ANSI/SMPTE 230M-1996
Revision of
ANSI/SMPTE 230M-1991

SMPTE STANDARD

for Television Analog Recording — 1/2-in Type L — Electrical Parameters, Control Code and Tracking Control

1 Scope

1.1 This standard specifies the electrical parameters of video, audio, time and control code, and tracking-control signals for 1/2-in type L helical-scan video tape recorders operating with video signals having a typical scanning structure of 525 lines, 59.94 fields per second, and 2:1 interlace. This standard specifies two recording modes: Mode 1 uses oxide-particle tape, and mode 2 uses metal-particle tape and permits audio frequency modulation (AFM) signals to be recorded.

1.2 Where nominal values are given without tolerances, interchange performance will be limited by implementation accuracy.

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/IEEE 152-1992, Audio Program Level Measurement

ANSI/SMPTE 12M-1995, Television, Audio and Film — Time and Control Code

ANSI/SMPTE 238M-1992, Television Analog Recording — 1/2-in Type L — Tapes and Cassettes

IEC 268-12 (1987), Part 12: Application of Connectors for Broadcast and Similar Use

ITU-R BT.470-4, Television Systems

3 Video recording

This component video recording system is intended to operate compatibly in an NTSC environment. To achieve this, the levels and ratios used in the format are derived from the monochrome or composite input signal as defined in 3.4.

The video recording system shall provide separate signal paths for the luminance and color-difference signals. These component signals shall be recorded on two separate tracks designated respectively as the Y track for the luminance signal and the C track for the color-difference signals. The R-Y and B-Y color-difference signals shall be recorded in the form of a compressed time-division multiplexed signal on the C track. When operating in mode 2, two AFM signals may be recorded in addition to the compressed color-difference signals.

3.1 Mode selection

3.1.1 Two modes of operation are defined for the following tape types:

- Oxide-particle tape: Mode 1
- Metal-particle tape: Mode 2

3.1.2 Sensing of tape type shall be automatic by means of a sensing hole in the cassette as described in ANSI/SMPTE 238M.

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3.2 Luminance channel

3.2.1 Signal Processing

A signal processing system, as specified in this standard, shall contain the following elements in the order of the signal flow.

3.2.1.1 A means for modifying the sync portion of the luminance signal.

3.2.1.2 A means for insertion of a vertical interval subcarrier is required in mode 2 when the signal to be recorded has been decoded from a composite source as defined in ITU-R BT.470-4. The vertical interval subcarrier (VISC) is optional in mode 1.

3.2.1.3 A video nonlinear preemphasis process.

3.2.1.4 A video preemphasis network.

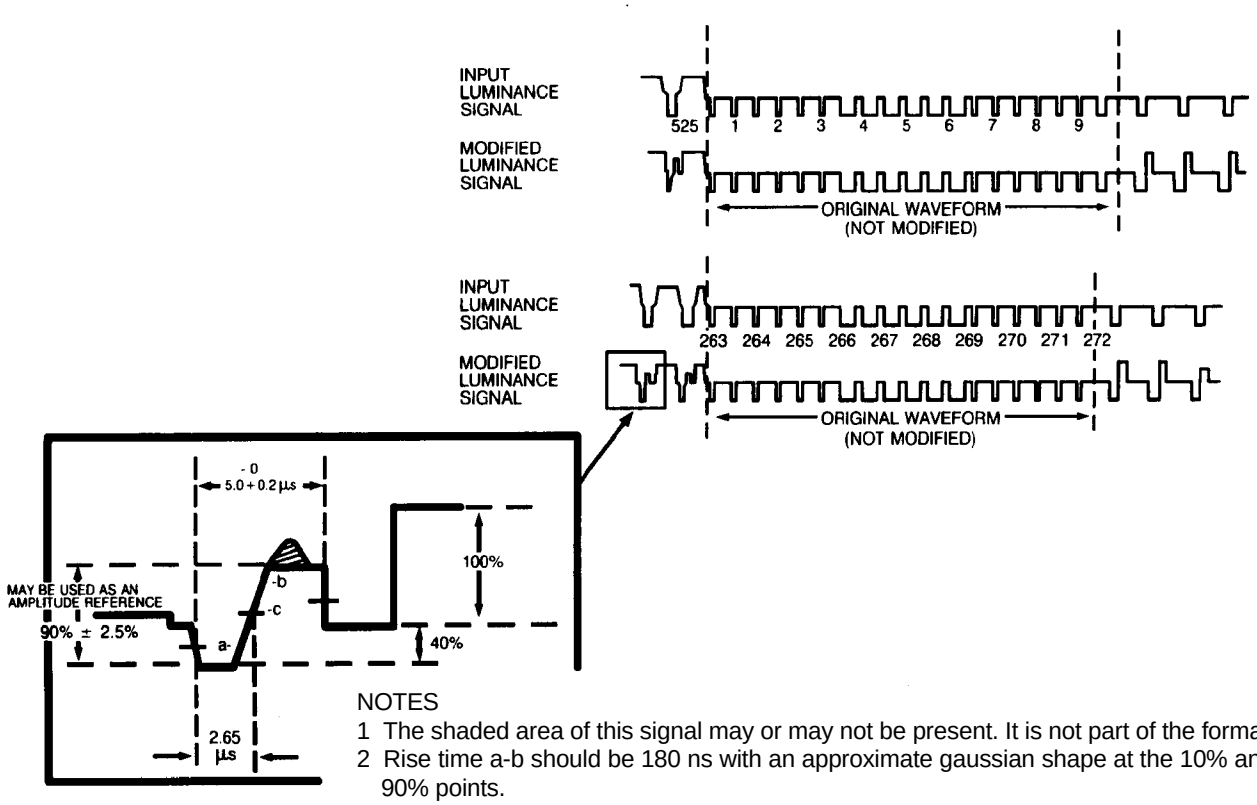
3.2.1.5 A means for clipping the video signal after preemphasis.

