Understanding HD & 3G-SDI Video

EYE

EYE DIAGRAM

The eye diagram is constructed by overlaying portions of the sampled data stream until enough data transitions produce the familiar display. A unit interval (UI) is defined as the time between two adjacent signal transitions, which is the reciprocal of clock frequency. UI is 3.7 ns for digital component 525 / 625 (SMPTE 259M), 673.4 ps for digital high-definition (SMPTE 292) and 336.7ps for 3G-SDI serial digital (SMPTE 424M) as shown in Table 1. A serial receiver determines if the signal is "high" or "low" in the center of each eye, and detects the serial data. As noise and jitter in the signal increase through the transmission channel, the best decision point is in the center of the eye, although some receivers select a point at a fixed time after each transition point. Any effect which closes the eye may reduce the usefulness of the received signal.

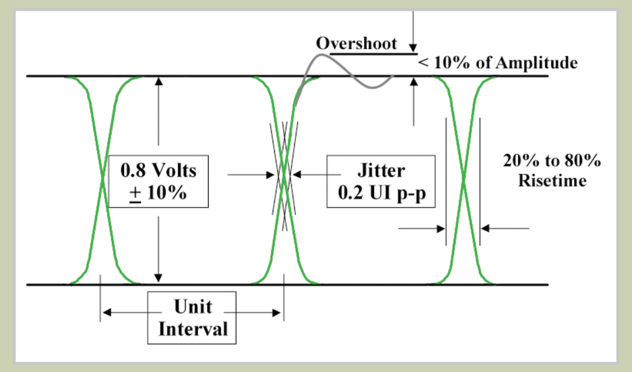
SMPTE standard 424M (3G-SDI), 292 (High Definition HD) and 259M (Standard Definition SD) defines a range of specifications for the physical layer for the eye diagram. The DC offset is defined by the mid-amplitude point of the signal and should be 0.0 V ±0.5 V. The amplitude of the signal is specified as 800 mV ±10%. Signal amplitude is important because of its relation to noise, and because the receiver estimates the required high-frequency compensation (equalization) based on the remaining half-clock-frequency energy as the signal arrives. Incorrect amplitude at the sending end could result in an incorrect equalization applied at the receiving end, thus causing signal distortions. Overshoot of the rising and falling edge should not exceed 10% of the waveform for SDI (Serial Digital Interface) formats. Overshoot could be the result of incorrect rise time, but is more likely caused by impedance discontinuities or poor return loss at the receiving or sending terminations. The rise and fall times determined between the 20% and 80% points shall be no greater than 135 ps and shall not differ by more than 50 ps for 3G-SDI, shall be no greater than 270 ps, and not differ by more than 100 ps for HD and shall be no less than 0.4ns, no greater than 1.50 ns, and shall not differ by more than 0.5 ns for SD as summarized in Table 2. Incorrect rise time could cause signal distortions such as ringing and overshoot; or, if too slow, could reduce the time available for sampling within the eye.

Unit Interval		
SD (259M)	HD (292)	3G-SDI (424M)
3.7ns	673.4ps	336.7ps

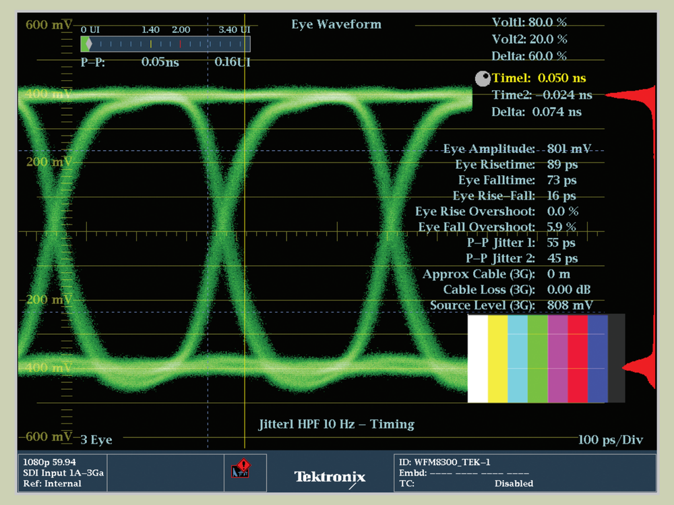
Table 1.

Rise/Fall Time		
SD (259M)	HD (292)	3G-SDI (424M)
Shall be no less than 0.4ns, no greater than 1.50ns, and shall not differby more than 0.5ns	Shall be no greater than 270ps and shall not differ by more than 100ps	Shall be no greater than 135ps and shall not differ by more than 50ps

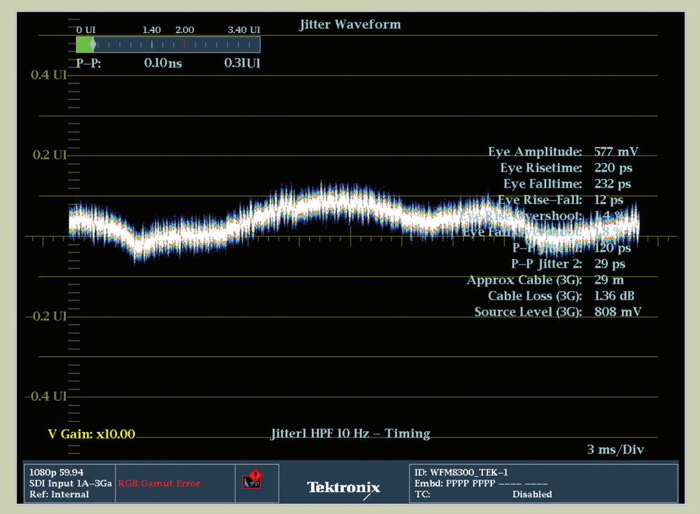
Table 2.



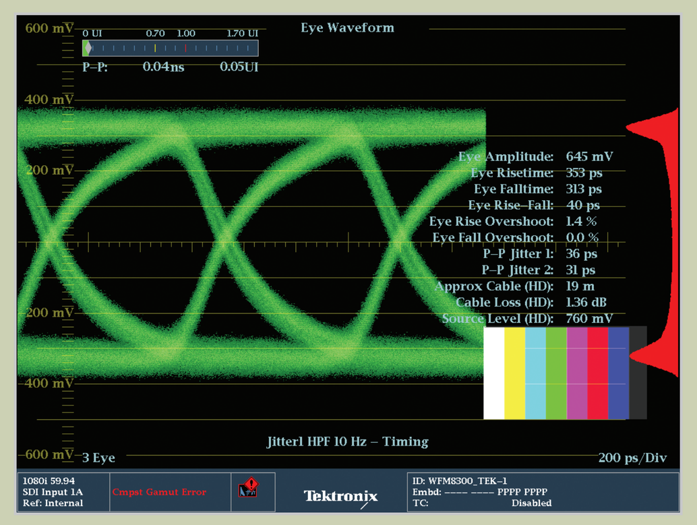
Maintaining a digital system within these specifications guarantees reliable transmission of this signal. Digital systems will work outside this specification, but will fail at some point. It is difficult to determine the failure point, so it is critical to maintain the health of the physical layer to prevent the system from falling off the digital cliff.



