SMPTE STANDARD

for Television — Bit-Serial Digital Interface for High-Definition Television Systems

1 Scope

This standard defines a bit-serial digital coaxial and fiber-optic interface for HDTV component signals operating at data rates in the range of 1.3 Gb/s to 1.5 Gb/s. Bit-parallel data derived from a specified source format are multiplexed and serialized to form the serial data stream. A common data format and channel coding are used based on modifications, if necessary, to the source format parallel data for a given high-definition television system. Coaxial cable interfaces are suitable for application where the signal loss does not exceed an amount specified by the receiver manufacturer. Typical loss amounts would be in the range of up to 20 dB at one-half the clock frequency. Fiber optic interfaces are suitable for application at up to 2 km of distance using single-mode fiber.

Several source formats are referenced and others operating within the covered data rate range may be serialized based on the techniques defined by this standard. Revisions to this standard may add other source formats when approved documents are available.

2 Normative references

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

SMPTE 260M-1992, Television — Digital Representation and Bit-Parallel Interface —1125/60 High-Definition Production System

ANSI/SMPTE 274M-1995, Television — 1920 × 1080 Scanning and Interface

ANSI/SMPTE 291M-1996, Television — Ancillary Data Packet and Space Formatting

SMPTE RP 184-1995, Measurement of Jitter in Bit-Serial Digital Interfaces

IEC 169-8 (1978), 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), and Appendix A (1993)

IEC 793-2 (1992), Optical Fibres, Part 2: Product Specifications

IEC 874-7 (1990), Part 7: Fibre Optic Connector Type FC

3 Definition of terms

3.1 source format: Data structure and documentation which defines the bit-parallel input to the serialization process for a given high-definition television system. Source formats are referenced in SMPTE 260M and ANSI/SMPTE 274M.

3.2 interim specifications: Values given in brackets are interim and subject to revision following further investigation by the SMPTE Committee on Television Signal Technology (see 8.1.2, 8.1.9, 8.2.1, and 9.1).

4 Source format data

4.1 Source data shall be 10-bit words representing an E_Y', E_{Cb}', E_{Cr}' signal, where E_Y' is one formatted parallel data stream and E_{Cb}', E_{Cr}'

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is a second formatted parallel data stream. This limits the serial data rate to 1.5 Gb/s although the source format parallel data may allow higher data rates for RGB or Y, C_b, C_r keytype operation.

4.2 Data for each television line are divided into four areas: SAV (start of active video) timing reference, digital active line, EAV (end of active video) timing reference, and digital line blanking as shown in figure 1. The number of words and defined data in each area are specified by the source format document.

4.3 Since not all bit-parallel digital television data formats have the same timing reference data, a modification may be required prior to multiplexing and serialization in order to meet the requirements of clause 5. Where additional words are required for EAV/SAV, data words from the adjacent digital blanking area shall be used. Modifications are typically made using a coprocessor in the parallel domain.