3.2.1.6 A linear frequency modulator having constant deviation with respect to the amplitude of the modulating frequencies.

3.2.1.7 An amplifier to provide current drive to the Y channel record heads.

3.2.2 Modification of sync portion

Means shall be used to modify the pulse width and amplitude of the sync portion as shown in figure 1.



NOTES
1 The shaded area of this signal may or may not be present. It is not part of the format.
2 Rise time a-b should be 180 ns with an approximate gaussian shape at the 10% and 90% points.
3 Dimension c is the midpoint of the a-b transition.
4 See annex A.1.

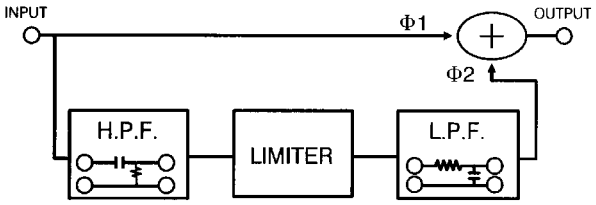
Figure 1 -- Waveform of the modified luminance sync (vertical sync and equalizing pulse portion remains unmodified)

3.2.3 Luminance nonlinear preemphasis

The luminance signal shall receive nonlinear preemphasis (see figure 2). The characteristics shall be as shown in table 1.

Table 1 – Video nonlinear preemphasis characteristics

	Input (dB)					
MHz	--30	--20	--15	--10	--5	0
0.2	0.4	0.4	0.4	0.4	0.3	0.2
0.5	1.9	1.7	1.7	1.4	0.8	0.4
1.0	4.6	4.0	3.5	2.4	1.3	0.7
1.5	6.7	5.6	4.6	3.0	1.6	0.9
2.0	8.0	6.6	4.9	3.3	1.8	1.1
3.0	9.5	7.5	5.3	3.6	2.2	1.3
4.0	9.9	7.6	5.3	3.6	2.2	1.4
5.0	9.9	7.3	5.1	3.3	2.0	1.2
Values are in decibels.						



NOTE -- The phase of the side chain (Φ2) shall be equal to the phase of the input signal (Φ1) at 3.58 MHz prior to the mixing.

Figure 2 -- Block diagram of video nonlinear preemphasis

3.2.4 Luminance preemphasis

Preemphasis is defined by the frequency and phase characteristics of the network shown in figure 3 when fed from a zero impedance source and feeding an infinite impedance load.

3.2.5 Amplitude clipping

For an input signal where blanking is at 0% and peak white at 100%, any positive or negative amplitude excursion exceeding the levels shown in table 2 shall be clipped.

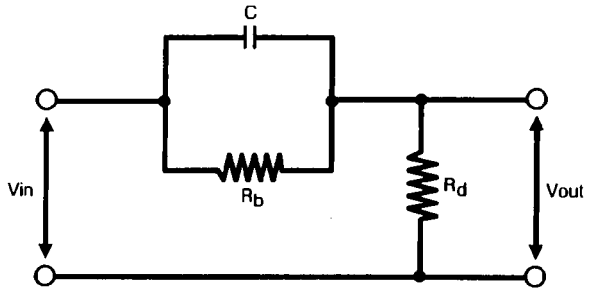


Figure 3 -- Preemphasis network

Table 2 – Luminance amplitude clipping characteristics

	Mode 1	Mode 2
Positive excursion limit	+310% nom	+324% nom
	+315% max	+329% max
Negative excursion limit	--125% nom	--214% nom
	--130% max	--219% max

3.2.6 Recorded carrier frequency

Carrier frequencies corresponding to reference video levels shall be as shown in table 3 when recording a flat-field signal.

Table 3 – Carrier frequencies corresponding to reference video levels

	Mode 1	Mode 2
100% white	6.4 MHz nom	7.7 MHz nom
50% level	5.7 MHz nom	7.0 MHz nom
Blanking	4.97 ± 0.05 MHz	6.27 ± 0.05 MHz
Sync tip	4.4 MHz nom	5.7 MHz nom
Deviation (blanking to peak white)	1.43 ± 0.05 MHz	1.43 ± 0.05 MHz

3.2.7 Y track record head current

3.2.7.1 The amplitude of the record current for the Y track shall be such that the maximum level of remanent flux on the tape is produced when recording a Y signal with 50% amplitude flat field.

3.2.7.2 The amplitude of the Y track record current shall decrease with increasing frequency in the range 2 MHz to 10 MHz, according to a straight line contained within limit lines as shown in figure 4.