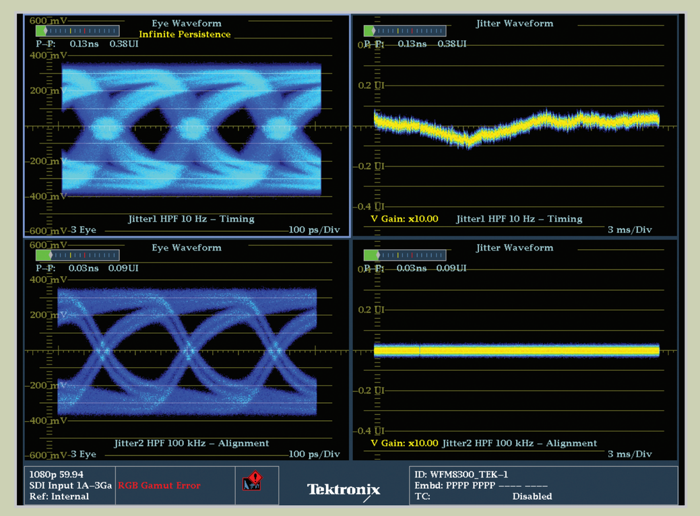
The 3G-SDI eye diagram is displayed on the WFM8300 with option PHY and shows a 3G-SDI signal connected on a short cable from the TG700 using the HD3G7 to generate a color bar signal. Amplitude cursors can be used to measure the amplitude of the signal that should be within ±10% of 800 mV (720 mV to 880 mV). Timing cursors can be used to measure the jitter of the signal. For simplicity a jitter bar measurement is made giving a direct readout of jitter. The PHY option also allows automatic measurement readouts of the physical layer parameters either in the SDI Status display or when the Eye display is in full mode. When making these measurements, a short piece of high-quality cable should be used between the device-under-test and the measurement instrument. A non stressing signal should be generated from the device such as 75% or 100% color bars.



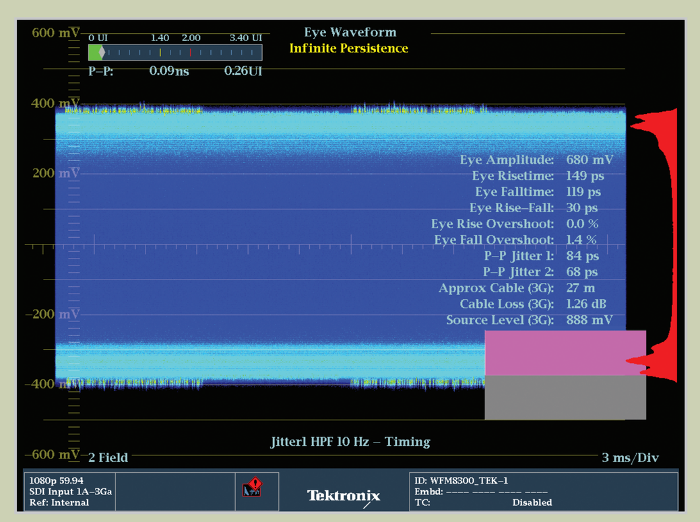
The WFM8300 PHY option jitter display can be used to show jitter variations based on the line or field. In this case, timing jitter across two fields has been selected with a 10 Hz high pass filter being used. The jitter display shows a measurement of 0.31UI (0.10ns) that is still within the specification of 1.0 UI. Further degradation of the signal along the transmission path could cause equipment to fall of the edge of the digital "cliff." By viewing the jitter display in two field mode it is easier to see jitter variation across each video field.



The WFM8300 can also be used to measure the HD and SD eye display if the PHY options is installed. Similar measurement characteristics are used for both SD and HD. This HD-SDI signal is being sent over a short cable run of approximately 19 meters. The longer the length of cable the amplitude of the signal will decrease as in this case. Note also how the longer length of cable affects the frequency response of the signal and produces an increase to rise and fall time of the transitions.



Using the FlexVu display of the WFM8300 the instrument can be configured to show a variety of physical layer parameters at a glance. In this case multiple eye and jitter displays are shown with Timing and Alignment filters selected. The top two tiles have the timing (10Hz) filter selected and the lower two tiles have the alignment filter selected (100kHz for HD and 3G-SDI). In this case the signal is within the specification of SMPTE 424M with less than 1.0UI of timing jitter and less than the preferred 0.2UI of alignment jitter for the 3G-SDI signal. The pseudo color display of the waveform traces helps to identify those parts of the trace that are occurring more frequently. Infinite persistence mode has been turned on in tile one to show the maximum variation of the eye pattern. Infinite persistence mode can be enabled from the Display menu.



An eye display in field mode shows the DC offset inserted into the signal path by the SDI Check Field test signal. WFM8300 shows the DC glitches in the first part of the SDI checkfield. Note Infinite persistence mode is turned on to aid in viewing these glitches within the display.

SMPTE recommended practice RP184 has a set of definitions and measurement procedures for the measurement of jitter. SMPTE 424M, 292 and 259M defines a set of frequency limits based on this recommended practice.

f1 = 10 Hz = Timing jitter lower band edge
f3 = 1 kHz = Alignment jitter lower band edge for SD
f3 = 100 kHz = Alignment jitter lower band edge for HD & 3G-SDI
f4 > 1/10 the clock rate = Upper band edge

Jitter is defined as the variation of a digital signal's significant instants (such as transition points) from their ideal positions in time. Jitter can cause the recovered clock and the data to become momentarily misaligned in time. Data may be misinterpreted (latched at the wrong time) if this misalignment becomes great enough.

Timing jitter is defined as the variation in time of the significant instances (such as zero crossings) of a digital signal relative to a jitter-free clock above some low frequency typically 10 Hz). It is preferable to use the original reference clock, but it is not usually available, so a heavily averaged oscillator in the measurement instrument can be used (Table 3).

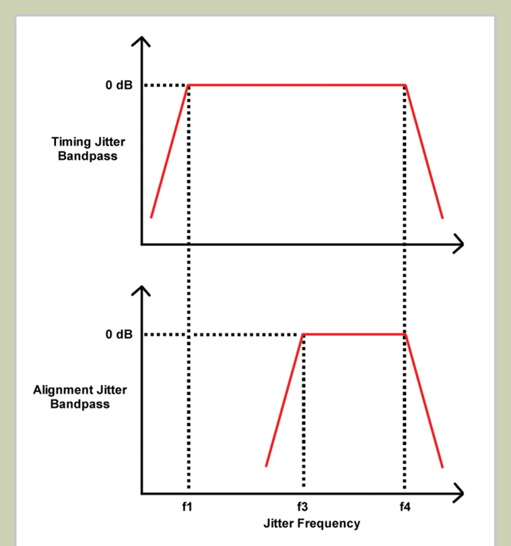
Alignment jitter, or relative jitter, is defined as the variation in time of the significant instants (such as zero crossings) of a digital signal relative to a hypothetical clock recovered from the signal itself. This recovered clock will track in the signal up to its upper clock recovery bandwidth, typically 1 kHz to 100 kHz. Measured alignment jitter includes those terms above this frequency. Alignment jitter shows signal-to-latch clock timing margin degradation (Table 4).

