ANSI/SMPTE 253M-1998

SMPTE STANDARD

for Television — Three-Channel RGB Analog Video Interface

1 Scope

This standard defines the component analog video interface for studio applications using three primary color signals carried on parallel channels for the interconnection of television equipment. The signals carried across the interface have a typical scanning structure of 525 lines, 59.94 fields/s, 2:1 interlace, and 4:3 or 16:9 aspect ratio. The signals have a vertical blanking interval that is divided into an active line period and a horizontal blanking interval. Signal characteristics are defined by a gamma-corrected set of red, green, and blue R′G′B′ (hereafter defined as RGB) primary video signals.

In addition to general interconnection of television equipment at the RGB component analog level of operation, the signals defined by this standard are suitable as inputs to analog-to-digital conversion systems in compliance with ANSI/SMPTE 125M and ANSI/SMPTE 267M or as inputs to NTSC composite encoders in compliance with ANSI/SMPTE 170M.

The three-channel interface defined by this standard (sync on green) is the preferred implementation. Some applications may require a four-channel interface (with sync carried separately). Such an implementation is described in annex A.

2 Normative reference

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

IEC 60169-8 (1978-01), Part 8: R.F. Coaxial Connectors with Inner Diameter of Outer Conductor 6.5 mm (0.256 in) with Bayonet Lock — Characteristic Impedance 50 Ohms (Type BNC); Appendix A (1993), Information for Interface Dimensions of 75-Ohm Characteristic Impedance Connectors with Unspecified Reflection Factors; and Amendment No. 1 (1996-03)

3 Scanning

3.1 The video signal shall correspond to scanning of the image at uniform velocities from left to right and from top to bottom. This will provide 525 nominally horizontal lines where alternate lines are scanned on each vertical pass for 2:1 interlace. As a result of vertical blanking, there are 483 active picture lines which are divided into an active picture period and a horizontal blanking period.

3.2 The aspect ratio of the active picture is entirely determined by the geometry of the pickup and display devices which should be appropriately matched. Parameters specified in this standard are not affected by the operational aspect ratio. Typical aspect ratios are 4:3 and 16:9.

4 System colorimetry

4.1 The RGB signals shall be suitable for a color display device having primary colors with the following chromaticities in the CIE S002 system of specifications:

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American National Standard

Approved March 3, 1998

		x	*y*
Red	(R)	0.630	0.340
Green	(G)	0.310	0.595
Blue	(B)	0.155	0.070

NOTES

1 The display primaries with the chromaticities specified above are commonly referred to as the SMPTE C set.

2 This specification does not preclude the continued use of equipment built to the color parameters of the NTSC 1953 color television transmission standard for which the chromaticities in the CIE S002 system were specified at the values listed below. Signals produced using the original NTSC specifications will not display properly on modern display devices:

		x	*y*
Red	(R)	0.67	0.33
Green	(G)	0.21	0.71
Blue	(B)	0.14	0.08

4.2 The system reference white is an illuminant which causes equal primary signals to be produced by a reference camera and which is reproduced by a reference display device when driven by equal primary signals. For this system, the reference white is specified in terms of its CIE S002 chromaticity coordinates which have been chosen to match those of CIE S002 illuminant D_{65}:

$x = 0.3127 \qquad y = 0.3290$

4.3 The individual component amplitudes shall be equal for picture areas whose chromaticity corresponds to the system reference white.

5 Transfer characteristics

5.1 The reference reproducer for this system is representative of cathode ray tube displays, which have an inherently nonlinear electro-optical transfer characteristic (see annex B). To achieve an overall system transfer characteristic that is linear, it is necessary to specify compensating nonlinearity elsewhere in the system. This is done at the signal source. For purposes of precision, particularly in digital signal processing applications, exactly inverse characteristics are specified for the reference camera and reproducer.

The respective transfer characteristics as defined in 5.1.1 and 5.2 shall be applied to all three channels. It is recognized that operating values may vary from the precise values given in order to meet operational requirements in practical systems.

5.1.1 Electro-optical transfer characteristic of the reference camera shall be:

$$V_C = 1.099 \times L_C^{(0.4500)} - 0.099 \text{ for } 0.018 \leq L_C \leq 1$$
$$V_C = 4.500 \times L_C \text{ for } 0 \leq L_C \leq 0.018$$

where V_C is the video signal output of the reference camera normalized to the system reference white and L_C is the light input to the reference camera normalized to system reference white.