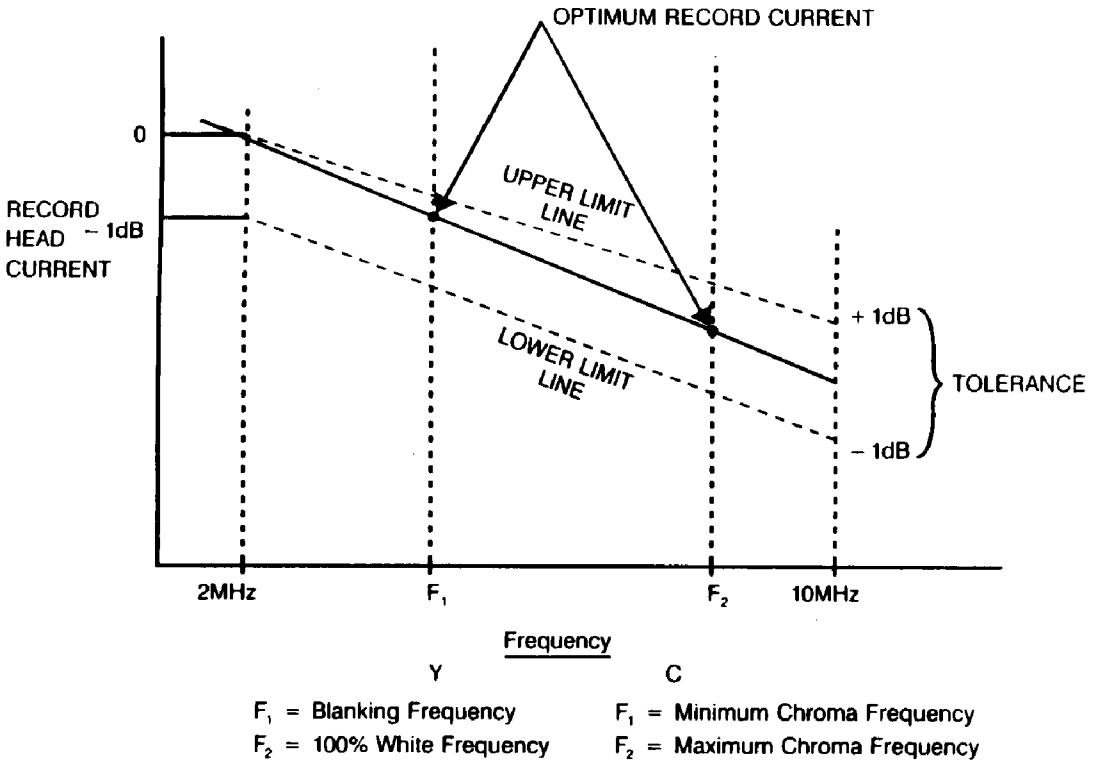


Figure 4 – Record equalization

3.3 C channel

3.3.1 Signal processing

A signal processing system, as specified by this standard, shall contain the following elements in the order of the signal flow:

3.3.1.1 A means of compressing the time scale of the R-Y and B-Y signals over a period of one horizontal line such that they may be time multiplexed into one horizontal line.

3.3.1.2 A means of adding a horizontal timing pulse.

3.3.1.3 A video nonlinear preemphasis process.

3.3.1.4 A video preemphasis network.

3.3.1.5 A means for clipping the video signal after preemphasis.

3.3.1.6 A linear frequency modulator having constant deviation with respect to the amplitude of the modulating frequencies.

3.3.1.7 A high-pass filter to reduce the low frequency component amplitude of the FM chrominance signal.

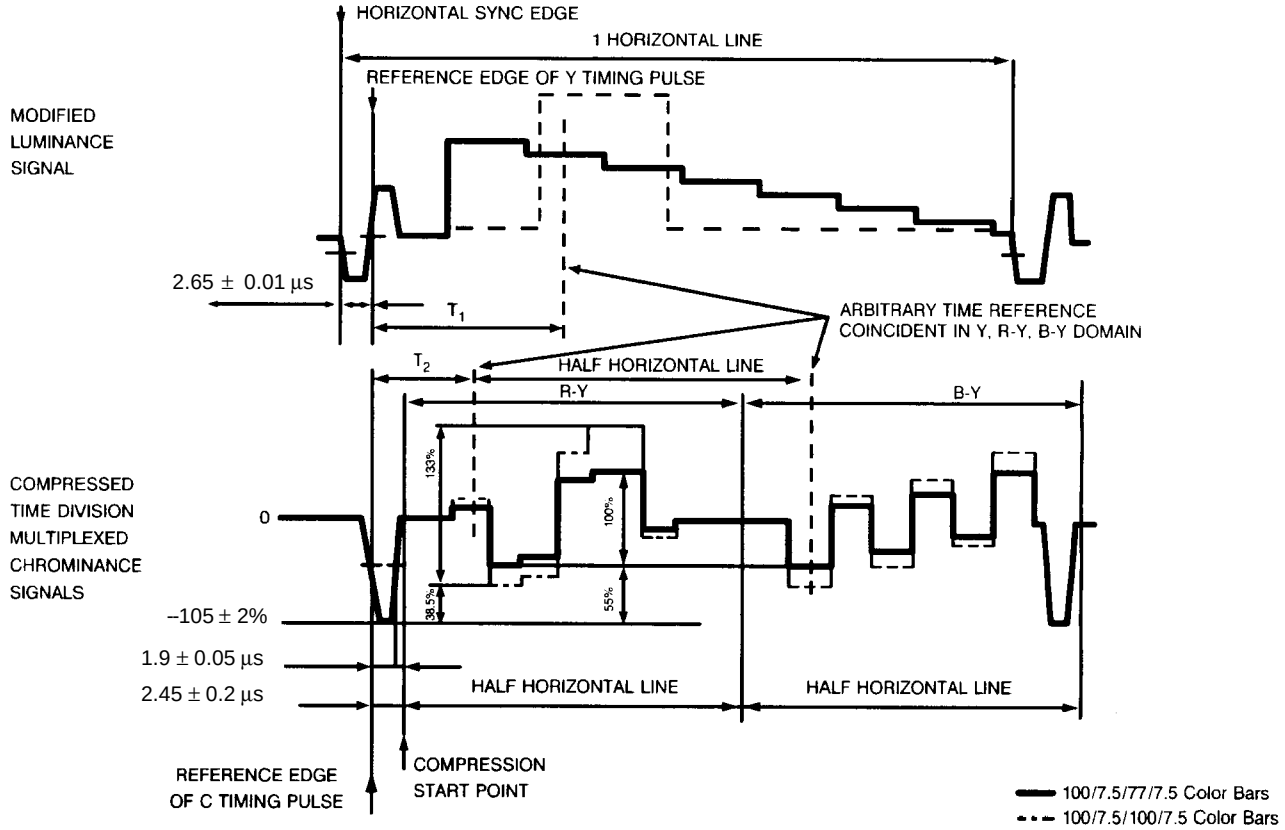
3.3.1.8 A means of combining the frequency modulated audio signal and the frequency modulated chrominance signal in mode 2 when the AFM signals are present.

