = \text{int}(h/2), \qquad ih = 0, 1, \ldots, 383$

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

Let Oblock be the outer block number within line L:

$\text{Oblock} = 0, 1, \ldots, 5$

Let Obyt be the sample number within outer block Oblock:

$\text{Obyt} = 0, 1, \ldots, 63$

(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:

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

The outer ECC coder places check bytes K3, K2, K1, and K0 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:

$\text{Row} = \text{Obyt}$

and

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

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:

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

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

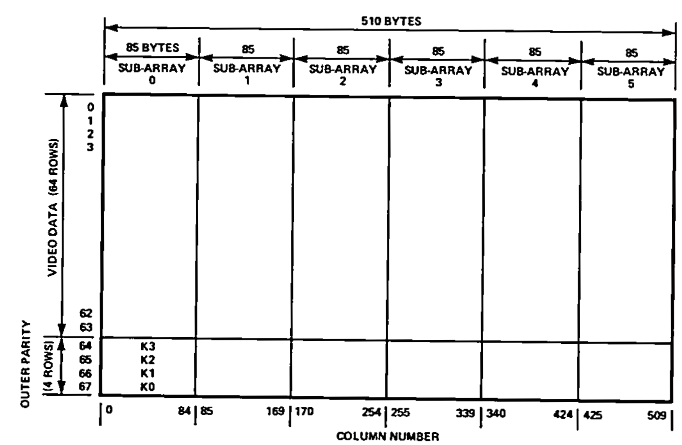

Fig. 11
Video Sector Array

Galois Field: GF (256)

Field Generator Polynominal: $x^8 + x^4 + x^3 + x^2 + 1$.

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

$x^4D(x)$ by G(x), where D(x) is the polynomial given by

$$D(x) = B_{63}x^{63} + B_{62}x^{62} + \ldots + B_2x^2 + B_1x + B_0$$

Equation of full code is given by

$$B_{63}x^{67} + B_{62}x^{66} + \ldots + B_1x^5 + B_0x^4 + K_3x^3 + K_2x^2 + K_1x + K_0$$

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. Fig. 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 S4.40-1985. 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: Two's 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 S4.40-1985

(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.)

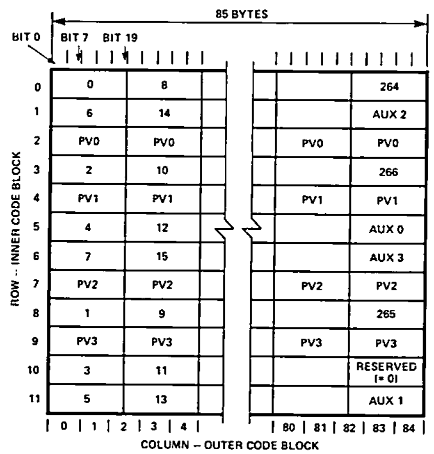

Fig. 12
Audio Data Block Layout

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

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.

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

(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 Fig. 13.

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, R, bits. (20 bits total per word.)

Auxiliary words: Five words of four-bits, plus two words of nine bits. (For security, the word EFLG is written four times in each audio block.)

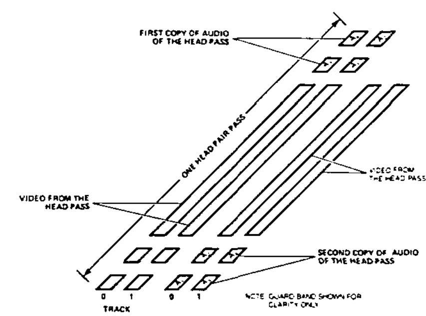

Fig. 13
Relative Audio-Video Timing
Note: Guard band shown for clarity only.

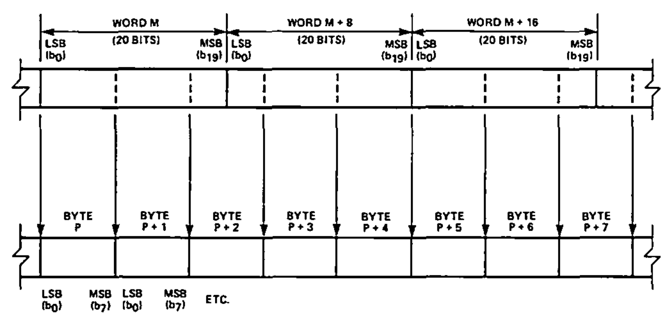

Fig. 14
Allocation of Audio Words to Bytes

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.

Table 3
Audio Data Word Mode

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

Note: Audio 1 represents bit 1 of the audio sample.