Timing Jitter (10 Hz)		
SD	HD	3G-SDI
0.2UI (740 ps)	1.0UI (673.4 ps @ 1.485 Gb/s) (674 ps @ 1.4835 Gb/s)	2.0UI 673.4 ps @ 2.97 Gb/s (674 ps @ 2.967 Gb/s)

Table 3.

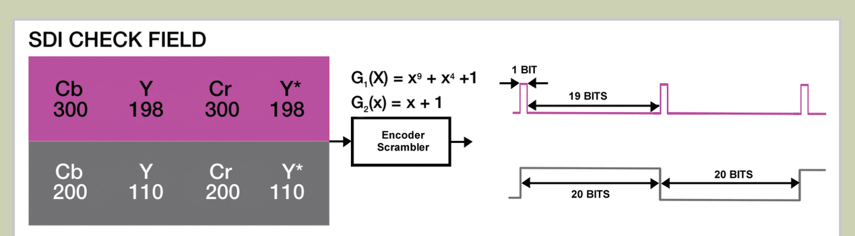
Alignment Jitter		
SD	HD	3G-SDI
0.2UI (740 ps) @ 1 kHz	0.2UI (135 ps) @ 100 kHz	0.3UI (101 ps) @ 100 kHz Maximum Preferred 0.2UI (67.3 ps) @ 100 kHz

Table 4.



SDI CHECK FIELD

The SDI Check Field (also known as a "pathological signal") is a full-field test signal and therefore must be performed out-of-service. It is specified to have a maximum amount of low-frequency energy, after scrambling, in two separate parts of the field. Statistically, this low-frequency energy occurs about once per frame. One component, the equalizer test, operates by generating a sequence of 19 0's followed by a 1 (or 19 1's followed by one 0). This occurs about once per field as the scrambler attains the required starting condition, and when it occurs it will persist for the full line and terminate with the EAV packet. This sequence produces a high DC component that stresses the analog capabilities of the equipment and transmission system handling the signal. The other part of the signal is designed to check phase-locked loop performance with an occasional signal consisting of 20 0's followed by 20 1's. This provides a minimum number of zero crossings for clock extraction. This part of the test signal may appear at the bottom of the picture display as a shade of gray, with luma set to 110_h and both chroma channels set to 200_h. If the SDI-check field fails to be transmitted successfully then tearing of the picture will be observed on a display.



DIGITAL SIGNAL

Digital video synchronization is provided by End of Active Video (EAV) and Start of Active Video (SAV) sequences which start with a unique three word pattern: $3FF_h$ (all bits in the word set to 1), 000_h (all 0's), 000_h (all 0's), followed by a fourth "XYZ" word whose format is described in Table 5.

In HD, both the luma and chroma signals have an EAV and SAV sequence that is multiplexed to form a twenty-bit word. The wide variety of HD formats have additional code words added to the EAV sequence. Code words LN0 and LN1 (Table 6) indicate the current line number of the HD format, while CR0 and CR1 (Table 7) represent a cyclic redundancy code (CRC) of each HD line. These code words are added to both the luma and chroma components after EAV.

Bit Number	9(MSB)	8	7	6	5	4	3	2	1	0(LSB)
Function	Fixed(1)	F	V	H	P3	P2	P1	P0	Fixed(0)	Fixed(0)

Table 5, Format of EAV/SAV "XYZ" word

Word	9 (MSB)	8	7	6	5	4	3	2	1	0(LSB)
LN0	Not B8	L6	L5	L4	L3	L2	L1	L0	R(0)	R(0)
LN1	Not B8	R(0)	R(0)	R(0)	L10	L9	L8	L7	R(0)	R(0)

Table 6, Bit distribution of line number words in high-definition formats

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

Table 7, Bit distribution of words making up luma and chroma CRCs in high-definition formats

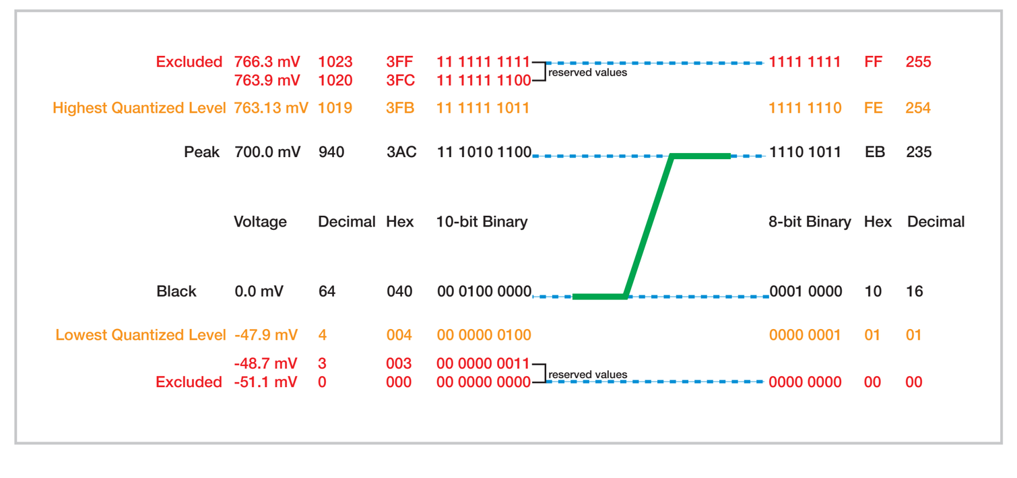
Y', R'-Y', B'-Y', COMMONLY USED FOR ANALOG COMPONENT ANALOG VIDEO		
Format	1125/60/2:1 750/60/1:1	525/59.94/2:1, 625/50/2:1, 1250/50/2:1
Y'	0.2126 R' + 0.7152 G' + 0.0722 B'	0.299 R' + 0.587 G' + 0.114 B'
R'-Y'	0.7874 R' - 0.7152 G' - 0.0722 B'	0.701 R' - 0.587 G' - 0.114 B'
B'-Y'	-0.2126 R' - 0.7152 G' + 0.9278 B'	-0.299 R' - 0.587 G' + 0.886 B'

Y', P'B, P'R ANALOG COMPONENT			
Format	1125/60/2:1 (SMPTE 240M)	1920x1080 (SMPTE 274M) 1280x720 (SMPTE 296M)	525/59.94/2:1 (SMPTE 125), 625/50/2:1 (ITU-R BT.601), 1250/50/2:1 (ITU-R BT.709)
Y'	0.212R' +0.701G' +0.087B'	0.2126R'+ 0.7152G'+ 0.0722B'	0.299R'+0.587G'+0.114B'
P'b	(B'-Y')/1.826	[0.5/(1-0.0722)](B'-Y')	0.564(B'-Y')
P'r	(R'-Y')/1.576	[0.5/(1-0.2126)](R'-Y')	0.713(R'-Y')