5.2 Electro-optical transfer characteristic of the reference reproducer shall be:

$$L_T = [(V_r + 0.099)/1.099]^{(1/0.4500)} \text{ for } 0.0812 \leq V_r \leq 1$$
$$L_T = 4.500 \text{ x } L_C \text{ for } 0 \leq V_r \leq 0.0812$$

where V_r is the video signal level driving the reference reproducer normalized to the system reference white and L_T is the light output from the reference reproducer normalized to system reference white.

6 RGB component set

The RGB component set, as shown in figure 1, originates as equiband and gamma-corrected (see clause 5) RGB primary signals from a picture source, such as a camera or telecine, or as synthetically generated RGB video from a character generator, graphics generator, or test signal generator. These video signals are positive going, and each shall have a maximum peak level of 700 mV from blanking level with zero setup. The green signal shall have a negative-going sync pulse of amplitude 300 mV from blanking level that conforms to the timing requirements of clause 7.

NOTES

1 Some applications may require a four-channel interface (with sync carried separately). Such an implementation is described in annex A.

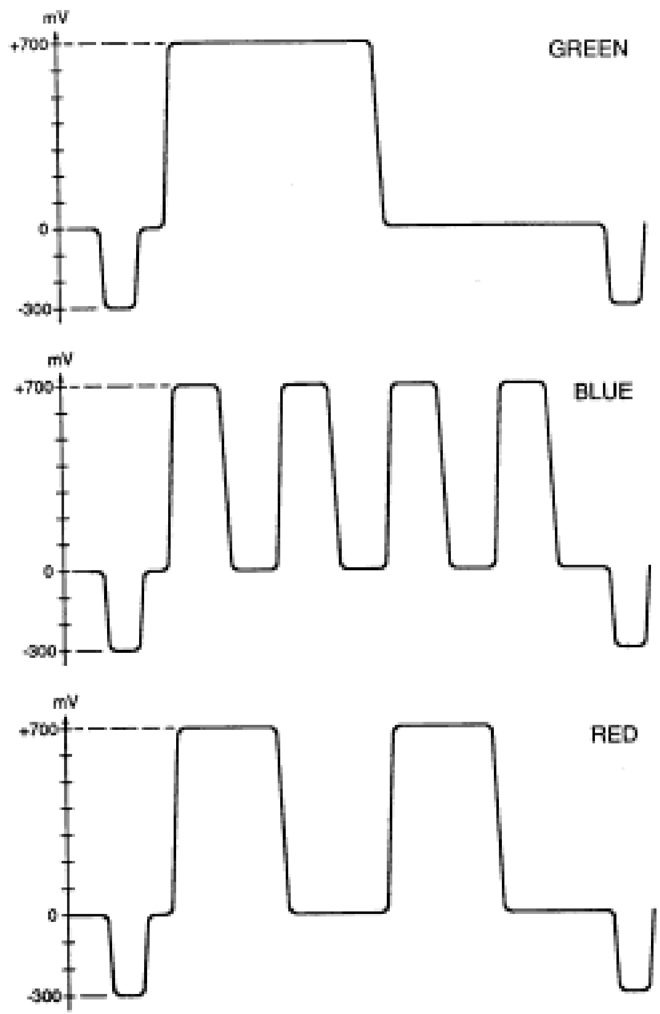

Figure 1 – RGB component set

2 Some applications may require sync on all of the three component channels. In that case, waveform specifications for the synchronizing area of the red and blue signals will be identical to those of the green signal. Such an implementation is not described further in this standard.

7 Horizontal blanking and synchronization

Each line outside the vertical blanking interval is divided into an active line period and a horizontal blanking interval. The horizontal blanking interval for the green signal contains the negative-going horizontal sync pulse. The remainder of the horizontal blanking interval is at blanking level and may be used for signal dc clamping. Horizontal timing is given in table 1 and shown in figure 2.

8 Vertical blanking and synchronization

In an interlaced raster, each television frame (one complete scanning of the picture) is divided into two fields. The fields carry every other scan line in succession with succeeding fields carrying the lines not scanned by the previous field.

Each field is divided into an active picture area and a vertical blanking interval. The vertical blanking interval for the green signal contains the vertical synchronizing information surrounded by blanking periods to properly position the vertical sync and by space allocated for special vertical interval signals (equalizing pulses) as shown in figure 3 (optional separate sync is also shown in annex A).

Table 1 – Video signal horizontal timing

	Measurement points	Value	Recommended tolerance	Units
Total line period (derived)		63.556		µs
Horizontal blanking rise time	10% – 90%	140	± 20	ns
Sync rise time	10% – 90%	140	± 20	ns
H-blanking start to H-reference	50%	1.3	± 0.1	µs
Horizontal sync	50%	4.7	± 0.1	µs
H-reference to H-blanking end	50%	9.0	+ 0.2 – 0.1	µs

NOTE – It is recognized that horizontal blanking operating values may vary from the precise values given in order to meet operational requirements in practical systems and to ensure that an encoded output signal meets that in ANSI/SMPTE 170M (M/NTSC).