4.4 Parameters for referenced source formats are shown in table 1.

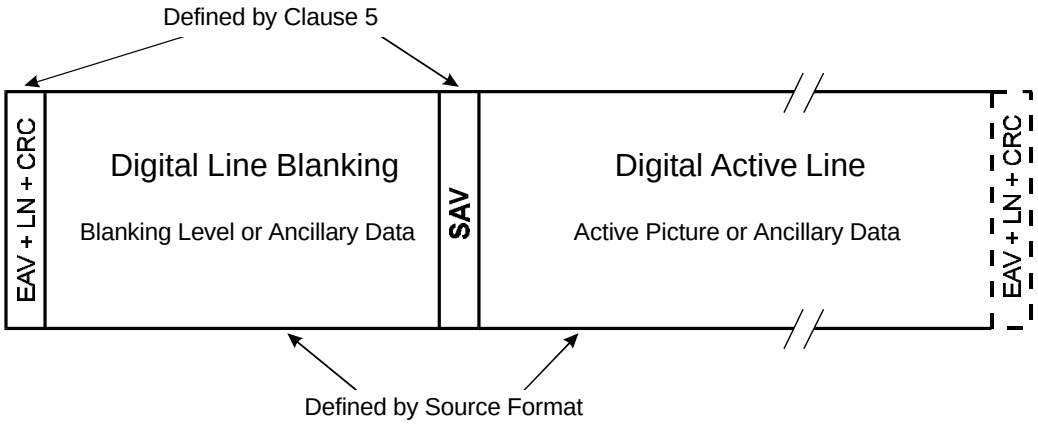


Figure 1 – Television horizontal line data

Table 1 – Referenced source format parameters

Reference document	SMPTE 260M	ANSI/SMPTE 274M	ANSI/SMPTE 274M
Parallel word rate (each channel Y C_r/C_b)	74.25 Mword/s	74.25 Mword/s	74.25/1.001 Mword/s
Lines per frame	1125	1125	1125
Words per active line (each channel Y C_r/C_b)	1920	1920	1920
Total active lines	1035	1080	1080
Words per total line (each channel Y C_r/C_b)	2200	2200	2200
Frame rate	30 Hz	30 Hz	30/1.001 Hz
Fields per frame	2	2	2
Total data rate	1.485 Gb/s	1.485 Gb/s	1.485/1.001 Gb/s
Field 1 EAV V = 1	Line 1121	Line 1124	Line 1124
Field 1 EAV V = 0	Line 41	Line 21	Line 21
Field 2 EAV V = 1	Line 558	Line 561	Line 561
Field 2 EAV V = 0	Line 603	Line 584	Line 584
EAV F = 0	Line 1	Line 1	Line 1
EAV F = 1	Line 564	Line 564	Line 564

5 Data format

5.1 Digital active line and digital line blanking consist of 10-bit words as defined by the source format document. Data values 000_h to 003_h and $3FC_h$ to $3FF_h$ are excluded.

5.2 Timing references SAV, EAV, line-number, and CRCs for each of the two parallel data streams shall be formatted as shown in figure 2 (see 4.3 regarding possible modification of source data).

5.3 Timing reference codes shall be as shown in table 2.

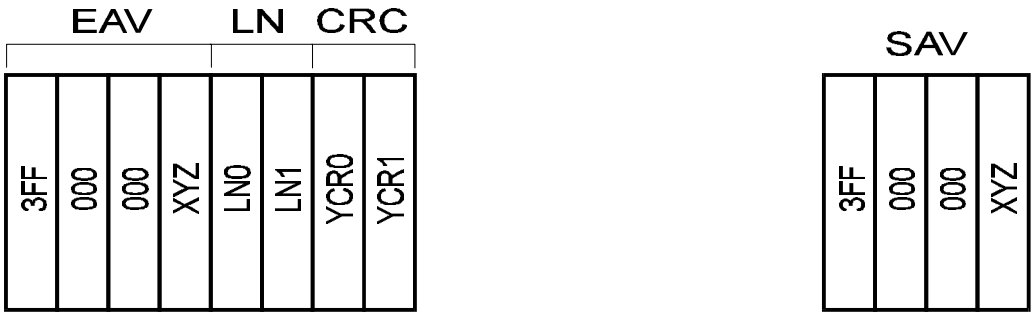


Figure 2 – Timing reference format (luminance channel shown)

Table 2 – Timing reference codes

Word	9 (MSB)	8	7	6	5	4	3	2	1	0 (LSB)
3FF	1	1	1	1	1	1	1	1	1	1
000	0	0	0	0	0	0	0	0	0	0
000	0	0	0	0	0	0	0	0	0	0
XYZ	1	F	V	H	P3	P2	P1	P0	0	0

NOTES
1 F = 0 during field 1; F = 1 during field 2.
2 V = 0 elsewhere; V = 1 during field blanking.
3 H = 0 in SAV; H = 1 in EAV.
4 MSB = most significant bit; LSB = least significant bit.
5 P0, P1, P2, P3 are protection bits defined below.