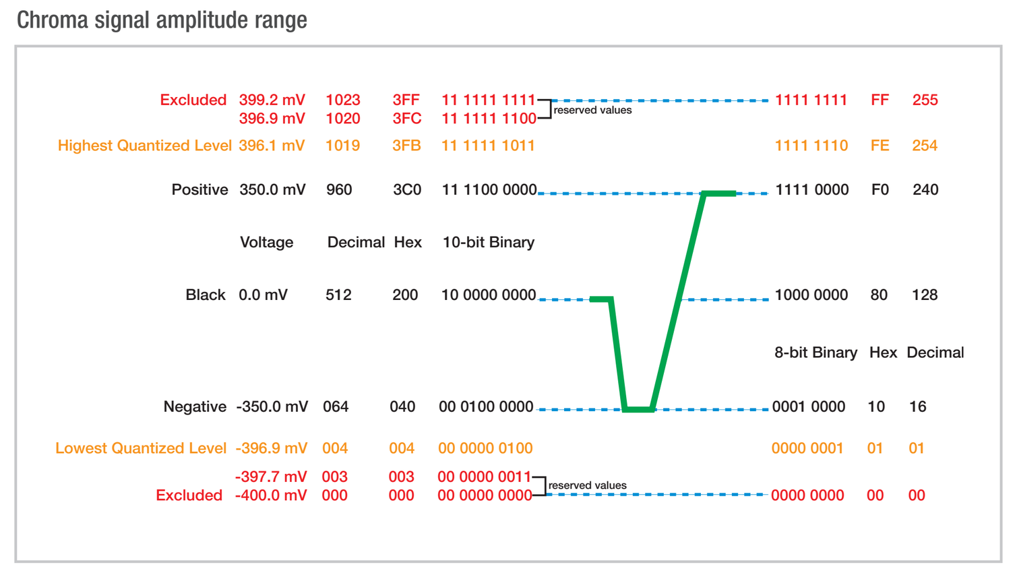
Y', C'B, C'R, SCALED AND OFFSET FOR DIGITAL QUANTIZATION		
Format	1920x1080 (SMPTE 274M) 1280x720 (SMPTE 296M)	525/59.94/2:1 (SMPTE 125), 625/50/2:1 (ITU-R BT.601), 1250/50/2:1 (ITU-R BT.709)
Y'	0.2126 R' + 0.7152 G' + 0.0722 B'	0.299 R' + 0.587 G' + 0.114 B'
C'b	0.5389 (B'-Y') + 350 mV	0.564 (B'-Y') + 350 mV
C'r	0.6350 (R'-Y') +350 mV	0.713 (R'-Y') + 350 mV

Table 8, Luma and chroma video components
The tables show the equations for converting R'G'B' to luma and color difference components.

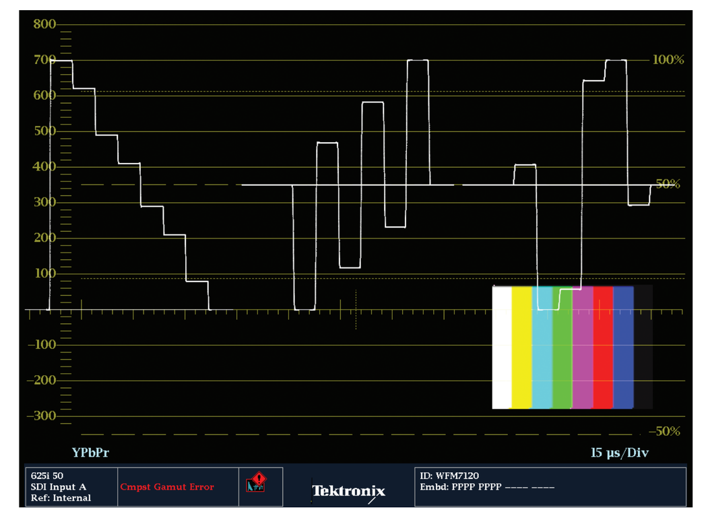
Luma signal amplitude range



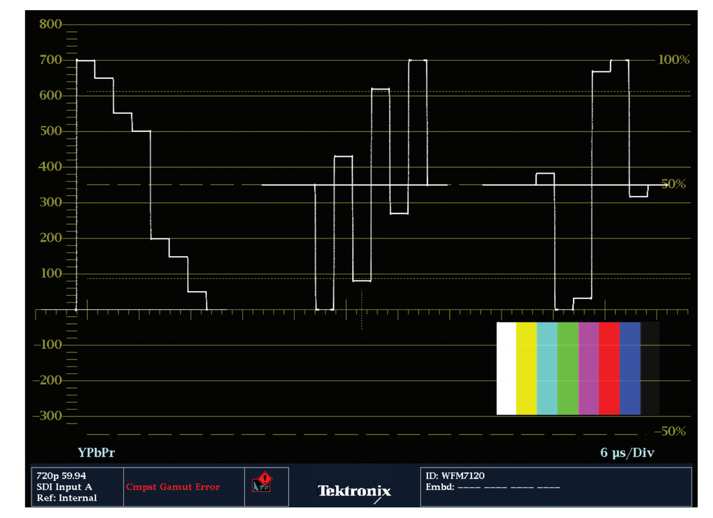
Chroma signal amplitude range



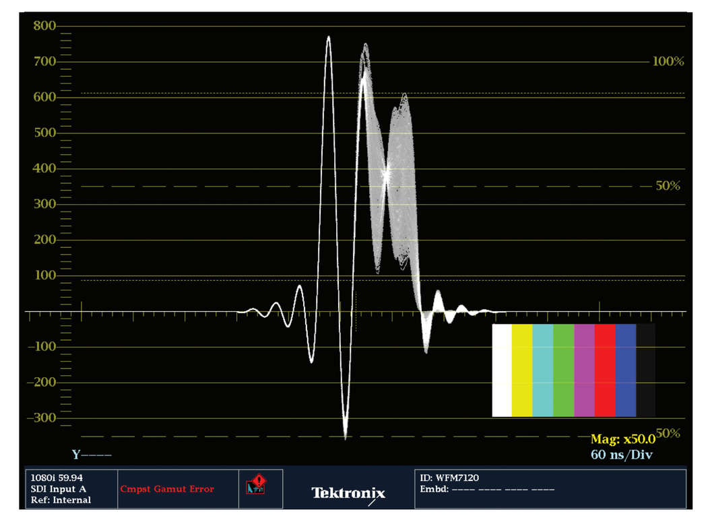
The SD and HD formats define digital values that represent their analog amplitudes for both 8-bit and 10-bit formats. The values of 00_h (8-bit) and FF_h (8-bit) are excluded values and, for compatibility, the values of $3FF_h$ (10-bit), $3FE_h$ (10-bit), $3FD_h$ (10-bit), $3FC_h$ (10-bit), 000_h (10-bit), 001_h (10-bit), 002_h (10-bit), 003_h (10-bit) are also excluded. The dynamic range of the color difference signal is greater than the luma signal.



The paraded waveform display shows a standard definition 625i 50 Hz serial digital signal with a 100 percent color bars signal. Note the differences between this waveform and the HD waveform (shown to the right). The different equations used for 525/625 compared to HD give rise to the amplitude changes with each of the component signals as described in Table 8.