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 Fig. 14, beginning with the LSB of the first word of the word group.

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

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

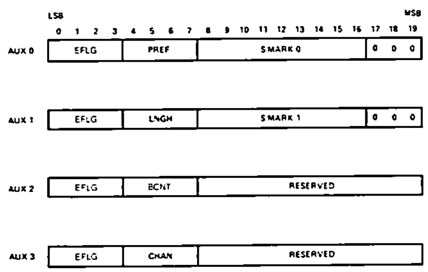

Fig. 15
Audio Data Block Auxiliary Data

Note: Reserved = 000_H

3.10.4.1 Channel Use (CHAN) — 4 Bits. Specifies the usage of the two input channels in an interface data stream. CHAN is derived from channel status byte 1.

LSB MSB

Bit 0 1 2 3 4 5 6 7 Channel Status (AES/EBU Byte 1)

↓ ↓ ↓ ↓

0 1 2 3 CHAN

Bit 0: Channel mode bit 0

Bit 1: Channel mode bit 1

Bit 2: Channel mode bit 2

Bit 3: Channel mode bit 3

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

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.

LSB MSB

Bit 0 1 2 3 4 5 6 7 Channel Status (AES/EBU Byte 0)

↓ ↓ ↓

0 1 2 PREF

Bit 0: Preemphasis bit 0

Bit 1: Preemphasis bit 1

Bit 2: Preemphasis bit 2

Bit 3: 0

	PREF BIT			
Mode	0	1	2	Value
0	0	0	0	Preemphasis off, (default)
1	0	0	1	Reserved
2	0	1	0	Reserved
3	0	1	1	Reserved
4	1	0	0	Preemphasis off
5	1	0	1	Reserved
6	1	1	0	50/15 microsecond (CD type)
7	1	1	1	Reserved

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 dervied from user control inputs.

LSB MSB

Bit 0 1 2 3 LNGH

Bit 0: Not used = 0

Bit 1: LNGH 1 (LSB)

Bit 2: LNGH 2

Bit 3: LNGH 3 (MSB)

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

X means that the ancillary bit is recorded.

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 Sec. 6 of ANSI S4.40-1985. S MARK 0 contains the word count, in the current block, of the first block sync detected, i.e., the word address in the block pointing to the first sample after the block sync mark. S MARK 1 identifies the last block sync detected. Where multiple marks are encountered, only the last one will be stored in S MARK 1.

LSB MSB

0 1 2 3 4 5 6 7 8 S MARK 0 / S MARK 1

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

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

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

3.10.4.5 Word Count (BCNT) — 4 Bits. BCNT specifies the number of useful samples in the current block, either 266 or 267.

LSB MSB

0 1 2 3 BCNT

Bit 0: BC

Bit 1: 0

Bit 2: 0

Bit 3: 0

Number Samples	BC
266	1
267	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. Fig. 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.

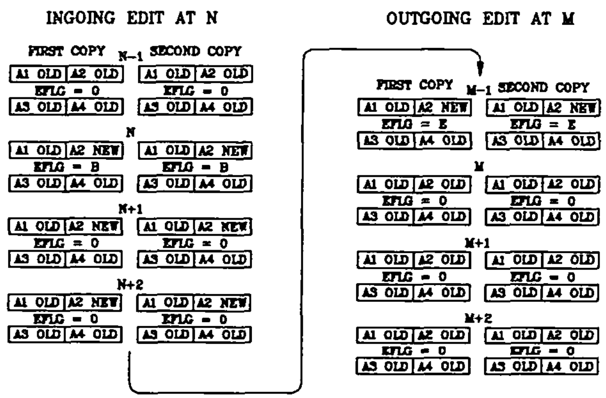

Fig. 16
Audio Edit (Channel A2 Only)

Code Generator Polynomial: in GF(256):
$G(X) = (x + 1)(x + a)(x + a^2)(x + a^3)$
where a is given by 02H 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

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

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 Fig. 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 Fig. 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 Fig. 13. The audio sectors labeled A1, A2, A3, and A4 correspond to audio input channels 1, 2, 3, and 4, respectively.

4. Control Track

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

4.1.1 The control track servo reference pulse, at the time of recording, shall be a series of pulse doublets with a period of 5.561 ms ± 6 μs, as shown in Fig. 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 ± 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 microseconds 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 Fig. 2(a) of 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 624-3, Fig. 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.