Bit	9 (MSB)	8	7	6	5	4	3	2	1	0 (LSB)
	1 Fixed	F	V	H	P3	P2	P1	P0	0 Fixed	0 Fixed
200_h	1	0	0	0	0	0	0	0	0	0
274_h	1	0	0	1	1	1	0	1	0	0
$2AC_h$	1	0	1	0	1	0	1	1	0	0
$2DB_h$	1	0	1	1	0	1	1	0	0	0
$31C_h$	1	1	0	0	0	1	1	1	0	0
368_h	1	1	0	1	1	0	1	0	0	0
380_h	1	1	1	0	1	1	0	0	0	0
$3C4_h$	1	1	1	1	0	0	0	1	0	0

5.4 Line number data are composed of two words and shall be as shown in table 3.

5.5 CRC (cyclic redundancy codes) are used to detect errors in the active digital line and the EAV. The error detection code consists of two words determined by the polynomial generator equation:

$$CRC(X) = X^{18} + X^5 + X^4 + 1$$

Initial value of the CRC is set to zero. The calculation starts at the first active line word and ends at the final word of the line number, LN1. Two CRCs are calculated, one for luminance data, YCR, and one for color difference data, CCR. CRC data shall be as shown in table 4.

5.6 Available ancillary data space is defined by the source format. The ancillary data header shall consist of the three words 000_h, $3FF_h$, $3FF_h$ with formatting of the ancillary data packet defined by ANSI/SMPTE 291M. Data values 000_h to 003_h and $3FC_h$ to $3FF_h$ are excluded from user ancillary data.

6 Serial data format

6.1 The two source format parallel data streams, with EAV and SAV constructed as defined in 5.3 through 5.5, shall be interleaved as shown in figure 3.

6.2 Interleaved data shall be serialized with the LSB (least significant bit) of each data word transmitted first.

7 Channel coding

7.1 The channel coding scheme shall be scrambled NRZI (non-return to zero inverted). (See annex A.)

7.2 The generator polynomial for the scrambled NRZ shall be $G_1(X) = X^9 + X^4 + 1$. Polarity-free scrambled NRZI sequence data shall be produced by $G_2(X) = X + 1$. The input signal to the scrambler shall be positive logic. (The highest voltage represents data 1 and the lowest voltage represents data 0).

7.3 Data word length shall be 10 bits.

Table 3 – Line number data

Word	9 (MSB)	8	7	6	5	4	3	2	1	0 (LSB)
LN0	not b8	L6	L5	L4	L3	L2	L1	L0	R	R
LN1	not b8	R	R	R	L10	L9	L8	L7	R	R

NOTES
1 L0 -- L10 = line number in binary code.
2 R = reserved, set to “0.”

Table 4 – CRC data

Word	9 (MSB)	8	7	6	5	4	3	2	1	0 (LSB)
YCR0	not b8	CRC8	CRC7	CRC6	CRC5	CRC4	CRC3	CRC2	CRC1	CRC0
YCR1	not b8	CRC17	CRC16	CRC15	CRC14	CRC13	CRC12	CRC11	CRC10	CRC9
CCR0	not b8	CRC8	CRC7	CRC6	CRC5	CRC4	CRC3	CRC2	CRC1	CRC0
CCR1	not b8	CRC17	CRC16	CRC15	CRC14	CRC13	CRC12	CRC11	CRC10	CRC9

8 Coaxial cable interface

8.1 Signal levels and specifications

These specifications are defined for measurement of the serial output of a source derived from a parallel domain signal whose timing and other characteristics meet good studio practices. Specifications at the output of equipment located at other places in an all-serial digital chain are not addressed by this standard.

8.1.1 The output of the generator shall be measured across a 75-ohm resistive load connected through a 1-m coaxial cable. Figure 4 depicts the measurement dimensions for amplitude, risetime, and overshoot.

