

COLOR SPACES OF VIDEO SEQUENCES DIGITAL CODING SYSTEMS

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КОЛІРНІ ПРОСТОРИ СИСТЕМ ЦИФРОВОГО КОДУВАННЯ ВІДЕОПОСЛІДОВНОСТЕЙ

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ЦВЕТОВЫЕ ПРОСТРАНСТВА СИСТЕМ ЦИФРОВОГО КОДИРОВАНИЯ ВИДЕОПОСЛЕДОВАТЕЛЬНОСТЕЙ

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Abstract. In the work it is built generalized description and comparison of color spaces defined by standards for digital encoding of video sequences MPEG-2 Video, MPEG-4 Visual, MPEG-4 AVC and MPEG-N HEVC taking into account the progress of encoding methods and corresponding MPEG standards, happened in recent years. Description built for proposed renovation and addition the corresponding tables in the Report ITU-R BT.2380, developed by the Rapporteur Group of the Working Group 6C of ITU-R Study Group 6 on the basis of studies conducted by the author on behalf of the Administration of Ukraine

Keywords: color space, digital encoding, MPEG-2 Video, MPEG-4 Visual, MPEG-4 AVC, MPEG-N HEVC

Анотація. У роботі побудовано узагальнений опис і зіставлення колірних просторів, визначених стандартами цифрового кодування відеопослідовностей MPEG-2, MPEG-4 Video, MPEG-4 AVC та MPEG-N HEVC з урахуванням прогресу методів кодування і відповідних стандартів MPEG, що стався за останні роки. Опис побудовано на предмет пропонуваної оновлення й доповнення відповідних таблиць в Звіті ITU-R BT.2380, розробленого групою доповідачів Робочої групи 6C Дослідної комісії 6 ITU-R на базі досліджень, що їх проводять автори у сфері ТВ колориметрії від імені Адміністрації зв'язку України

Ключові слова: колірний простір, цифрове кодування, MPEG-2 Video, MPEG-4 Visual, MPEG-4 AVC, MPEG-N HEVC

Аннотация. В работе построено обобщённое описание и сопоставление цветовых пространств, определённых стандартами цифрового кодирования видеопоследовательностей MPEG-2 Video, MPEG-4 Visual, MPEG-4 AVC и MPEG-N HEVC с учётом прогресса методов кодирования и соответствующих стандартов MPEG, происшедшего за последние годы. Описание построено на предмет предлагаемого обновления и дополнения соответствующих таблиц в Отчёте ITU-R BT.2380, разработанного группой докладчиков Рабочей группы 6C Исследовательской комиссии 6 МСЭ-Р на базе исследований, проводимых в авторами в сфере ТВ колориметрии от имени Администрации связи Украины

Ключевые слова: цветовое пространство, цифровое кодирование, MPEG-2 Video, MPEG-4 Visual, MPEG-4 AVC, MPEG-N HEVC

Color spaces of coded video images are important part of image processing and digital coding. Generalized description and comparison of color spaces defined by standards for digital encoding of video sequences MPEG-2 Video [1], MPEG-4 Visual [2, 3], MPEG-4 AVC [4] and MPEG-H HEVC [5, 6] taking into account the progress of encoding methods and corresponding MPEG standards happened in recent years. Description built for proposed renovation and addition the corresponding tables in the Report ITU-R BT.2380 [7], developed by the Rapporteur Group of the Working Group 6C of ITU-R Study Group 6 on the basis of studies conducted by the authors on behalf of the Administration of Ukraine

Digital video coding system colorimetric characteristics specified in MPEG video coding standards are shown in the Tables 1, 2, 3, which combine according data from Tables 6-7, 6-8, 6-9 from MPEG-2 Video, Tables 6-8, 6-9, 6-10 from MPEG-4 Visual, Tables E-8, E-9, E-10 from MPEG-4 AVC and Tables E-3, E-4, E-5 from MPEG-H HEVC.

Primaries chromaticity and reference white coordinates for given parameter values of colour primaries are shown it Table 1.

Opto-electronic conversion characteristics – transfer primaries channel characteristics for given parameter values of transfer characteristics are shown in Table 2. The table specifies:

L – image primaries tristimulus values, that are relative luminance levels, R, G, B image components;

V – relative levels of gamma-corrected signals R, G, B – image components E'_R, E'_G, E'_B ;

E'_Y – normalized luminance signal normalized to $\overline{0;1}$;

E'_{PR}, E'_{PB} – colour-difference signals normalized to $\overline{-0.5;+0.5}$.