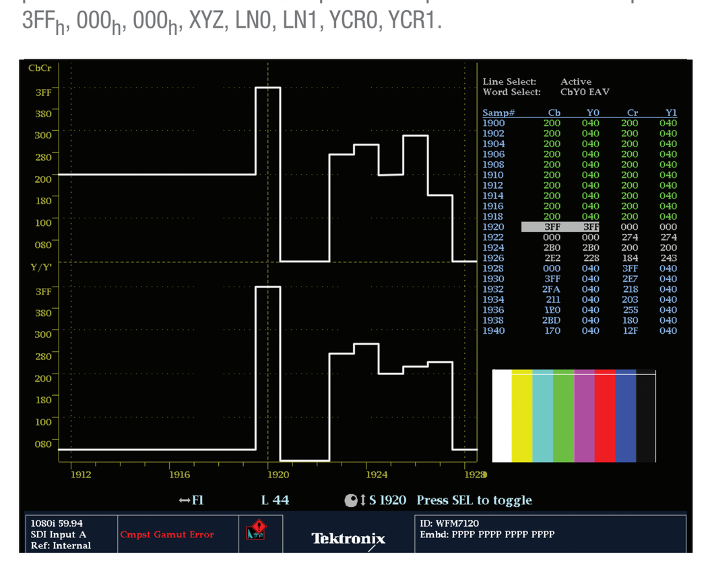


Here, a paraded waveform display shows a HD 720p 59.94 Hz serial digital signal with a 100 percent color bars signal applied to the input. This format uses colorimetry based on the specifications of ITU-R BT.709 and is defined by equations in Table 8. The amplitude of the luma signal and color difference signals are different than for typical SD signals. The green-to-magenta transition of the luma signal is significantly different.

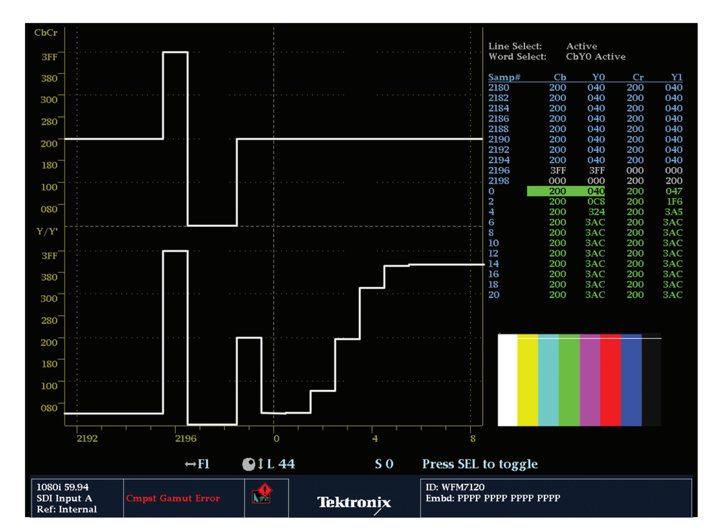


On the waveform monitor, select PASS EAV-SAV to view the values on the waveform display. The transition from 000_h to $3FF_h$ or XYZ produces ringing on the display when passed through the digital to analog filters. The luma (Y') channel is selected on the waveform monitor and is positioned to show the HD EAV pulse. This pulse contains the sequence $3FF_h$, 000_h, 000_h, XYZ, LN0, LN1, YCR0, YCR1.

The HD SAV pulse is simpler than the HD EAV pulse, containing only the code words $3FF_h$, 000_h, 000_h, XYZ. In HD formats, luma and chroma contain EAV and SAV sequences.



Data mode has been selected on the WFM7120 waveform monitor. The luma signal is displayed on the left side and the data structure of the SDI signal is shown on the right. In this case, a 1080i 59.94 Hz signal has been applied to the instrument and positioned so the hexadecimal values of the EAV signal are displayed.



The waveform monitor is set up to show the simpler SAV data from the same signal. The "XYZ" word is 200_h. This is broken down into F=0, V=0 & H=0, indicating Field 1, Active Video, and SAV, as shown in Table 9.

The "XYZ" word is a ten-bit word with the two least significant bits set to zero, allowing translation to and from an eight-bit system. Bits of the "XYZ" word have the following functions:

- Bit 9 – (Fixed bit) always fixed at 1
- Bit 8 – (F-bit) always 0 in a progressive scan system; 0 for field one and 1 for field two in an interlaced or segmented frame system.
- Bit 7 – (V-bit) 1 in vertical blanking interval; 0 during active video lines
- Bit 6 – (H-bit) 1 indicates the End of Active Video (EAV) sequence; 0 indicates the Start of Active Video (SAV) sequence
- Bits 5, 4, 3, 2 – (Protection bits) provide a limited error correction of the data in the F, V, and H bits
- Bits 1, 0 (Fixed bits) set to 0 to have identical word values in 10-bit or 8-bit systems

1125(1080), 750(720), 525 & 625 FORMAT, "XYZ" WORDS

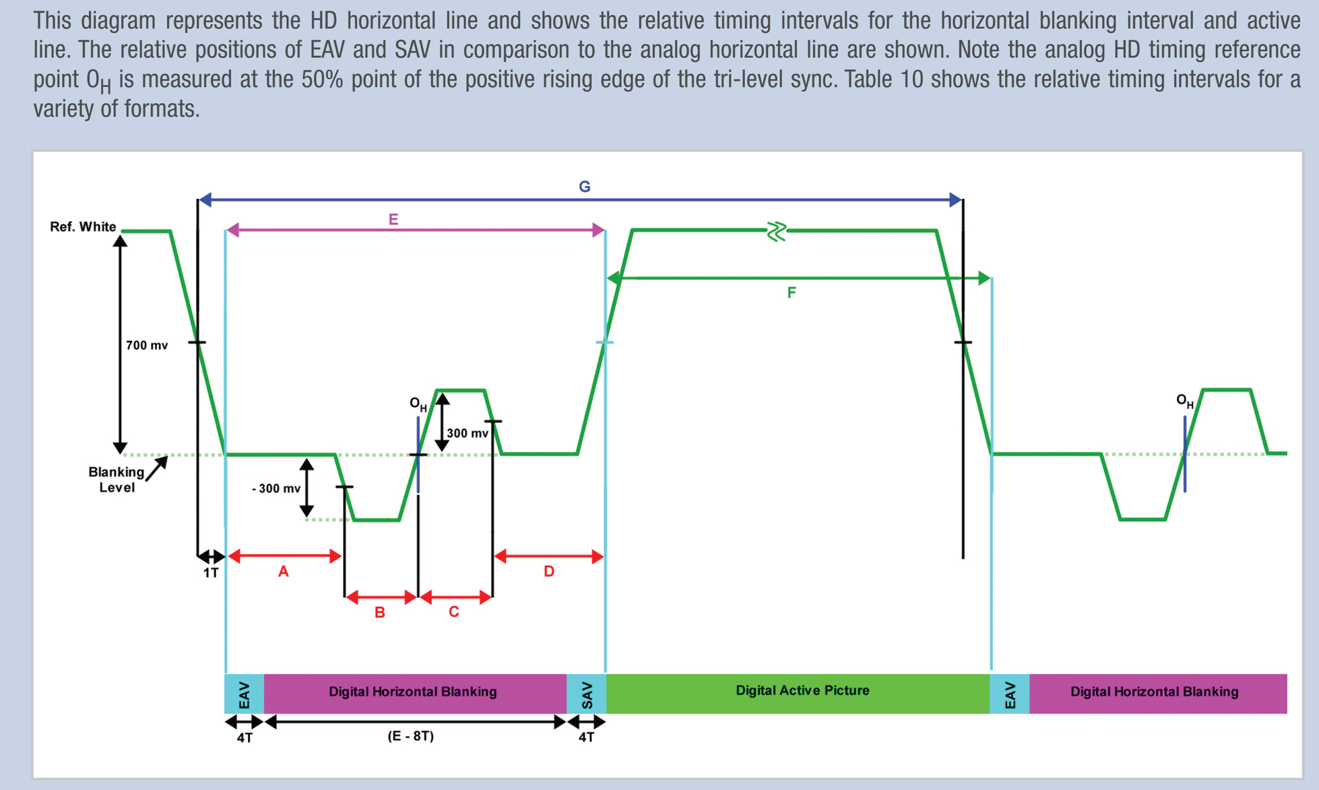
	Field	525 Line	625 Line	1080p Line	1080i Line	1035i Line	720p Line	SAV (hex)	EAV (hex)	9	F	V	H	P3	P2	P1	P0	1	0
Active Video	1	20-263	23-310	42-1121	21-560	41-557	26-745	200_h		1	0	0	0	0	0	0	0	0	0
									274_h	1	0	0	1	1	1	0	1	0	0
Field Blanking	1	4-19 264-265	1-22 311-312	1-41 1122-1125	1-20 561-563	1-40 558-563	1-25 746-750	$2AC_h$		1	0	1	0	1	0	1	1	0	0
									$2D8_h$	1	0	1	1	0	1	1	0	0	0
Active Video	2	283-525	336-623	–	584-1123	603-1120	–	$31C_h$		1	1	0	0	0	1	1	1	0	0
									368_h	1	1	0	1	1	0	1	0	0	0
Field Blanking	2	1-3 266-282	624-625 313-335	–	1124-1125 564-583	1121-1125 564-602	–	$3B0_h$		1	1	1	0	1	1	0	0	0	0
									$3C4_h$	1	1	1	1	0	0	0	1	0	0