3.3.1.9 An amplifier to provide amplitude current drive to the C channel record heads

3.3.2 Time compression and multiplexing

3.3.2.1 The R-Y and B-Y signals shall each be compressed into a half-time scale as shown in figure 5.

3.3.2.2 The compressed R-Y and B-Y signals shall be multiplexed alternately and delayed by one horizontal line with respect to the luminance signal as shown in figure 6.



Where T_2 is = 1/2 T_1 – 0.01 µs $\leq T_2 + \Delta t \leq$ 1/2 T_1 + 0.01 µs

Δt = + 0.006 µs; refer to annex A.2.

Figure 5 – Waveform of compressed R–Y, B–Y signals (525/60)

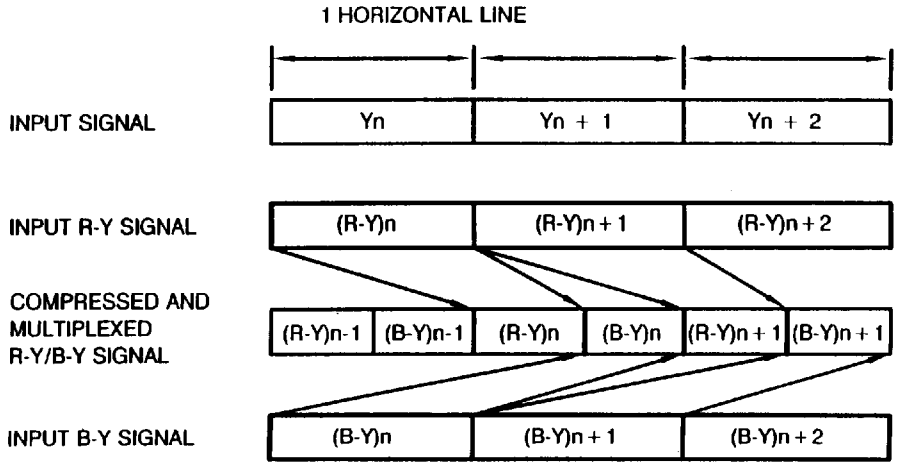


Figure 6 – Time compression and multiplexing system

3.3.3 Addition of horizontal timing pulses

The horizontal timing pulses which are continuous through the vertical interval shall be added to the compressed and multiplexed R-Y and B-Y signals as shown in figure 6. The sync shall have an approximate gaussian shape with a fall time of 220 ns between the 10% and 90% points.

3.3.4 R-Y and B-Y nonlinear preemphasis

The video signal shall receive nonlinear preemphasis which has the characteristics shown in table 1 and figure 2.

3.3.5 R-Y and B-Y preemphasis

Preemphasis is defined by the frequency and phase characteristics of the network as shown in figure 3, when fed from a zero impedance source and feeding an infinite impedance load.

3.3.6 Amplitude clipping

For an input signal of (100, 7.5, 77, 7.5) color bars which produces a color-difference signal defined as 100% for clipping reference, any positive or negative amplitude excursions shall be clipped according to limits defined in table 4.

3.3.7 Recorded carrier frequency

The carrier frequencies obtained using a flat field input test signal with appropriate levels corresponding to reference video (100, 7.5, 77, 7.5) color bar levels shall be as shown in table 5.

3.3.8 C track record head current

3.3.8.1 The amplitude of the record current for the C track shall be such that the maximum level of remanent flux on the tape is produced when recording the chrominance blanking level.

3.3.8.2 The amplitude of the C track record current shall decrease with increasing frequency in the range 2 MHz to 10 MHz according to a straight line contained within limit lines as shown in figure 4.

3.3.9 Low-frequency amplitude of chrominance FM signal

If the AFM signals are recorded in mode 2, the chrominance signal shall be subject to high-pass filtering prior to combining with the AFM signals. The filter response is shown in figure 7.