Luminance signals and colour-difference signals matrixes coefficients for given parameter values of matrix coefficients are shown in Table 3 with exception of cases when matrix coefficients values are equal to 0 and 8. Value 8 in MPEG-2 Video, MPEG-4 AVC and MPEG-H HEVC corresponds to signal coding Y, C_R, C_B processed by algorithms specified in these standards where C_R, C_B signals are in terms of C_G, C_O . Value 0 in IEC 61966-2-2, MPEG-4 AVC and MPEG-H HEVC corresponds to RGB space signals E'_R, E'_G, E'_B coding processed by algorithms specified in these standards.

Replacement the content of the Tables 2.8, 2.9, 2.10 in new version of the Report ITU-R BT.2380 by the content of the Tables 1,2,3 may provide latest information on color spaces of coded video sequences used in the world for the moment of publication this work.

REFERENCES

- 1 Recommendation ITU-T H.262:2012 | ISO/IEC 13818-2:2013 *Information technology – Generic coding of moving pictures and associated audio information: Video*
- 2 ISO/IEC 14496-2:2004 *Information technology – Coding of audio-visual objects – Part 2: Visual*
- 3 ISO/IEC 14496-2:2004/Amd. 3:2007 *Information technology – Coding of audio-visual objects – Part 2: Visual, Amendment 3: Support for colour Spaces+Technical corrigendum 1:2008*
- 4 Recommendation ITU-T H.264:2014 | ISO/IEC 14496-10:2012 *Information technology – Coding of audio-visual objects – Part 10: Advanced video coding*
- 5 Recommendation ITU-T H.265:2015 | ISO/IEC 23008-2:2015 *Information technology – High efficiency coding and media delivery in heterogeneous environments – Part 2: High efficiency video coding*
- 6 ISO/IEC JTC1/SC29/WG11 MPEG / WD of ISO/IEC 23008-2:201x/Amd.1 *Additional colour description indicators* February 2016

TABLE 1

Colour primaries for digital video coding in MPEG-2 Video, MPEG-4 Visual, MPEG-4 AVC, and MPEG-H HEVC