Table 9, Format of "XYZ" word for various HD and SD standards

TIMING

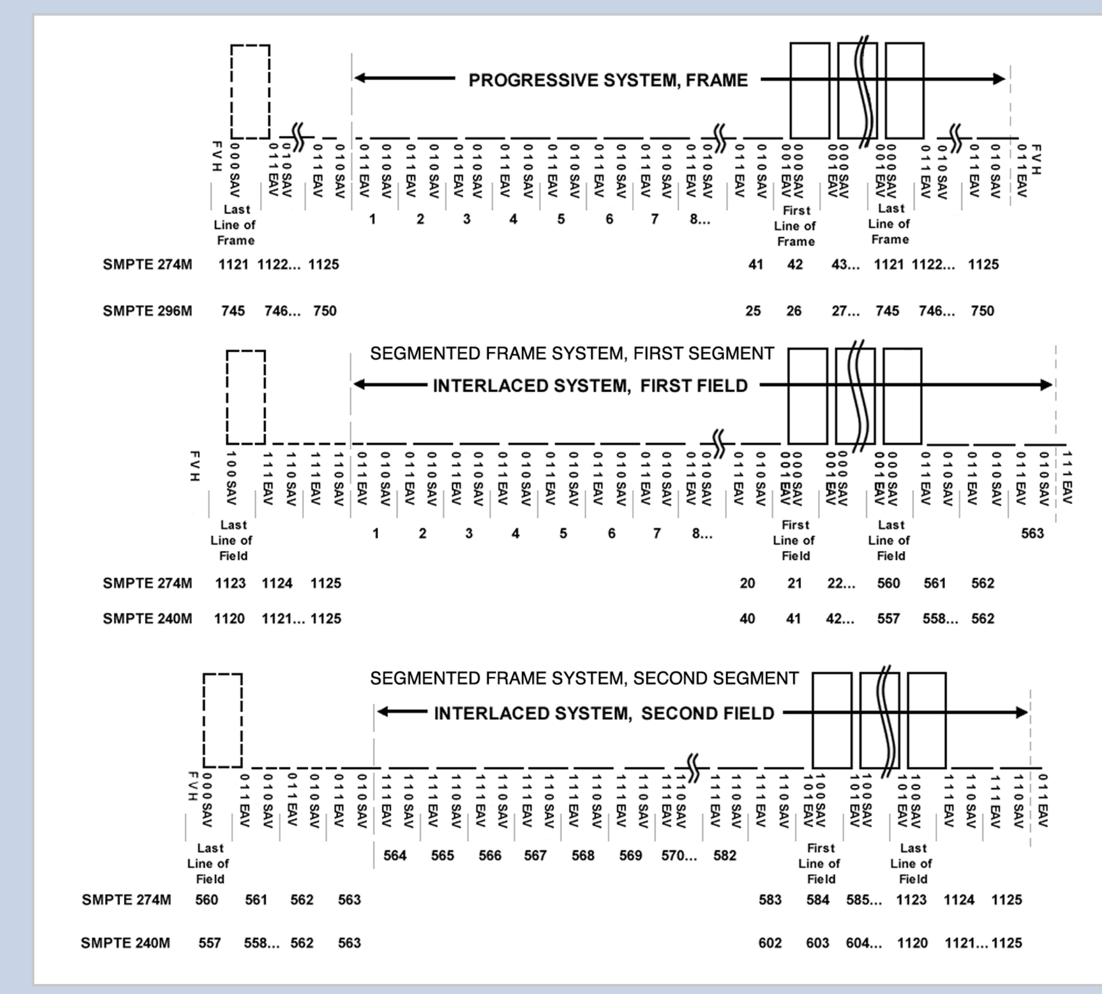
HORIZONTAL LINE TIMING

This diagram represents the HD horizontal line and shows the relative timing intervals for the horizontal blanking interval and active line. The relative positions of EAV and SAV in comparison to the analog horizontal line are shown. Note the analog HD timing reference point 0_H is measured at the 50% point of the positive rising edge of the tri-level sync. Table 10 shows the relative timing intervals for a variety of formats.