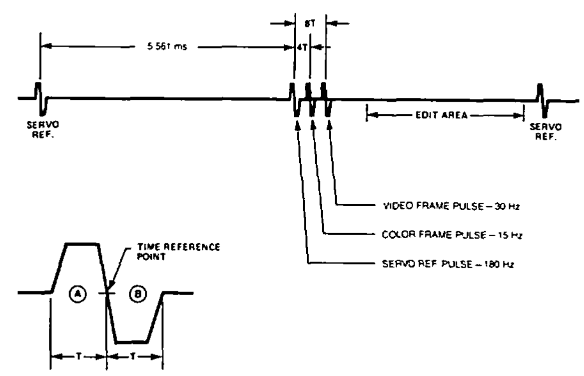

Fig. 17
Control Waveform-Timing

Notes: 1. T ≅ 104 μs
2. Rise Time < 15 μs

Proposed American National Standard

for television digital recording —

19-mm type D-2 composite format — cue record and time and control code record

SMPTE 248M

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 SMPTE 245M. The document applies to recorders operating in the 525-line television system with a frame frequency of 29.97 Hz.

2. Referenced Documents

This standard is intended for use in conjunction with the following documents:

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

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

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

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

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

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

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

CCIR Report 624-3, Characteristics of Systems for Monochrome and Colour Television

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 spefied in 3.2
Tape tension	Wound on a reel at a tension of 0.6 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 Fig. 2(b) of SMPTE 245M.

The start of address of the time code as recorded on the tape is defined by Dimension P_2, Fig. 2(b), 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, Fig. 2(b) of 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 Sec. 4.1.5 of SMPTE 247M.

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 ± 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_ϕ is the relative tape 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 ± 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-1986.

PROPOSED

SMPTE ENGINEERING GUIDELINE — EG 20

Tape Transport and 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 SMPTE 245M. The parameters are for reference purposes only.

2. *Referenced Documents*

This guideline is intended for use in conjunction with the following documents:

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

SMPTE 244M, Television Digital Recording—Representation of NTSC Encoded (System M) Video Signal—Active Video Portion

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

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

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

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

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

3. *General Specifications*

3.1 Dimensions are in the metric system.

3.2 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

4. *Scanner Specifications*

4.1 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.

4.2 Two possible designs are shown in Table 1 and Table 2, and Fig. 1 and Fig. 2.

4.3 The longitudinal head locations and tape wrap for design 1 are shown in Fig. 3.

4.4 The longitudinal head locations and tape wrap for design 2 are shown in Fig. 4.

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Table 1
Pole Tip Relationships

Parameters		Design 1	Design 2
Relevant figures		Fig. 1	Fig. 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