8.1.2 The generator shall have an unbalanced output circuit with a source impedance of 75 ohms and a return loss of at least [15 dB] over a frequency range of 5 MHz to the clock frequency of the signal being transmitted.

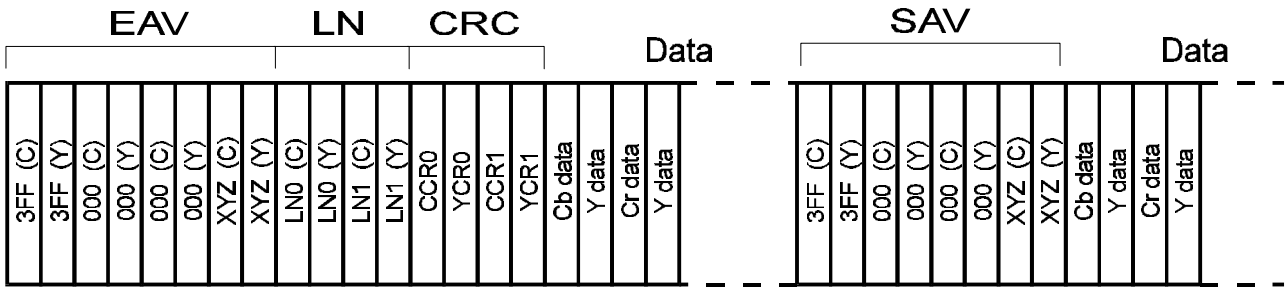


Figure 3 – Interleaved data stream

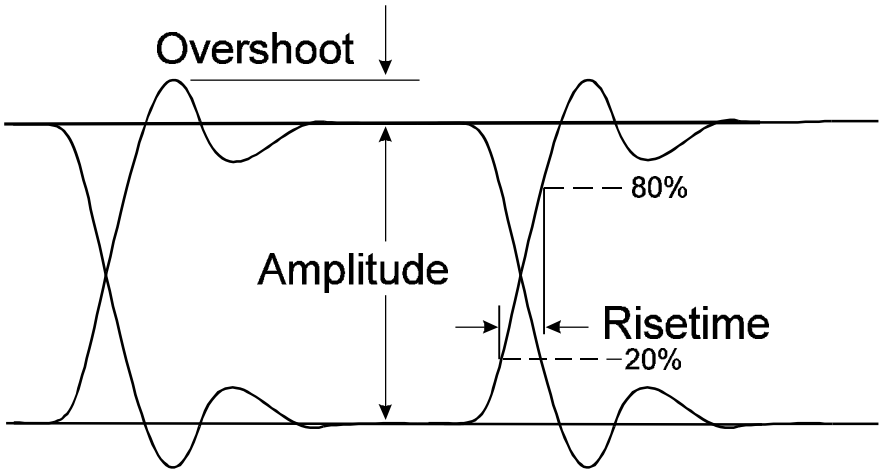


Figure 4 – Waveform measurement dimensions

8.1.3 The peak-to-peak signal amplitude shall be 800 mV ± 10% measured as specified in 8.1.1.

8.1.4 The dc offset, as defined by the mid-amplitude point of the signal, shall be nominally 0.0 V ± 0.5 V.

8.1.5 The rise and fall times, determined between the 20% and 80% amplitude points shall be no greater than 270 ps and shall not differ by more than 100 ps.

8.1.6 Overshoot of the rising and falling edges of the waveform shall not exceed 10% of the amplitude.

8.1.7 Output amplitude excursions due to signals with a significant dc component occurring for a horizontal line (pathological signals) shall not exceed 50 mV above or below the average peak-to-peak signal envelope. (In effect, this specification defines a minimum output coupling time constant.)

8.1.8 The jitter in the timing of the transitions of the data signal shall be measured in accordance with SMPTE RP 184. Measurement parameters are defined in SMPTE RP 184 and shall have the values shown in table 5 for compliance with this standard.