System Nomenclature	Samples per Active Line	Active Lines per Frame	Frame Rate (Hz)	Scanning Format	Luma Sampling Frequency (MHz) (1/T)	A	B	C	D	E	Samples per Active Line F	Luma Samples per Total Line G	Total Lines per Frame
1920x1080/60/1:1	1920	1080	60.00	Progressive	148.500	44T	44T	44T	148T	280T	1920T	2200T	1125
1920x1080/59.94/1:1	1920	1080	59.94	Progressive	148.352	44T	44T	44T	148T	280T	1920T	2200T	1125
1920x1080/50/1:1	1920	1080	50.00	Progressive	148.500	484T	44T	44T	148T	720T	1920T	2640T	1125
1920x1080/60/2:1	1920	1080	30.00	2:1 Interlace	74.250	44T	44T	44T	148T	280T	1920T	2200T	1125
1920x1080/59.94/2:1	1920	1080	29.97	2:1 Interlace	74.176	44T	44T	44T	148T	280T	1920T	2200T	1125
1920x1080/50/2:1	1920	1080	25.00	2:1 Interlace	74.250	484T	44T	44T	148T	720T	1920T	2640T	1125
1920x1080/30/1:1	1920	1080	30.00	Progressive	74.250	44T	44T	44T	148T	280T	1920T	2200T	1125
1920x1080/29.97/1:1	1920	1080	29.97	Progressive	74.176	44T	44T	44T	148T	280T	1920T	2200T	1125
1920x1080/25/1:1	1920	1080	25.00	Progressive	74.250	484T	44T	44T	148T	720T	1920T	2640T	1125
1920x1080/24/1:1	1920	1080	24.00	Progressive	74.250	594T	44T	44T	148T	830T	1920T	2750T	1125
1920x1080/23.98/1:1	1920	1080	23.98	Progressive	74.176	594T	44T	44T	148T	830T	1920T	2750T	1125
1920x1080/30/SF	1920	1080	30.00	Prog. SF	74.250	44T	44T	44T	148T	280T	1920T	2200T	1125
1920x1080/29.97/1:1SF	1920	1080	29.97	Prog. SF	74.176	44T	44T	44T	148T	280T	1920T	2200T	1125
1920x1080/25/1:1SF	1920	1080	25.00	Prog. SF	74.250	484T	44T	44T	148T	720T	1920T	2640T	1125
1920x1080/24/1:1SF	1920	1080	24.00	Prog. SF	74.250	594T	44T	44T	148T	830T	1920T	2750T	1125
1920x1080/23.98/1:1SF	1920	1080	23.98	Prog. SF	74.176	594T	44T	44T	148T	830T	1920T	2750T	1125
1280x720/60/1:1	1280	720	60.00	Progressive	74.250	70T	40T	40T	220T	370T	1280T	1650T	750
1280x720/59.94/1:1	1280	720	59.94	Progressive	74.176	70T	40T	40T	220T	370T	1280T	1650T	750
1280x720/50/1:1	1280	720	50.00	Progressive	74.250	400T	40T	40T	220T	700T	1280T	1980T	750
1280x720/30/1:1	1280	720	30.00	Progressive	74.250	1720T	40T	40T	220T	2020T	1280T	3300T	750
1280x720/29.97/1:1	1280	720	29.97	Progressive	74.176	1720T	40T	40T	220T	2020T	1280T	3300T	750
1280x720/25/1:1	1280	720	25.00	Progressive	74.250	2380T	40T	40T	220T	2680T	1280T	3960T	750
1280x720/24/1:1	1280	720	24.00	Progressive	74.250	2545T	40T	40T	220T	2845T	1280T	4125T	750
1280x720/23.98/1:1	1280	720	23.98	Progressive	74.176	2545T	40T	40T	220T	2845T	1280T	4125T	750
625/50/2:1 (BT.601)	720	576	25.00	2:1 Interlace	13.500	--	--	--	--	--	720T	864T	625
525/59.94/2:1 (BT.601)	720	486	29.97	2:1 Interlace	13.500	--	--	--	--	--	720T	858T	525
625/50/1:1	720	576	50	Progressive	27.000	--	--	--	--	--	720T	864T	625
525/59.94/1:1	720	483	59.94	Progressive	27.000	--	--	--	--	--	720T	858T	525

Table 10, Scanning Formats for Studio Digital Video



VERTICAL TIMING

The digital vertical timing interval for the HD formats SMPTE 240M (1920x1035i), SMPTE 274M (1920x1080) and SMPTE 296M (1280x720) is shown above. Both progressive and interlaced vertical intervals are shown for comparison. The values of the F, V & H bits are indicated appropriately for each SAV and EAV value throughout the vertical interval. The complete calculation of these values as "XYZ" words is given in binary and hexadecimal in Table 9.

ANSI/SMPTE 125M – Television – Component Video Signal 4:2:2 – Bit-Parallel Digital Interface
ANSI/SMPTE 170M – Television – Composite Analog Video Signal – NTSC for Studio Applications
ANSI/SMPTE 240M – Television (Archived) – Signal Parameters – 1125-Line High-Definition Production Systems
ANSI/SMPTE 244M – Television – System M/NTSC Composite Video Signals – Bit-Parallel Digital Interface
ANSI/SMPTE 259M – Television – 10-Bit 4:2:2 Component and 4fsc NTSC Composite Digital Signals – Serial Digital Interface
ANSI/SMPTE 260M – Television (Archived) – 1125/60 High Definition Production System – Digital Representation and Bit-Parallel Interface
ANSI/SMPTE 266M – Television – 4:2:2 Digital Component Systems – Digital Vertical Interval Time Code
ANSI/SMPTE 267M – Television – Bit-Parallel Digital Interface – Component Video Signal 4:2:2 16:9 Aspect Ratio
ANSI/SMPTE 272M – Television – Formatting AES/EBU Audio and Auxiliary Data into Digital Video Ancillary Data Space
ANSI/SMPTE 274M – Television – 1920x1080 Image Sample Structure, Digital Representation and Digital Timing Reference Sequences for Multiple Picture Rates
ANSI/SMPTE 276M – Television – Transmission of AES-EBU Digital Audio Signals Over Coaxial Cable
ANSI/SMPTE 291M – Television – Ancillary Data Packet and Space Formatting
ANSI/SMPTE 292 – Television – 1.5 Gb/s Signal / Data Serial Interface
ANSI/SMPTE 293M – Television – 720x483 Active Line at 59.94 Hz Progressive Scan Production – Digital Representation
ANSI/SMPTE 294M – Television – 720x483 Active Line at 59.94 Hz Progressive Scan Production – Bit-Serial Interface
ANSI/SMPTE 295M – Television (Archived) – 1920x1080 50 Hz – Scanning and Interface
ANSI/SMPTE 296M – Television – 1280x720 Progressive Image Sample Structure – Analog and Digital Representation and Analog Interface
ANSI/SMPTE 299M – Television – 24-Bit Digital Audio Format for SMPTE 292 Bit-Serial Interface
ANSI/SMPTE 305M – Television – Serial Data Transport Interface (SDTI)
SMPTE 318M – Television and Audio – Synchronization of 59.94 or 50 Hz Related Video and Audio Systems in Analog and Digital Areas – Reference Signals