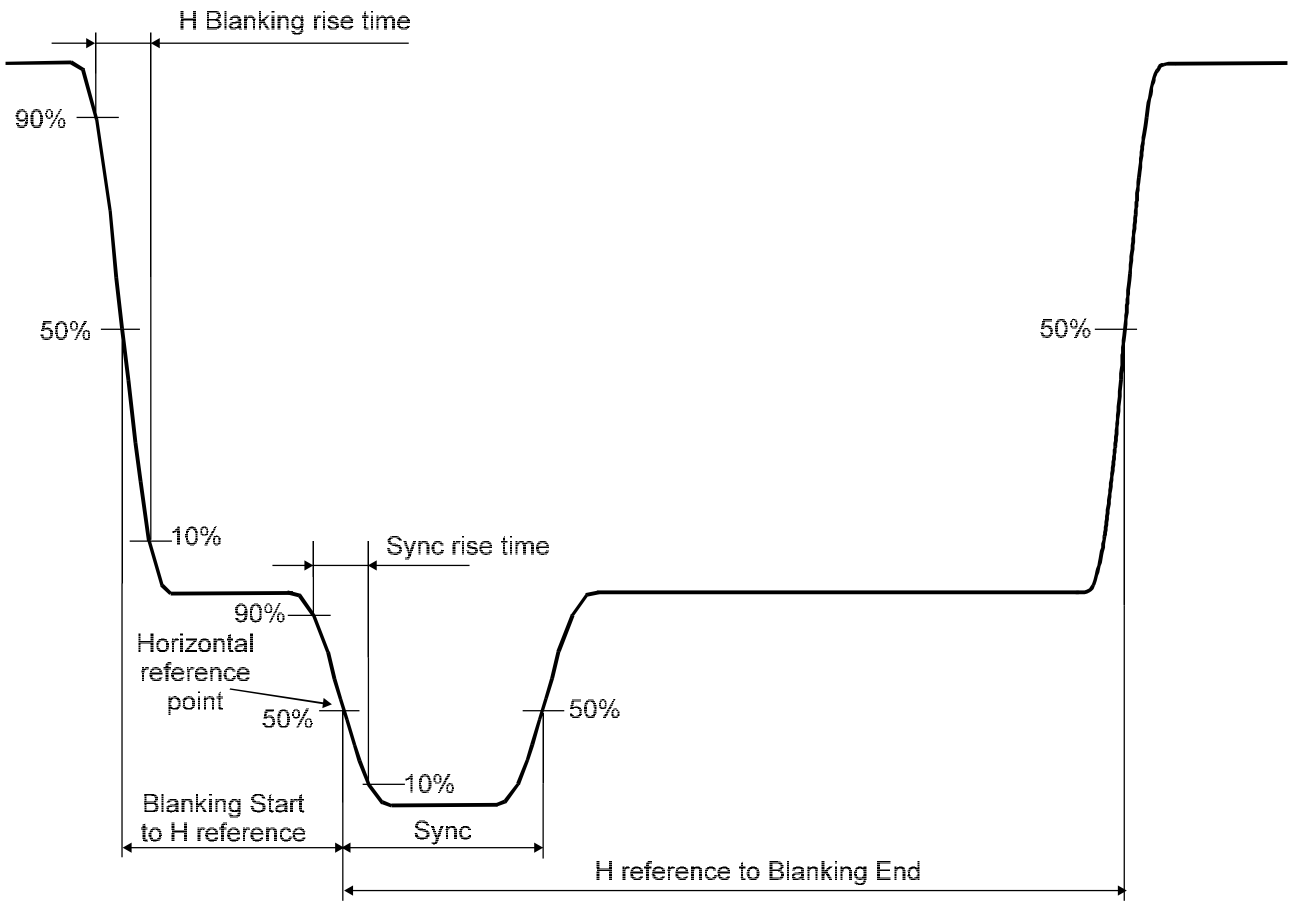

Figure 2 – Horizontal blanking interval, green signal

The vertical synchronization signal consists of a nine-line block divided into three, three line long segments. The first segment contains six preequalizing pulses. The second segment contains the vertical synchronizing pulse with six serrations provided to maintain horizontal synchronization. The third segment contains six post-equalizing pulses.