Table 4 – Chrominance amplitude clipping characteristics

	Mode 1	Mode 2
Positive excursion limit	+175% nom	+230% nom
	+180% max	+235% max
Negative excursion limit	--305% nom	--305% nom
	--310% max	--310% max

Table 5 – Recorded carrier frequency

	Mode 1	Mode 2
Positive video excursion	4 MHz nom	4.8 MHz nom
Negative video excursion	5 MHz nom	5.8 MHz nom
Blanking	4.5 MHz ± 0.05 MHz	5.3 MHz ± 0.05 MHz
Sync tip	5.55 MHz nom	6.35 MHz nom
Deviation peak to peak	1.0 MHz ± 0.05 MHz	1.0 MHz ± 0.05 MHz

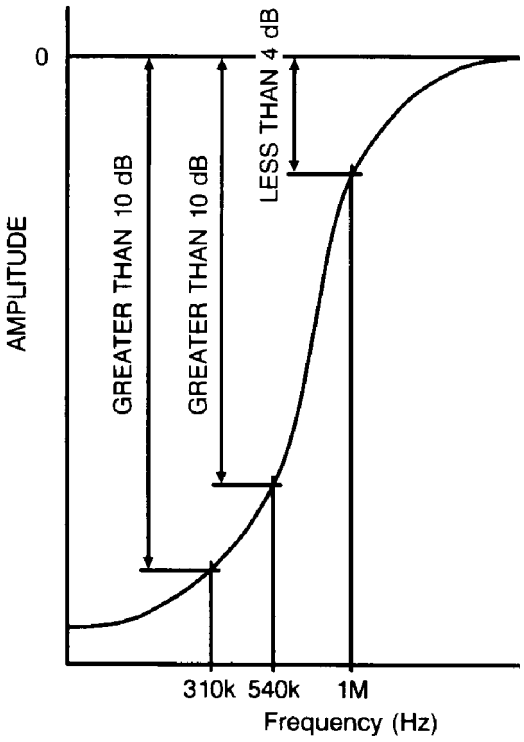


Figure 7 – Low-frequency amplitude of chrominance FM signal (in mode 2 when AFM signal is present)

3.4 Reference Y, R-Y, B-Y amplitudes

The reference Y, R-Y, and B-Y component signal amplitudes shall be as shown in table 6.

Table 6 – NTSC 75% color bar amplitude (100/7.5/77/7.5)

	Luminance % with 7.5% setup	Color difference %	
		R--Y	B--Y
Gray	76.9	0	0
Yellow	69.0	+ 8.1	--50.0
Cyan	56.1	--50.0	+16.9
Green	48.2	--41.9	--33.1
Magenta	36.2	+41.9	+33.1
Red	28.2	+50.0	--16.9
Blue	15.4	-- 8.1	+50.0
White	100.0	0	0
Sync	--40.0	--	--

NOTE -- The ratio of 100% amplitude of luminance and chrominance shall be 714:700.

4 Decoding and color field identification

4.1 Vertical interval subcarrier (VISC) reference

4.1.1 When operating in mode 2, a VISC signal shall be inserted on lines 11 and 274 of the Y signal prior to any signal preemphasis. This signal shall only be present when the signal to be recorded is the result of decoding a composite NTSC signal with a coherent subcarrier. The VISC signal is optional in mode 1.

4.1.2 The format of the VISC signal is shown in figure 8.

4.1.3 The frequency of the VISC signal shall be equal to the frequency of the subcarrier of the NTSC video signal.

4.1.4 The phase of the VISC signal shall be within $\pm 5°$ of the burst phase of the NTSC signal prior to decoding.

4.2 Field identification

4.2.1 When operating in mode 1 and mode 2, a color field identification signal shall be inserted into the chrominance as shown in figure 9, when the signal to be recorded is the result of decoding a composite NTSC signal meeting ITU-R BT.470-4.

4.2.2 When operating in mode 2 and recording signals that originated directly from color components, the identification signal shall identify a four-field sequence as shown in figure 9. When there is an associated time code signal, it is preferred that the flag indicating field one correspond to an even-numbered time code frame.