colour_primaries	Systems and standards	Primaries and reference white chromaticity coordinates															
0	Forbidden (<i>only MPEG-2 Video and MPEG-4 Visual</i>) Reserved (<i>only MPEG-4 AVC</i>)	For future use ITU-T/ISO/IEC															
1	Recommendation ITU-R BT.709 [8] IEC 61966-2-1 [9] (sRGB or sYCC) (<i>only MPEG-4 AVC and MPEG-H HEVC</i>) IEC 61966-2-4 [10] SMPTE RP 177 [11] (1993) Annex B	<table border="1"> <thead> <tr> <th>Primary</th> <th>x</th> <th>y</th> </tr> </thead> <tbody> <tr> <td>Red</td> <td>0.640</td> <td>0.330</td> </tr> <tr> <td>Green</td> <td>0.300</td> <td>0.600</td> </tr> <tr> <td>Blue</td> <td>0.150</td> <td>0.060</td> </tr> <tr> <td>White D₆₅</td> <td>0.3127</td> <td>0.3290</td> </tr> </tbody> </table>	Primary	x	y	Red	0.640	0.330	Green	0.300	0.600	Blue	0.150	0.060	White D ₆₅	0.3127	0.3290
Primary	x	y															
Red	0.640	0.330															
Green	0.300	0.600															
Blue	0.150	0.060															
White D ₆₅	0.3127	0.3290															
2	Unspecified	Image characteristics are unknown or are determined by the application															
3	Reserved	For future use by ITU-T/ISO/IEC															
4	Recommendation ITU-R BT.470 [12] system M (historical) NTSC 1953 Recommendation for transmission standards for colour television (<i>only MPEG-2 Video and MPEG-4 AVC and MPEG-H HEVC</i>) US 47 CFR 73.682 (a) (20) (<i>only MPEG-2 Video and MPEG-4 AVC and MPEG-H HEVC</i>)	<table border="1"> <thead> <tr> <th>Primary</th> <th>x</th> <th>y</th> </tr> </thead> <tbody> <tr> <td>Red</td> <td>0.67</td> <td>0.33</td> </tr> <tr> <td>Green</td> <td>0.21</td> <td>0.71</td> </tr> <tr> <td>Blue</td> <td>0.14</td> <td>0.08</td> </tr> <tr> <td>White C</td> <td>0.310</td> <td>0.316</td> </tr> </tbody> </table>	Primary	x	y	Red	0.67	0.33	Green	0.21	0.71	Blue	0.14	0.08	White C	0.310	0.316
Primary	x	y															
Red	0.67	0.33															
Green	0.21	0.71															
Blue	0.14	0.08															
White C	0.310	0.316															
5	Recommendation ITU-R BT.1700 [13] 625 PAL or 625 SECAM (<i>only MPEG-2 Video and MPEG-4 AVC and MPEG-H HEVC</i>) Recommendation ITU-R BT.601 [14] 625 (<i>only MPEG-2 Video and MPEG-4 AVC and MPEG-H HEVC</i>) Recommendation ITU-R BT.470 systems B, G (historical)	<table border="1"> <thead> <tr> <th>Primary</th> <th>x</th> <th>y</th> </tr> </thead> <tbody> <tr> <td>Red</td> <td>0.64</td> <td>0.33</td> </tr> <tr> <td>Green</td> <td>0.29</td> <td>0.60</td> </tr> <tr> <td>Blue</td> <td>0.15</td> <td>0.06</td> </tr> <tr> <td>White D₆₅</td> <td>0.3127</td> <td>0.3290</td> </tr> </tbody> </table>	Primary	x	y	Red	0.64	0.33	Green	0.29	0.60	Blue	0.15	0.06	White D ₆₅	0.3127	0.3290
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6	Recommendation ITU-R BT.1700 NTSC (<i>only MPEG-2 Video and MPEG-4 AVC and MPEG-H HEVC</i>) SMPTE 170 Recommendation ITU-R BT.601 525 NTSC (<i>only MPEG-2 Video and MPEG-4 AVC and MPEG-H HEVC</i>)	<table border="1"> <thead> <tr> <th>Primary</th> <th>x</th> <th>y</th> </tr> </thead> <tbody> <tr> <td>Red</td> <td>0.630</td> <td>0.340</td> </tr> <tr> <td>Green</td> <td>0.310</td> <td>0.595</td> </tr> <tr> <td>Blue</td> <td>0.155</td> <td>0.070</td> </tr> <tr> <td>White D₆₅</td> <td>0.3127</td> <td>0.3290</td> </tr> </tbody> </table>	Primary	x	y	Red	0.630	0.340	Green	0.310	0.595	Blue	0.155	0.070	White D ₆₅	0.3127	0.3290
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Green	0.310	0.595															
Blue	0.155	0.070															
White D ₆₅	0.3127	0.3290															

TABLE 2.6 (continued)

colour_primaries	Systems and standards	Primaries and reference white chromaticity coordinates			
7	SMPTE 240 [15]	Primary	x	y	
		Red	0.630	0.340	
		Green	0.310	0.595	
		Blue	0.155	0.070	
		White D ₆₅	0.3127	0.3290	
8	Reserved (<i>only MPEG-2 Video</i>) Generic film (colour filters using standard illuminant C) (<i>only MPEG-4 Video, MPEG-4 AVC, and MPEG-H HEVC</i>)	For future use by ITU-T ISO/IEC			
		Primary	x	y	
		Red	0.681	0.319	(Wratten 25)
		Green	0.243	0.692	(Wratten 58)
		Blue	0.145	0.049	(Wratten 47)
		White C	0.310	0.316	
9	Reserved (<i>only MPEG-2 Video and MPEG-4 Visual</i>) Rec. ITU-R BT.2020 [16] (<i>only MPEG-4 AVC and MPEG-H HEVC</i>) Rec. ITU-R BT.2100 [17] (<i>only MPEG-4 AVC and MPEG-H HEVC</i>)	For future use by ITU-T ISO/IEC			
		Primary	x	y	
		Red	0.708	0.292	
		Green	0.170	0.797	
		Blue	0.131	0.046	
		White D ₆₅	0.3127	0.3290	
10	Reserved (<i>only MPEG-2 Video and MPEG-4 Visual</i>) SMPTE ST 428-1 CIE 1931 XYZ) (<i>only MPEG-4 AVC and MPEG-H HEVC</i>)	For future use by ITU-T ISO/IEC			
		Primary	x	y	
		X	1	0	
		Y	0	1	
		Z	0	0	
		White	1/3	1/3	