8.1.9 The receiver of the serial interface signal shall present an impedance of 75 ohms with a return loss of at least [15 dB] over a frequency range of 5 MHz to the clock frequency of the signal being transmitted.

8.1.10 Receivers operating with input cable losses in the range of up to 20 dB at one-half the clock frequency are nominal; however, receivers designed to work with greater or lesser signal attenuation are acceptable.

8.1.11 When connected to a line driver operating at the lower limit of voltage permitted by 8.1.3, the receiver must sense correctly the binary data in the presence of the superimposed interfering signal at the following levels:

dc	± 2.5 V
Below 5 kHz	< 2.5 V p-p
5 kHz to 27 MHz	< 100 mV p-p
Above 27 MHz	< 40 mV p-p

Table 5 – Jitter specifications

B1	10 Hz	Timing jitter lower band edge	
B2	100 kHz	Alignment jitter lower band edge	
B3	> 1/10 the clock rate	Upper band edge	
A1	1 UI	Timing jitter	(Note 1)
A2	.2 UI	Alignment jitter (UI = unit interval)	
Test signal	Color bar test signal		(Note 2)
n	≠ 10 (preferred)	Serial clock divided	(Note 3)

NOTES

1 Designers are cautioned that parallel signals conforming to interconnection standards, such as SMPTE 260M, may contain jitter up to 2 ns p-p. Direct conversion of such signals from parallel to serial could result in excessive serial signal jitter.

2 Color bars are chosen as a nonstressing test signal for jitter measurements. Use of a stressing signal with long runs of zeros may give misleading results.

3 Use of a serial clock divider value of 10 may mask word correlated jitter components.

4 See SMPTE RP 184 for definition of terms.

NOTE – Receivers intended for use in environments with minimum interfering signal levels do not need to meet the low frequency interference specifications of 8.1.11 (see annex B).

8.2 Connector and cable types

8.2.1 The connector shall have the 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 and shall be usable at frequencies up to 2.4 GHz based on a return loss of 1.5 GHz that is greater than [15 dB]. However, the electrical characteristics of the connector and its associated interface circuitry shall provide a resistive impedance of 75 ohms. Where a 75-ohm connector is used, its mechanical characteristics must reliably interface with the nominal 50-ohm BNC type defined by IEC 169-8.

8.2.2 Application of this standard does not require a particular type of coax. It is necessary for the frequency response of the coax loss, in decibels, to be approximately proportional to $1/\sqrt{f}$ from 1 MHz to the clock frequency of the signal being transmitted to ensure correct operation of automatic cable equalizers over moderate to maximum lengths.

8.2.3 Return loss of the correctly terminated transmission line shall be greater than 15 dB over a frequency range of 5 MHz to the clock frequency of the signal being transmitted.