4.2.3 When there is no way to detect the beginning of a four-field color sequence, the sequence may start arbitrarily.

4.2.4 When operating in mode 1, the color field identification signal referred to in 4.2.2 and 4.2.3 is optional.

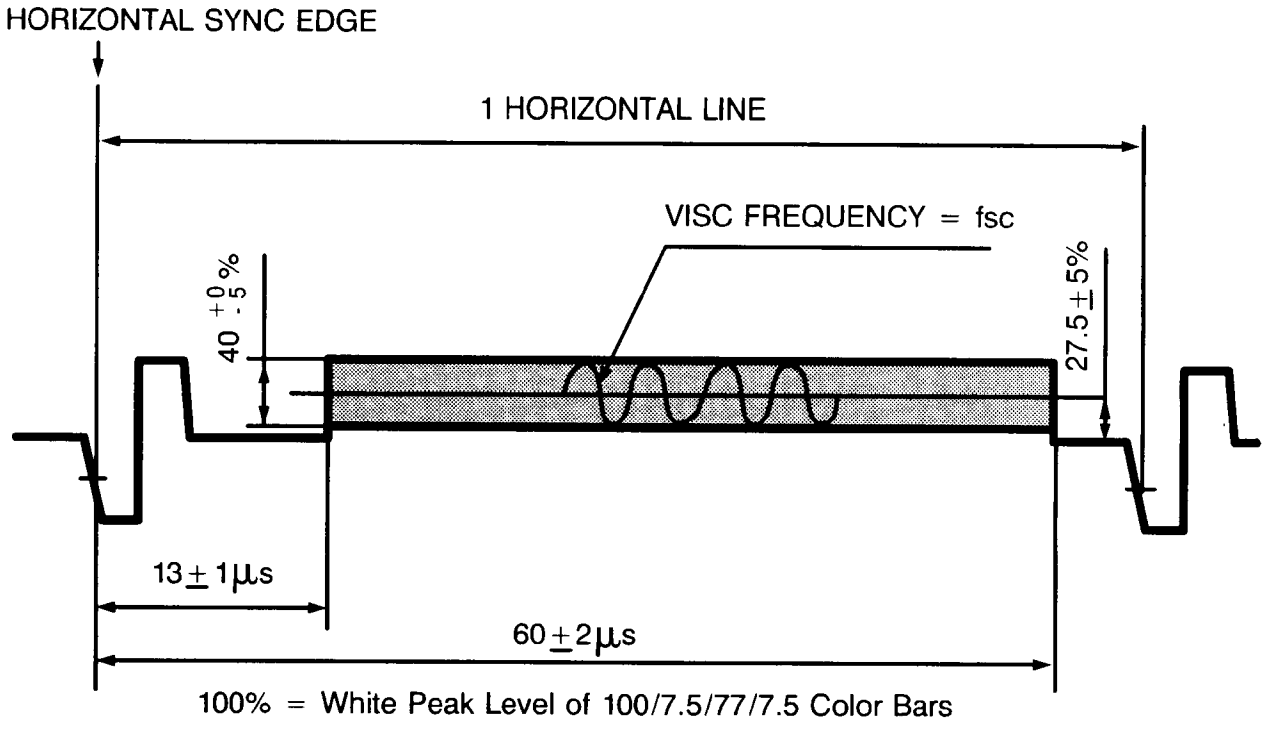


Figure 8 – Vertical interval subcarrier signal

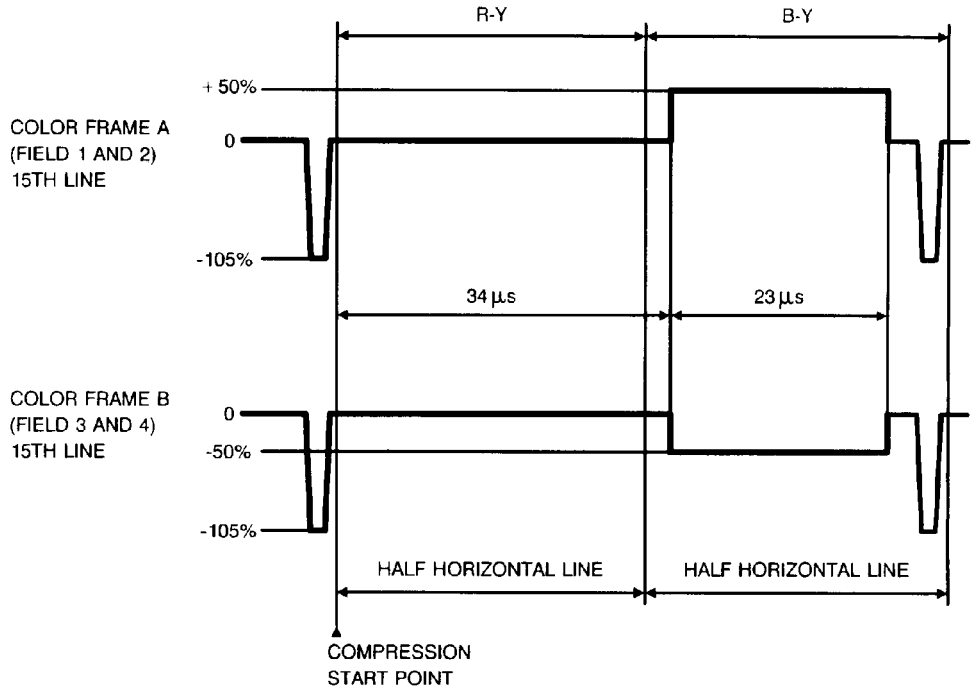


Figure 9 – Color field identification signal (525/60)

5 Longitudinal audio signal recording

5.1 Reference levels

5.1.1 Recording method

All recordings shall be made using the anhysteretic (bias) method.

5.1.2 Recording and reproducing level indicator

The audio recording and reproducing levels of the video tape recorder shall be adjusted with reference to a standard volume indicator or equivalent, as specified in ANSI/ IEEE 152.

5.1.3 Recorder reference level

When a recording is made from a sinusoidal signal having a frequency of 1000 Hz such that the rms short circuit tape flux per unit track width on the record is 85 nWb/m ± 3 nWb/m, the recording volume indicator shall be adjusted to deflect to its reference level scale mark.

5.2 Frequency response

5.2.1 Recorder flux/frequency response

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

$$L(f) = 10 \log_{10} \frac{1 + \left(\frac{F_l}{f}\right)^2}{1 + \left(\frac{f}{F_h}\right)^2} \text{ [dB]}$$

where

L is the relative tape flux level
f is the frequency at which the response is being computed
F_l is the low-frequency transition frequency (50 Hz)
F_h is the high-frequency transition frequency (4547 Hz).

5.2.2 Reproducer flux/frequency response

When a tape record having a short circuit tape flux versus frequency given in 5.2.1 is reproduced, the output voltage level versus frequency of the reproducer shall be constant.

5.2.3 Noise reduction characteristics

Noise reduction, if applied, shall have the static encoding characteristics shown in table 7.

Table 7 – Longitudinal audio frequency response of noise reduction encoding level

	Input level (dB)						
Frequency (Hz)	0	--10	--20	--30	--40	--50	--60
100	0.2	0.9	2.7	2.9	2.9	2.9	2.9
200	0.1	1.5	5.3	8.0	8.1	8.1	8.1
300	0	1.6	6.1	10.7	12.0	12.0	12.0
500	0	1.7	6.3	11.8	15.6	16.2	16.2
1k	--0.3	1.5	5.9	11.4	16.2	19.4	19.6
3k	--1.6	--0.1	3.7	9.2	13.9	19.2	20.7
5k	--2.3	--0.6	2.9	8.4	13.5	18.7	20.4
10k	--3.5	--1.4	2.6	8.2	13.6	18.1	19.2
15k	--6.3	--3.3	1.5	7.3	12.2	15.0	15.0

NOTES
1 Values are in decibels.
2 The input level of 0 dB is the reference audio input level at 1000 Hz.
3 The encode level of 0 dB is the recorded reference audio level specified in 5.1.3.