TABLE 2.6 (end)

colour_primaries	Systems and standards	Primaries and reference white chromaticity coordinates															
11	Reserved (<i>Only MPEG-2 Video and MPEG-4 Visual</i>) SMPTE RP 431-2 [19] (<i>only MPEG-4 AVC and MPEG-H HEVC</i>)	For future use by ISO/IEC <table border="1"> <thead> <tr> <th>Primary</th> <th>x</th> <th>y</th> </tr> </thead> <tbody> <tr> <td>Red</td> <td>0.680</td> <td>0.320</td> </tr> <tr> <td>Green</td> <td>0.265</td> <td>0.690</td> </tr> <tr> <td>Blue</td> <td>0.150</td> <td>0.060</td> </tr> <tr> <td>White</td> <td>0.314</td> <td>0.351</td> </tr> </tbody> </table>	Primary	x	y	Red	0.680	0.320	Green	0.265	0.690	Blue	0.150	0.060	White	0.314	0.351
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13-21	Reserved	For future use by ITU-T ISO/IEC															
22	Reserved (<i>Only MPEG-2 Video and MPEG-4 Visual</i>) EBU Tech. 3213-E	For future use by ITU-T ISO/IEC <table border="1"> <thead> <tr> <th>Primary</th> <th>x</th> <th>y</th> </tr> </thead> <tbody> <tr> <td>Red</td> <td>0.630</td> <td>0.340</td> </tr> <tr> <td>Green</td> <td>0.295</td> <td>0.605</td> </tr> <tr> <td>Blue</td> <td>0.155</td> <td>0.077</td> </tr> <tr> <td>White</td> <td>0.3127</td> <td>0.3290</td> </tr> </tbody> </table>	Primary	x	y	Red	0.630	0.340	Green	0.295	0.605	Blue	0.155	0.077	White	0.3127	0.3290
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Blue	0.155	0.077															
White	0.3127	0.3290															
23-255	Reserved	For future use by ISO/IEC															

TABLE 2.7

Transfer characteristics for digital video coding in MPEG-2 Video, MPEG-4 Visual, MPEG-4 AVC, MPEG HEVC ^{1) 2)}

transfer_characteristic	Systems and standards	Transfer characteristic
0	Forbidden (<i>only MPEG-2 Video and MPEG-4 Visual</i>) Reserved (<i>only MPEG-4 AVC and MPEG-H HEVC</i>)	For future use by ITU-T ISO/IEC
1	Recommendation ITU-R BT.709	$V = \alpha L^{0.45} - \alpha - 1$ for $\beta \leq L \leq 1$ $V = 4.500L$ for $0 \leq L < \beta$ where $L = R, G, B$ – colour primaries tristimulus values, $V = R', G', B'$ – colour primaries signals
2	Unspecified	Image characteristics are unknown or are determined by the application
3	Reserved	For future use by ITU-T ISO/IEC
4	Recommendation ITU-R BT.470 system M Recommendation ITU-R BT.1700 625 PAL or 625 SECAM (<i>only MPEG-4 AVC and MPEG-H HEVC</i>) US NTSC 1953 Recommendation for transmission standards for colour television US 47 CFR 73.682 (a) (20)	Assumed displayed gamma 2.2
5	Recommendation ITU-R BT.1700 625 PAL or 625 SECAM (<i>only MPEG-2 Video and MPEG-4 Visual and MPEG-4 AVC</i>) Recommendation ITU-R BT.470 systems B, G (historical)	Assumed displayed gamma 2.8 <i>Note.</i> This value conflicts with Recommendation ITU-R BT.1700 (2007 revision) and accordingly to this Recommendation has to be changed to 2.2
6	Recommendation ITU-R BT.1700 NTSC Recommendation ITU-R BT.601 525 or 625 (<i>only MPEG-2 Video and MPEG-4 AVC and MPEG-H HEVC</i>) SMPTE 170 AVC	$V = \alpha L^{0.45} - \alpha - 1$ for $\beta \leq L \leq 1$ $V = 4.500L$ for $0 \leq L < \beta$
7	SMPTE 240M [2.26]	$V = \alpha L^{0.45} - \alpha - 1$ for $\beta \leq L \leq 1$ $V = 4.0L$ for $0 \leq L < \beta$
8	Linear transfer characteristic	$V = L$
9	Logarithm transfer characteristic (100:1 range)	$V = 1.0 + \text{Log}_{10} L / 2$ for $0.01 \leq L \leq 1$ $V = 0.0$ for $0 \leq L < 0.01$