9 Optical fiber interface

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

9.1 Source characteristics shall be as shown in table 6.

9.2 Optical fiber characteristics shall be as shown in table 7.

9.3 Receiver characteristics shall be as shown in table 8.

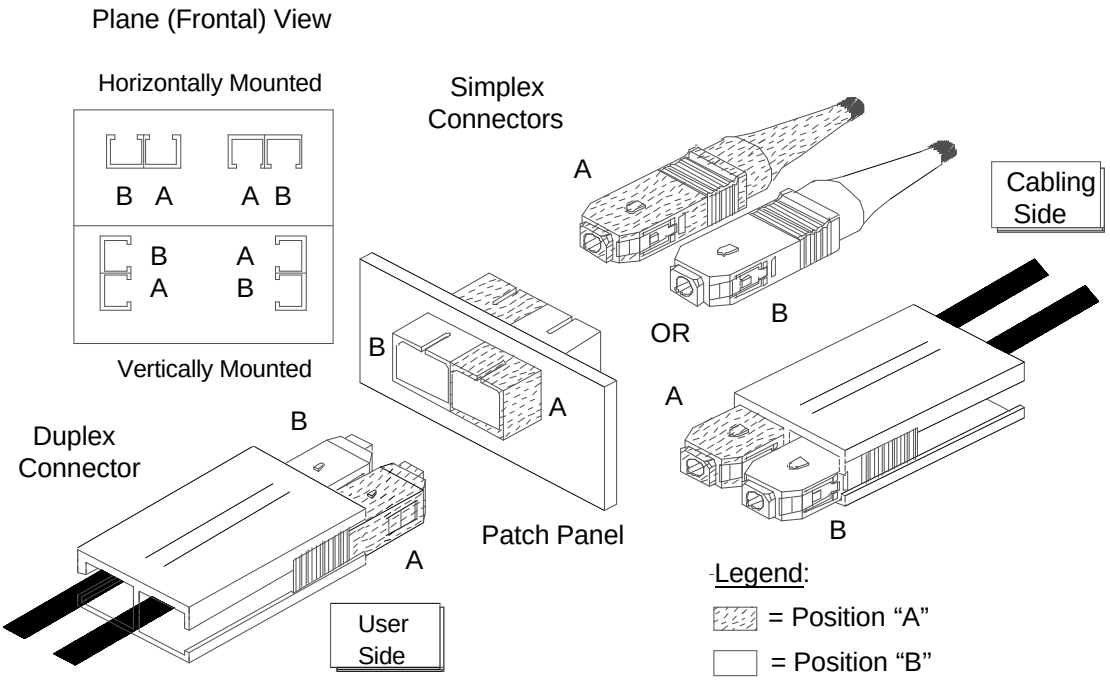
Table 6 – Optical source characteristics

Optical wavelength	1310 nm ± 40 nm
Maximum spectral line width between half-power points	10 nm
Output power maximum	-- 7.5 dBm
Output power minimum	-- 12 dBm
Rise and fall times	< 270 ps (20% to 80%)
Extinction ratio	5:1 min, 30:1 max
Jitter	[0.2 UI]
Maximum reflected power	4%

NOTES
1 Power is average power measured with an average-reading power meter.
2 Rise and fall times in the electrical domain must meet the requirements of 8.1.5.

Table 7 – Optical fiber link characteristics

Fiber type	Single mode (IEC 793-2)
Connector (see figure 5)	Type SC/PC (IEC 874-7)



NOTE--- Shading for clarification only.

Figure 5 – SC connector (patch panel shown for information only)

Table 8 – Optical receiver characteristics

Maximum input power	-- 7.5 dBm
Minimum input power	-- 20 dBm
Detector damage threshold	+ 1 dBm
Output rise and fall times	see 8.1.5
Output jitter	see 8.1.8

Annex A (informative)
Channel code

When scrambled NRZI channel coding is applied to certain video signals (informally called pathological signals), repeated long strings of 19 or 20 zeros may occur during the period of one horizontal television line. A stressing test signal (SDI checkfield, SMPTE RP 178) that produces this effect has been defined for 525- and 625-line component digital systems conforming to ANSI/SMPTE 259M. An equivalent test signal is being developed by SMPTE for the serial HDTV system defined in this standard. Additional SMPTE work is in process to recommend methods that may be used to avoid the occurrence of pathological signals in normal television operations.

Annex B (informative)
Receiver type

Receivers conforming to the specifications of 8.1.11 should be labeled “Type A.” Receivers that may not conform to the specifications of 8.1.11 should be labeled “Type B.”

Annex C (informative)
Bibliography

ANSI/SMPTE 259M-1993, Television — 10-Bit 4:2:2 Component and $4f_{sc}$ NTSC Composite Digital Signals — Serial Digital Interface

SMPTE RP 178-1996, Serial Digital Interface Checkfield for 10-Bit 4:2:2 Component and $4f_{sc}$ Composite Digital Signals