5.3 Track usage

5.3.1 Nonstereo audio

The primary program audio channel shall be recorded on the audio 1 track.

5.3.2 Stereo audio

When separate channels are used for stereo audio, the left channel shall be recorded on the audio 1 track, and the right channel on the audio 2 track.

5.4 Program audio head phasing

When the same signal is recorded on audio 1 and audio 2 tracks, the tracks shall be so phased that, when reproduced with a head wide enough to sense the recorded flux on both records, the result will be additive.

5.5 Recording polarity

When a positive-going waveform is present on pin 2 of the input connector, as defined in IEC 268-12, the audio head shall generate a magnetic flux such that the direction of remanent flux on the tape is from north to south.

6 AFM signal recording

FM audio signals can only be recorded in mode 2. Audio signals for the two channels shall be used to individually frequency modulate two carriers. The carriers shall be located in the low-frequency range and added to the frequency modulated chrominance signal.

6.1 Signal processing

A signal processing system as specified by this standard shall contain the following elements:

6.1.1 An audio noise-reduction scheme incorporating compression.

6.1.2 A linear frequency modulator having constant deviation with respect to the amplitude of the modulating frequencies.

6.1.3 A means of adding the two AFM signals to the chrominance signal in the ratio specified.

6.2 Reference levels

6.2.1 Recording and reproducing level indicator

The audio recording and reproducing levels of the video tape recorder shall be adjusted with reference to a standard volume indicator or equivalent, as specified in ANSI/IEEE 152.

6.2.2 Recorder reference level

When a recording is made from a sinusoidal signal having a frequency of 400 Hz with the reference deviation, the recording volume indicator shall be adjusted to deflect to its reference level scale mark.

6.3 Noise reduction

A noise-reduction scheme shall be employed having the following characteristics:

6.3.1 Compression ratio

The compression ratio shall be a 2:1 logarithmic scale.

6.3.2 Frequency response

The frequency response of the compressor at a reference input level shall be in accordance with table 8. (Figure 10 represents a possible implementation.)

6.3.3 Transient response

The transient response shall be:

- Attack time 18 ms ± 0.4 ms
- Recovery time 40 ms ± 8 ms
- Hold time 15 ms ± 3 ms

The dynamic characteristics of the compression are shown in figure 11.

6.4 Frequency modulation

6.4.1 Carrier frequencies

The carrier frequencies shall be as shown below.

- Left channel (CH3) 310 ± 5 kHz
- Right channel (CH4) 540 ± 5 kHz

Table 8 – Frequency response of compressor

Frequency (Hz)	50	100	200	400	700	1k	2k	4k	7k	10k	14k
Response (dB)	0	0	0	0	+0.1	+0.3	+1.2	+2.7	+4.1	+4.8	+5.3