TABLE 2.7 (continued)

transfer_characteristic	Systems and standards	Transfer characteristic
10	Logarithm transfer characteristic (100·Sqrt(10):1 range)	$V = 1.0 + \text{Log}_{10} L / 2.5 \quad \text{for } \text{Sqrt } 10 / 1000 \leq L \leq 1$ $V = 0.0 \quad \text{for } 0 \leq L < \text{Sqrt } 10 / 1000$
11	IEC 61966-2-4	$V = \alpha L^{0.45} - \alpha - 1 \quad \text{for } \beta \leq L$ $V = 4.500L \quad \text{for } -\beta \leq L \leq \beta$ $V = -\left[\alpha - L^{0.45} - \alpha - 1 \right] \quad \text{for } L \leq -\beta$
12	Extended colour gamut system (<i>historical</i>)	$V = \alpha L_c^{0.45} - \alpha - 1 \quad \text{for } \beta \leq L_c < 1.33$ $V = 4.500L_c \quad \text{for } -0.0045 \leq L_c < \beta$ $V = -\left[\alpha - 4L_c^{0.45} - \alpha - 1 \right] / 4 \quad \text{for } -0,25 \leq L_c < -0.0045$
13	Reserved (<i>only MPEG-2 Video and MPEG-4 Visual</i>) IEC 61966-2-1 (sRGB or sYCC) (<i>only MPEG-H HEVC</i>)	For future use by ITU-T ISO-IEC $V = \alpha L^{1/2.4} - \alpha - 1 \quad \text{for } \beta \leq L \leq 1$ $V = 12.92L \quad \text{for } 0 \leq L \leq \beta$
14	Reserved (<i>only MPEG-2 Video and MPEG-4 Visual</i>) Rec. ITU-R BT.2020 for 10 bit system (<i>only MPEG-H HEVC</i>)	For future use by ITU-T ISO-IEC $V = \alpha L^{0.45} - \alpha - 1 \quad \text{for } \beta \leq L \leq 1$ $V = 4.5L \quad \text{for } 0 \leq L \leq \beta$
15	Reserved (<i>only MPEG-2 Video and MPEG-4 Visual</i>) Rec. ITU-R BT.2020 for 12 bit system (<i>only MPEG-H HEVC</i>)	For future use by ITU-T ISO-IEC $V = \alpha L^{0.45} - \alpha - 1 \quad \text{for } \beta \leq L \leq 1$ $V = 4.5L \quad \text{for } 0 \leq L \leq \beta$

TABLE 2.7 (end)

transfer_characteristic	Systems and standards	Transfer characteristic
16	Reserved (<i>only MPEG-2 Video and MPEG-4 Visual AVC</i>) SMPTE ST 2084 [22] for 10, 12, 14 and 16 bit systems (<i>MPEG-4 AVC and MPEG-H HEVC</i>) Rec. ITU-R BT.2100 perceptual quantization (PQ) system	For future use by ITU-T ISO-IEC $V = \frac{c_1 + c_2 L_C^n}{1 + c_3 L_C^m}$ for all values of L_C $c_1 = c_3 - c_2 + 1 = 3424/4096 = 0.8359375$ $c_2 = 32 \times 2413/4096 = 18.8515625$ $c_3 = 32 \times 2392/4096 = 18.6875$ $m = 128 \times 2523/4096 = 78.84375$ $n = 0.25 \times 2610/4096 = 0.1593017578125$ for which L_C equal to 1 for peak white is ordinarily intended to correspond to a display luminance level of 10 000 candelas per square metre
17	Reserved (<i>MPEG-2 Video and MPEG-4 Visual AVC</i>) SMPTE ST 428-1 (<i>MPEG-4 AVC and MPEG-H HEVC</i>)	For future use by ITU-T ISO-IEC $V = 48 L_C / 52.37^{1/2.6}$ for all values of L_C , for which L_C equal to 1 for peak white is ordinarily intended to correspond to a display luminance level of 48 candelas per square metre
18	Reserved (<i>MPEG-2 Video and MPEG-4 Visual and MPEG-4 AVC</i>) ARIB STD-B67 (<i>MPEG-H HEVC</i>) Rec. ITU-R BT.2100 Hybrid Log Gamma(<i>MPEG-H HEVC</i>)	For future use by ITU-T ISO-IEC $V = a \cdot \ln 12L - b + c$ for $1/12 < L \leq 1$ $V = \text{Sqrt } 3 \cdot L^{0.5}$ for $0 \leq L \leq 1/12$ $a = 0.17883277$ $b = 0.28466892$ $c = 0.55991073$
19-255	Reserved	For future use by ITU-T ISO-IEC
1) For transfer_characteristic =1, 6, 11, 12, 14, 15 $\alpha=1.099\ 296\ 826\ 809\ 442\dots$; $\beta=0.018\ 053\ 968\ 510\ 807\dots$ 2) For transfer_characteristic =13 $\alpha=1.055$; $\beta=0.31308$		