The remainder of the vertical blanking interval not used for the nine-line vertical sync block is available for special vertical interval signals. When such signals are carried on a particular line, the signals must conform to the period between horizontal blanking intervals. When such signals are not carried on a particular line, the line must be maintained at blanking level.

9 Interface characteristics

9.1 Each of the three signals shall be carried on an unbalanced coaxial cable whose nominal impedance is 75 ohms. Preferred channel numbering is Ch1 = green, Ch2 = blue, Ch3 = red.

NOTE – In color-difference systems not covered by this standard, Ch1 = luminance, Ch2 = P_B, Ch3 = P_R.

9.2 Signal sources shall have an unbalanced output circuit with a source impedance of 75 ohms and a return loss of at least 30 dB over a frequency range of 1 kHz to the maximum of the frequency range used.

9.3 Signal amplitudes shall conform to clauses 4, 5, and 6.

9.4 Any pair of signals in the set shall be time coincident with respect to each other ± 5 ns when used in a totally component system. When used as the input to an encoder, all signals shall be time coincident with respect to encoder output sync, with adjustments for encoder internal delays.

9.5 The dc offset, as defined by the blanking level of the signal, shall be 0.0 V ± 1.0 V.

9.6 The terminating impedance of a receiver signal shall be 75 ohms with a return loss of at least 30 dB over a frequency range of 1 kHz to the maximum of the frequency range used.

Table 2 – Video signal vertical timing

	Measurement points	Value	Recommended tolerance	Units
Field period (derived)		16.6833		ms
Frame period (derived)		33.3667		ms
Vertical blanking start before first equalizing pulse	50%	1.5	± 0.1	µs
Vertical blanking (63.556 µs × 20 lines + 1.5 µs) (approximate value, see notes)		20 lines[1)] plus 1.5 µs	0[1)] ± 0.1	lines µs
Preequalizing duration		3		lines
Preequalizing pulse width	50%	2.3	± 0.1	µs
Vertical sync duration		3		lines
Vertical serration pulse width	50%	4.7	± 0.1	µs
Post-equalizing duration		3		lines
Post-equalizing pulse width	50%	2.3	± 0.1	µs

NOTES

1 Some component equipment does not blank lines 20 and 282, resulting in 19-line (± 1.5 µs) vertical blanking.

2 All pulse rise and fall times, unless otherwise specified, are to be 140 ns ± 20 ns measured from 10% to 90% amplitude points. All pulses are measured at 50% amplitude points.