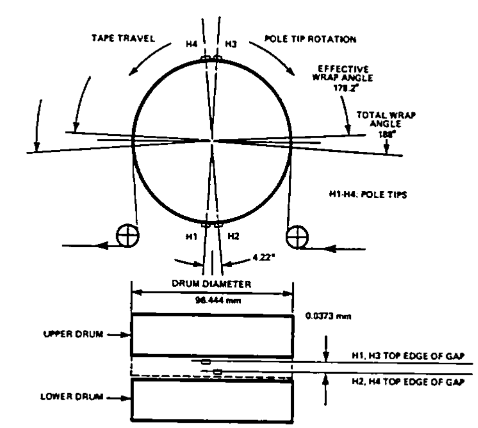

Fig. 1
Scanner Configuration for Design 1

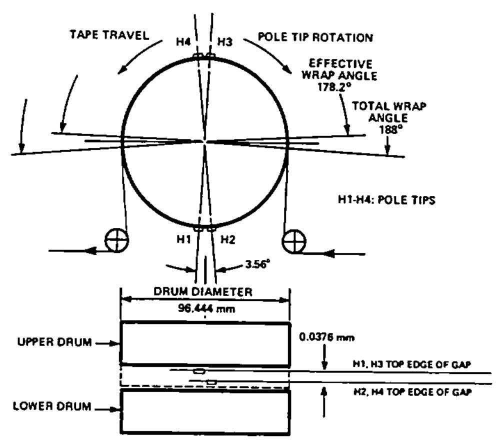

Fig. 2
Scanner Configuration for Design 2

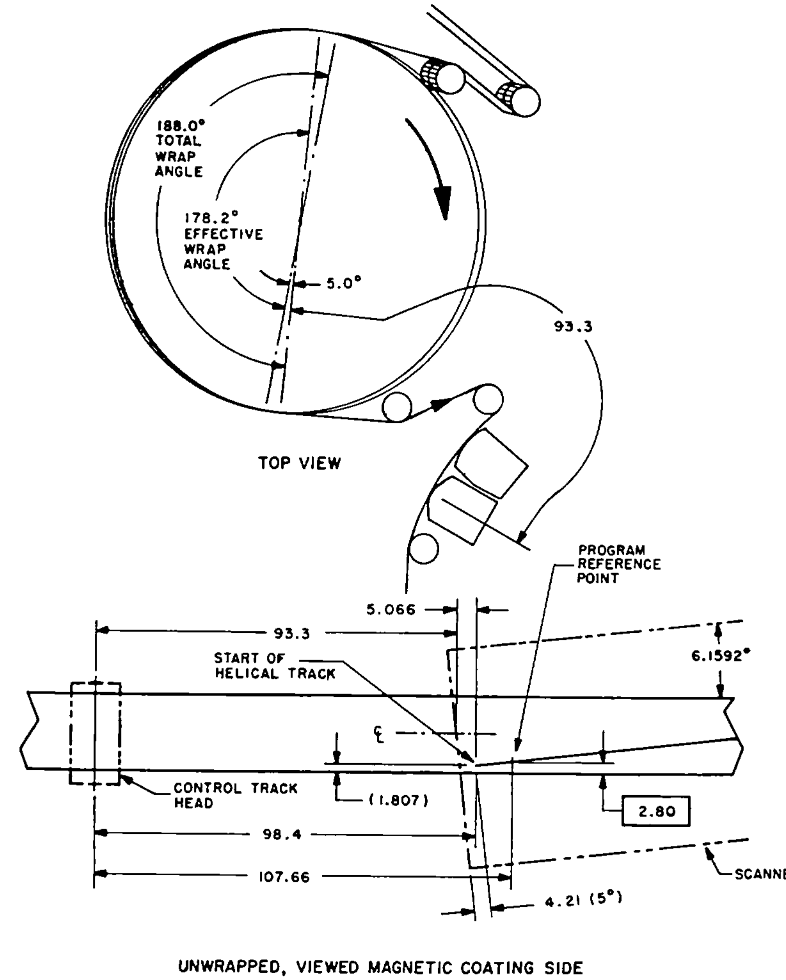

Fig. 3
Longitudinal Head Locations and Tape Wrap for Design 1

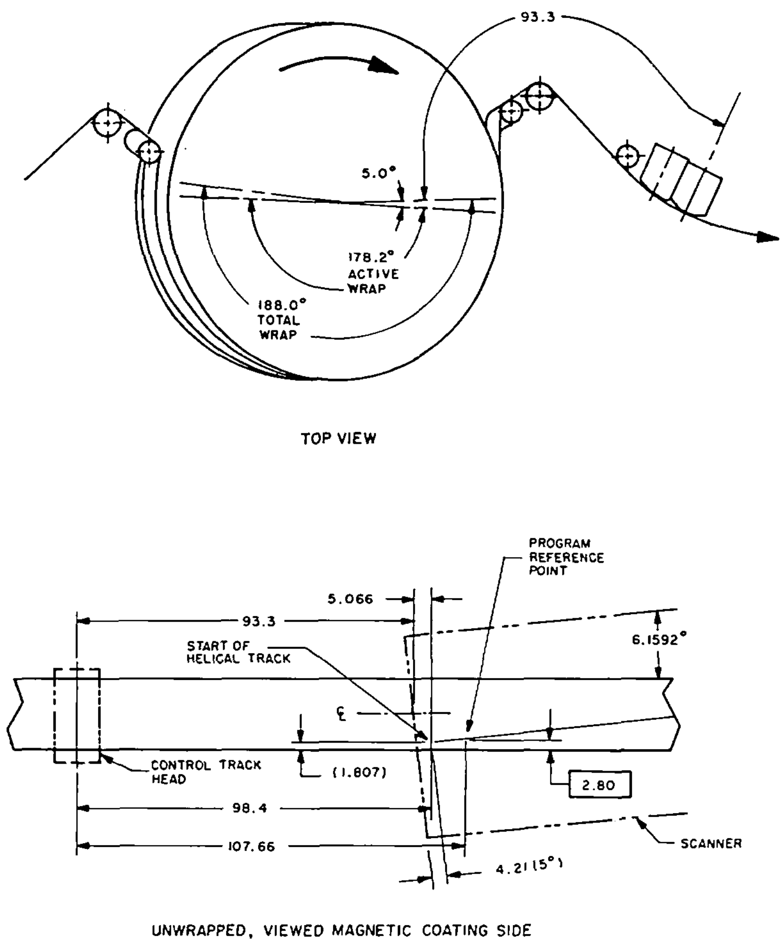

Fig. 4
Longitudinal Head Locations and Tape Wrap for Design 2

PROPOSED

SMPTE ENGINEERING GUIDELINE — EG 22

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. *Referenced Documents*

This guideline is intended for use in conjunction with the following documents:

ANSI S4.40-1985, Digital Audio Engineering—Serial Transmission Format for Linearly Represented Digital Audio Data

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

SMPTE 244M, Television Digital Recording—Representation of NTSC Encoded (System M) Video Signal —Active Video Portion

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

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

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

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

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

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

CCIR Report 624-3, Characteristics of Systems for Monochrome and Colour Television

3. *General Description*

This format uses 19-mm class 1500 tape as described in SMPTE 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 SMPTE 245M. The content of the helical record which contain video and audio data, and of the longitudinal control track record are defined in SMPTE 247M. The content of the longitudinal cut track record and of the longitudinal time and control code record is defined in SMPTE 248M.

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

4. *Index to Documents*

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List of Illustrations

List of Tables

PROPOSED

SMPTE ENGINEERING GUIDELINE — EG 21

Nomenclature for Television Digital Recording, 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 television recording formats.

2. *Referenced Documents*

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

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

CCIR Recommendation 601, Encoding Parameters of Digital Television for Studios

CCIR Report 624-3, Characteristics of Systems for Monochrome and Colour Television

3. *General Definitions*

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

3.2 D-2 Format Recorder: A 19-mm cassette-based digital recorder for composite video and other television signals in accordance with SMPTE 247M.

3.3 Program Areas: That part of the tape on which is digitally recorded the program video and audio signals.

3.4 Program Area Track Pattern: The arrangement of video and audio sectors on helical-scan tracks within the program area.

4. *Track Pattern Allocation—Video and Audio Segments*

4.1 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.

4.2 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.

5. *Electrical Signal Allocation*

5.1 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.

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

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

5.1.1.2 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.

5.1.1.3 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.

5.1.1.4 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.

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

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5.1.2.1 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.

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

6. *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:

6.1 Bit: A contraction of binary and digit to define a unit of information.

6.2 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.

6.3 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.

6.4 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.

6.5 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.

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

6.6.1 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 2 color difference channels and 8-bit PCM encoding of each sample, the bit rate is 216 million bits per second.

6.6.2 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.

6.7 Bus: A signal line or a set of signal lines used by an interface to which a multiplicity of devices are connected and over which messages are carried.

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

6.9 Positive Binary: The condition where the most positive of the two possible signal levels is a logical 1.

6.10 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.

6.11 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.

6.12 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.

6.13 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.

6.14 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.

6.15 LSB: Least significant bit of a data word.

6.16 MSB: Most signficant bit of a data word.

6.17 Parallel Interface: Pertaining to a transmission system wherein all bits of a particular character are sent simultaneously.

6.18 Serial Interface: Pertains to a transmission system wherein all bits are sent in serial (series) order.

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

7. *Error Protection Strategy*

7.1 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.

7.1.1 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.

7.1.2 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.

7.1.3 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.

8. *Error Protection—Data Organization*

8.1 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.

8.2 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.

8.2.1 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.

8.2.2 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.

8.2.3 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.

8.3 Video and Audio Data Redistribution

8.3.1 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.

8.3.2 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.

9. *Coding and Modulation*

9.1 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.

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

9.3 Scrambling: Alternate term for randomization.

9.4 Mapping: The recording 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.

9.5 Composite Video Signal (Analog): The color-picture signal, encoded in the NTSC standard, including blanking and all synchronizing signals.

9.6 Composite Encoded Signal (Digital): A digital representation of a composite video signal.

9.7 Digitize: To sample, quantize, and code an analog signal.

9.8 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.

9.9 Linear PCM: Pertaining to quantizing intervals that are equal throughout the range of the system.

9.10 Quantization: The division of a continuous range of values into a finite number of distinct values.

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

9.12 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 624-3, Fig. 5(c).

10. *Mechanical Terms*

10.1 Basic Dimension: A basic dimension is a fundamental dimension to which no tolerance is applicable.

10.2 Derived Dimension: A derived dimension is obtained from other fundamental dimensions by computation and is given for information purposes only.

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

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

10.5 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.

10.6 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.

10.7 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.

10.8 Track Angle: An angle of the helical track record with respect to the reference edge of the tape.

10.9 Effective Wrap Angle: An angle at the center of the drum subtended by the start and end-point of the track.

10.10 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.

10.11 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.

11. *Editing Definitions*

11.1 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.

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