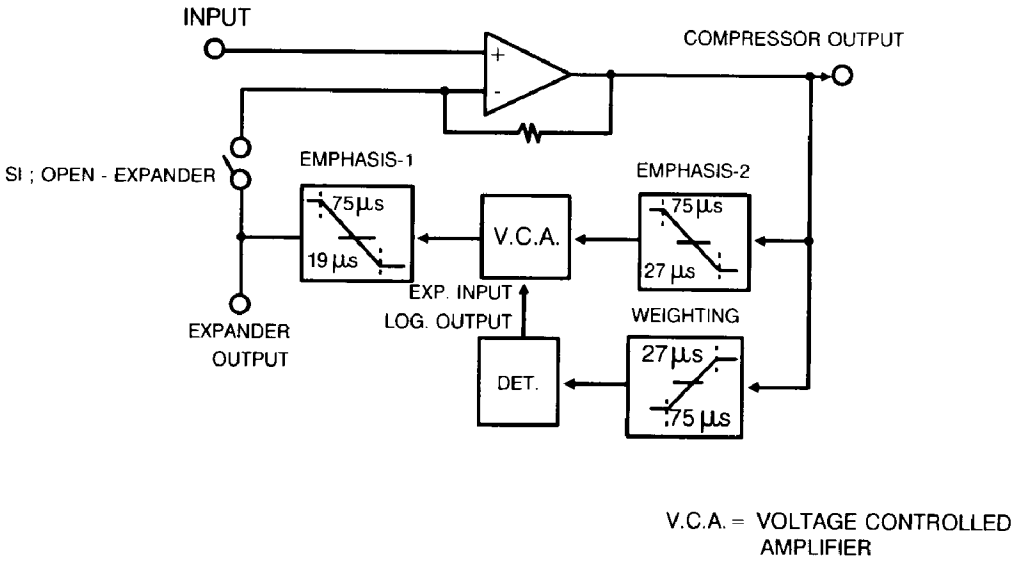


Figure 10 – AFM noise-reduction system

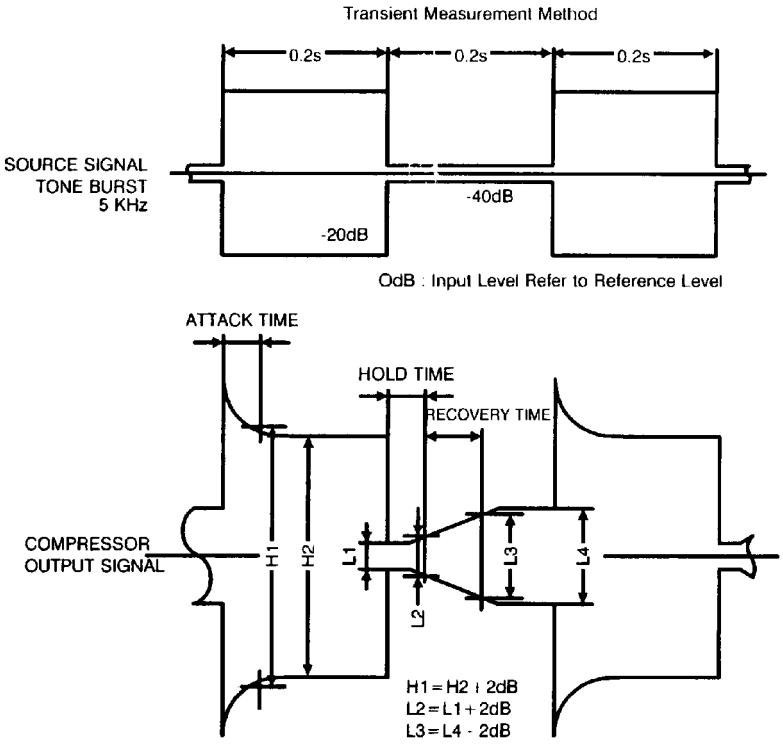


Figure 11 – AFM noise-reduction transient response characteristics

6.4.2 Frequency deviation

6.4.2.1 Reference deviation

The recording reference deviation shall be ± 25 kHz nom ± 0.75 kHz at a reference audio frequency of 400 Hz.

6.4.2.2 Maximum deviation

The maximum deviation shall not exceed ± 75 kHz.

6.5 The recording current for the two AFM carriers relative to the chrominance recording current specified in 3.3.8.1 shall be --24 dB ± 2 dB for channel 3, and --26 dB ± 2 dB for channel 4.

7 Time and control code

7.1 Designated track for time and control code

The longitudinal track identified as the time and control code track shall be used for recording the code specified in ANSI/SMPTE 12M.

7.2 Recording level

The recording level shall be at saturation of the magnetic domains which is defined as that point above which a 0.5 dB increase in output level results from a 1 dB increase of input level as indicated on an rms reading meter.

8 Tracking control

8.1 Tracking-control signal

8.1.1 The tracking-control record shall be a series of constant flux levels alternating in polarity at a field rate and completing one cycle per frame as shown in figure 12.

8.1.2 The polarity of the tracking control record flux shall be such that the transition from the south pole of the magnetic domains to the north pole of the magnetic domains points in the direction of tape travel during the vertical intervals identifying field I and the transition of the north pole of the magnetic domains to the south pole of the magnetic domains points in the direction of tape travel during the vertical intervals identifying field II.

8.2 Tracking control and video timing

Recording current transition representing video fields shall occur at 1.5 ± 1.0 lines after the negative-going transition of the first broad pulse, as shown in figure 12. The south-to-north transition shall occur in field I, identified as the field which ends with a half line of video information.

8.3 Recording level

The recording level shall be at saturation of the magnetic domains which is defined as that point above which a 0.5 dB increase in output level results from a 1 dB increase of input level as indicated on an rms reading meter.

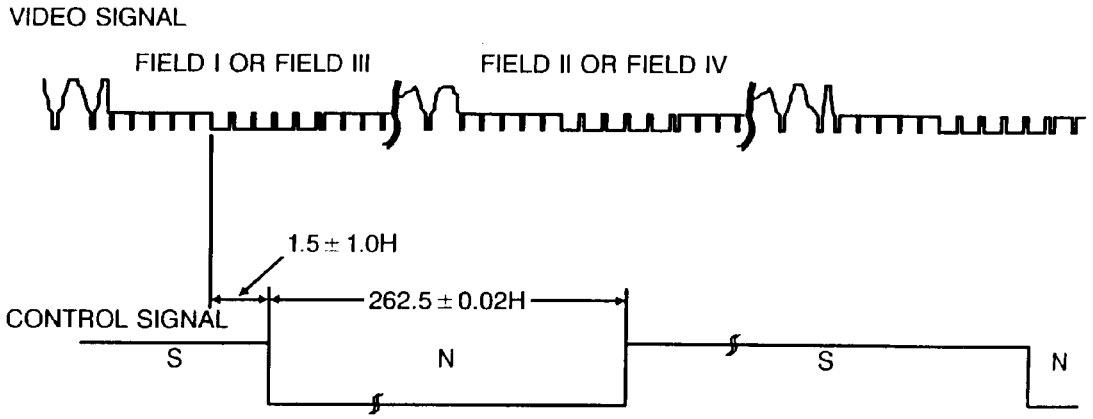


Figure 12 – Tracking-control waveform and timing

Annex A (informative)
Additional information

A.1 Manufacturers of format L compatible equipment should be aware that some equipment may produce an additional machine-generated pulse on line 1.

A.2 The offset timing, Δt, shown in figure 5 ensures signal timing interchange between early format L machines and later models.

Annex B (informative)
Bibliography

ANSI/SMPTE 35M-1991, Television Analog Recording — 1/2-in Type G — Cassette and Tape

ANSI/SMPTE 229M-1996, Television Analog Recording — 1/2-in Type L — Records