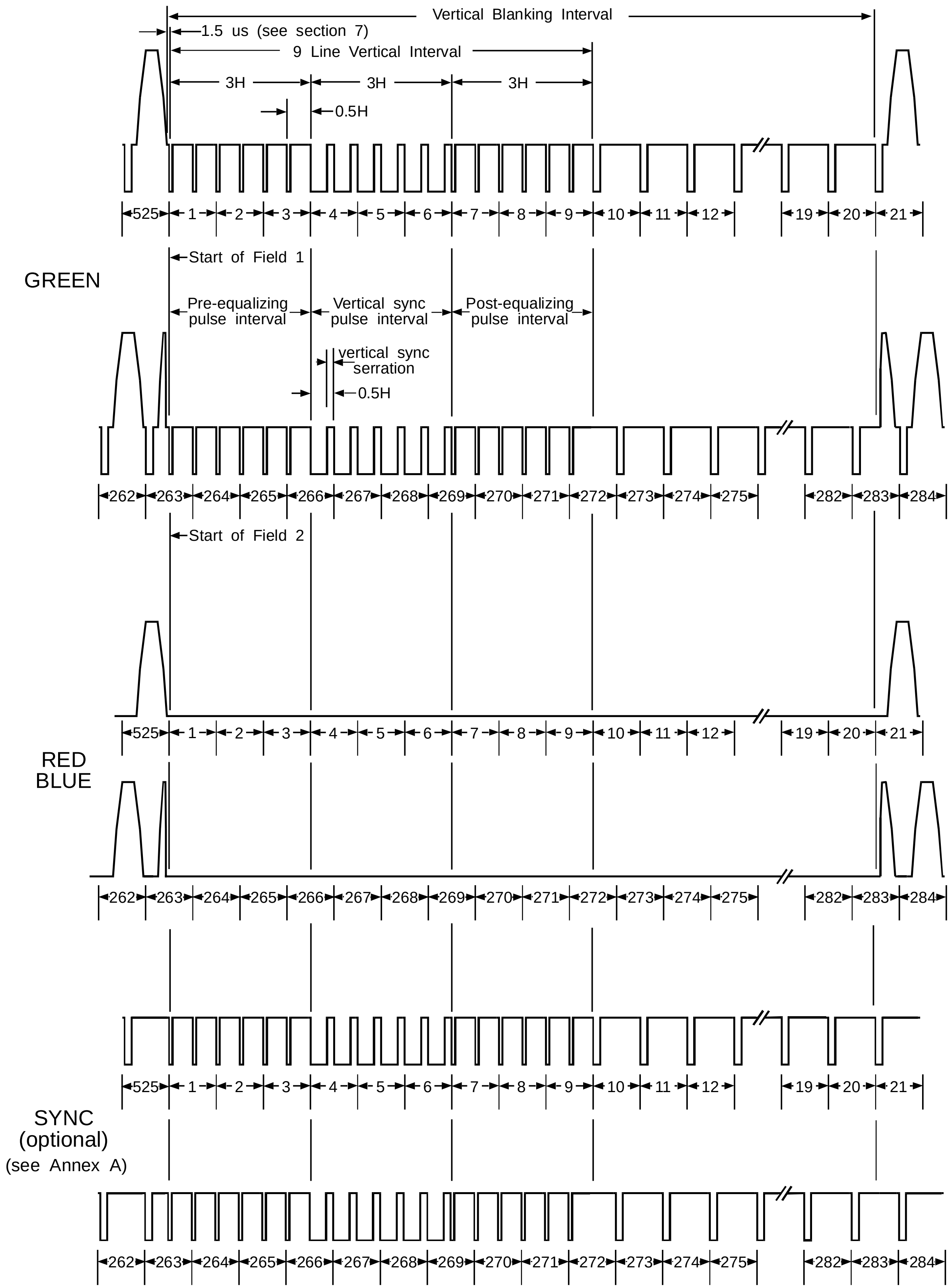

Figure 3 – Vertical blanking interval

9.7 The connector shall have mechanical characteristics conforming to the 50-ohm BNC type. Mechanical dimensions of the connector may produce either a nominal 50-ohm or nominal 75-ohm impedance. Where a 75-ohm connector is used, its mechanical characteristics must reliably interface with the nominal 50-ohm BNC type defined by IEC 60169-8.

Annex A (informative)
Implementation using four channels

In some applications, it may be necessary to implement systems using four separate channels rather than the three channels specified in the main body of this standard. Although the three-channel implementation is the preferred method, a four-channel approach is provided as defined in this annex.

In a four-channel interface, the fourth channel is used to carry the synchronizing signal. The first three channels are used to carry the RGB component signal set. These are identical to the signals used in the three-channel implementation with the exception that sync need not be added to the green signal. Although sync is not required on any of the video signals, it is not precluded, and system designers are advised to allow for the possibility that sync will appear on one or all of the video signals.

The waveform amplitude for all three video signals shall be as shown for red and blue in figure 1. Peak amplitude of the separate synchronizing signal is typically 4 V p-p (nominal) in these applications.

Annex B (informative)
Reference camera and reproducer

In clause 5, the electro-optical transfer characteristics of the reference camera and reproducer are defined. These references do not represent the transfer characteristics of real devices; rather, they are mathematical descriptions of a transfer function, the reproducer being the inverse of the camera leading to a linear system that is convenient for many analyses. Experience has shown that, for the most pleasing subjective picture quality, television systems are often adjusted to have an overall light transfer characteristic represented by a power function whose exponent is slightly greater than unity. Therefore, real reproducers will often implement a transfer function whose power function exponent is somewhat greater than the value specified in this standard.

Annex C (informative)
ANSI/SMPTE 170M (NTSC) encoders

ANSI/SMPTE 170M requires an input signal of 714 mV, not the 700 mV of this standard. However, most system M/NTSC encoders have input gain adjustments. Even if the encoder has no input gain adjustment, the resulting error from using a 700 mV input would be less than 2% (1.769...%) at the output of the ANSI/SMPTE 170M encoder.

Annex D (informative)
Bibliography

ANSI/SMPTE 125M-1995, Television — Component Video Signal 4:2:2 — Bit-Parallel Digital Interface

ANSI/SMPTE 170M-1994, Television — Composite Analog Video Signal — NTSC for Studio Applications

ANSI/SMPTE 267M-1995, Television — Bit Parallel Digital Interface — Component Video Signal 4:2:2 16x9 Aspect Ratio

SMPTE RP 177-1993 (R1997), Derivation of Basic Television Color Equations

NTSC 1953, Recommendation for Transmission Standards for Color Television

CIE S002, Colorimetric Observers

CIE Publication 15.2 (1986), Colorimetry, Second Edition