SMPTE 344M – Television (Archived) – 540 Mb/s Serial Digital Interface
SMPTE 346M – Television (Archived) – Time Division Multiplexing Video Signals and Generic Data over High Definition Television Interfaces
SMPTE 348M – Television (Archived) – High Data Rate Serial Data Transport Interface (HD-SDTI)
SMPTE 372 – Dual Link 1.5 Gb/s Digital Interface for 1920x1080 and 2048x1080 Picture Formats
SMPTE 424M – Television – 3G-SDI Signal/Data Serial Interface
SMPTE 425M – 3G-SDI Signal/Data Serial Interface – Source Image Format Mapping
SMPTE 428-1 – D-Cinema Distribution Master (DCDM) – Image Characteristics
SMPTE 435-1 – 10 Gb/s Serial Signal/Data Interface – Part 1: Basic Stream Distributions
SMPTE 435-2 – 10 Gb/s Serial Signal/Data Interface – Part 2: Basic Stream Data Mapping
SMPTE 435-3 – 10 Gb/s Serial Signal/Data Interface – Part 3: 10.6992 Gb/s Optical Fiber Interface
SMPTE 2010 – Vertical Ancillary Data Mapping of ANSI/SCTE 104 Messages
SMPTE 2016-1 – Television – Format for Active Format Description and Bar Data
SMPTE 2016-2 – Television – Format for Pan-Scan Information
SMPTE 2016-3 – Television – Vertical Ancillary Data Mapping of Active Format Descriptor and Bar Data
SMPTE 2016-4 – Television – Vertical Ancillary Data Mapping of Pan-Scan Information
SMPTE 2020-1 – Format of Audio Metadata and Description of the Asynchronous Serial Bitstream Transport
SMPTE 2020-2 – Vertical Ancillary Data Mapping of Audio Metadata – Method A
SMPTE 2020-3 – Vertical Ancillary Data Mapping of Audio Metadata – Method B
SMPTE 2031 – Carriage of DVB/SCTE VBI Data in VANC
SMPTE 2036-1 – Ultra High Definition Television – Image Values for Program
SMPTE 2036-2 – Ultra High Definition Television – Audio Characteristics and Audio Channel Mapping for Program Production

ITU-R BT.470 Conventional television systems
ITU-R BT.601 Studio encoding parameters of digital television for standard 4:3 and wide-screen 16:9 aspect ratios
ITU-R BT.656 Interfaces for digital component video signals in 525-line and 625-line television systems operating at the 4:2:2 level of Recommendation ITU-R BT.601 (Part A)
ITU-R BT.709 Parameter values for the HDTV standards for production and international programme exchange
ITU-R BT. 799 Interfaces for digital component video signals in 525-line and 625-line television systems operating at the 4:4:4 level of Recommendation ITU-R BT.601 (Part A)
ITU-R BT. 801 Test signals for digtally encoded colout television signals conforming with Recommendations ITU-R BT.601 and ITU-R BT. 656
ITU-R BT. 119 Wide-screen signaling for broadcast (signaling for wide screen and other enhanced television parameters)
ITU-R BT. 1120 Digital interfaces for HDTV studio signals
ITU-R BT. 1304 Checksum for error detection and status information in interfaces conforming to Recommendations ITU-R BT.656 and ITU-R BT.799
ITU-R BT. 1305 Digital audio and auxiliary data as ancillary data signals in interfaces conforming to Recommendations ITU-R BT.656 and ITU-R BT.799
ITU-R BT. 1358 Studio parameters of 625-line and 525-line progressive scan television systems
ITU-R BT. 1361 Worldwide unified colorimetry and related characteristics of future television and imaging systems
ITU-R BT. 1362 Interfaces for digital component video signals in 525-line and 625-line progressive scan television systems
ITU-R BT. 1363 Jitter specifications and methods for jitter measurements of bit-serial signals conforming to Recommendations ITU-R BT.656, ITU-R BT.799 and ITU-R BT.1120
ITU-R BT. 1364 Format of ancillary data signals carried in digital component studio interfaces
ITU-R BT. 1365 24-Bit digital audio format as ancillary data signals in HDTV serial interfaces
ITU-R BT. 1366 Transmission of time code and control code in the ancillary data space of a digital television stream according to ITU-R BT.656, ITU-R BT.799 and ITU-R BT.1120
ITU-R BT. 1379 Safe areas of wide-screen 16:9 and standard 4:3 aspect ratio productions to achieve a common format during a transition period to wide-screen 16:9 broadcasting
ITU-R BT. 1543 1280x720, 16:9 progressively-captured image format for production and international programme exchange in the 60 Hz environment
ITU-R BT. 1576 Transport of alternate source formats through Recommendation ITU-R BT. 1120
ITU-R BT. 1577 Serial digital interface-based transport interface for compressed television signal in networked television production based on Recommendation ITU-R BT. 1120
ITU-R BT. 1619 Vertical ancillary data mapping for serial digital interface
ITU-R BT. 1674 Metadata requirements for production and post-production in broadcasting
ITU-R BT. 1847 1280x720, 16:9 progressively-captured image for production and international programme exchange in the 50Hz environment

SMPTE Engineering Guideline EG 32: Emphasis of AES/EBU Audio in Television Systems and Preferred Audio Sampling Rate
SMPTE Engineering Guideline EG 33: Jitter Characteristics and Measurements
SMPTE Engineering Guideline EG 34: Pathological Conditions in Serial Digital Video Systems
SMPTE Engineering Guideline EG 36: Transformation Between Television Component Color Signals
SMPTE Engineering Guideline EG 43: System Implementation of CEA 708-B and CEA 608-B Closed Cpationing

SMPTE RP160 – Three-Channel Parallel Analog Component High-Definition Video Interface
SMPTE RP165 – Error Detection Checkwords and Status Flags for Use in Bit-Serial Digital Interfaces for Television
SMPTE RP168 – Definition of Vertical Interval Switching Point for Synchronous Video Switching
SMPTE RP174 – Bit-Parallel Digital Interface for 4:4:4:4 Component Video Signal (Single Link)
SMPTE RP175 – (Archived) Digital Interface for 4:4:4:4 Component Video Signals (Dual Link)
SMPTE RP177 – Derivation of Basic Television Color Equations

SMPTE RP178 – Serial Digital Interface Checkfield for 10-Bit 4:2:2 Component and 4fsc Composite Digital Signals
SMPTE RP184 – Specification of Jitter in Bit-Serial Digital Interfaces
SMPTE RP186 – Video Index Information Coding for 525- and 625-Line Television Systems
SMPTE RP187 – Center, Aspect Ratio and Blanking of Video Images
SMPTE RP188 – Transmission of Time Code and Control Code in the Ancillary Data Space of a Digital Television Data Stream
SMPTE RP192 – Jitter Measurement Procedures in Bit-Serial Digital Interfaces
SMPTE RP196 – Transmission of LTC and VITC Data as HANC Packets in Serial Digital Television Interfaces

SMPTE RP198 – Bit-Serial Digital Checkfield for Use in High-Definition Interfaces
SMPTE RP199 – Mapping of Pictures in Wide-Screen (16:9) Scanning Structure to Retain Original Aspect Ratio of the Work
SMPTE RP211 – (Archived) Implementation of 24P, 25P, and 30P Segmented Frames for 1920x1080 Production Format
SMPTE RP218 – Specification for Safe Area and Safe Title Areas for Television Systems
SMPTE RP219 – High Definition, Standard Definition Compatible Color Bar Signal
SMPTE RP221 – Specification for Extraction of 4x3 Areas from Digital 16x9 Images for Television Systems
SMPTE RP222 – Standard Definition Evaluation Masters for Digital Television
SMPTE RP223 – Packing UMID and Program Identification Label Data into SMPTE 219M Ancillary Data Packets
SMPTE RP2007 – Closed Caption CDP and "Grand Alliance" Serial Interfaces for DTV

SMPTE RDD6 Television – Description and Guide to the Use of the Dolby E Audio Metadata Serial Bitstream
SMPTE RDD8 – Storage and Distribution of Teletext Subtitles and VBI Data for High Definition Television

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