TABLE 2.8

Matrix coefficients for video coding in MPEG-2 Video, MPEG-4 Visual, MPEG-4 AVC, MPEG HEVC

matrix_coefficients	Systems and standards	Matrix
0	Forbidden (<i>MPEG-2 Video, MPEG-4 Visual</i>) sRGB (IEC 61966-2-1) (<i>only MPEG-4 AVC, MPEG-H HEVC</i>)	Typically referred as <i>RGB</i> . Also may be used for <i>XYZ</i>
1	Recommendation ITU-R BT.709 IEC 61966-2-1 (sYCC) (<i>only MPEG-2 Video and MPEG-4 AVC and MPEG-H HEVC</i>) IEC 61966-2-4 xvYCC ₇₀₉ (<i>only MPEG-2 Video and MPEG-4 AVC and MPEG-H HEVC</i>) SMPTE RP 177 Annex B (<i>only MPEG-2 Video and MPEG-4 AVC and MPEG-H HEVC</i>)	$E'_Y = 0.2126E'_R + 0.7152E'_G + 0.0722E'_B$ $E'_{PR} = E'_R - E'_Y / 1.5748$ $E'_{PB} = E'_B - E'_Y / 1.8556$
2	Unspecified	Image characteristics are unknown or determined by the application
3	Reserved	For future use by ITU-T/ISO/IEC
4	US NTSC 1953 Recommendation for transmission standards for colour television (<i>only MPEG-2 Video</i>) US 47 CFR 73.682 (a) (20)	$E'_Y = 0.30E'_R + 0.59E'_G + 0.11E'_B$ $E'_{PR} = E'_R - E'_Y / 1.40$ $E'_{PB} = E'_B - E'_Y / 1.78$
5	Recommendation ITU-R BT.1700 625 PAL and 625 SECAM (<i>only MPEG-2 Video and MPEG-4 AVC and MPEG-H HEVC</i>) IEC 61966-2-4 xvYCC ₆₀₁ (<i>only MPEG-2 Video, MPEG-4 AVC, MPEG-4 HEVC</i>) Recommendation ITU-R BT.470 systems B, G(historical) Recommendation ITU-R BT.601 625 (<i>only MPEG-2 Video and MPEG-4 AVC and MPEG-H HEVC</i>)	$E'_Y = 0.299E'_R + 0.587E'_G + 0.114E'_B$ $E'_{PR} = E'_R - E'_Y / 1.402$ $E'_{PB} = E'_B - E'_Y / 1.772$

TABLE 2.8 (continued)

matrix_coefficients	Systems and standards	Matrix
6	Recommendation ITU-R BT.1700 NTSC SMPTE 170 NTSC Recommendation ITU-R BT.601 525 (<i>only MPEG-2 Video, MPEG-4 AVC, MPEG-H HEVC</i>)	$E'_Y = 0.299E'_R + 0.587E'_G + 0.114E'_B$ $E'_{P_R} = E'_R - E'_Y / 1.402$ $E'_{P_B} = E'_B - E'_Y / 1.772$
7	SMPTE 240 (1999)	$E'_Y = 0.212E'_R + 0.701E'_G + 0.087E'_B$ $E'_{PR} = 0.500E'_R - 0.445E'_G - 0.055E'_B$ $E'_{PB} = -0.116E'_R - 0.384E'_G + 0.500E'_B$
8	<i>(only MPEG-2, MPEG-4 AVC, MPEG-H HEVC)</i>	<p style="text-align: center;">$YCgCo$ where Cg and Co may be referred as C_B and C_R respectively, where for n bit video Y, C_B and C_R are related to R, G and B as: $Y = \text{round}\left[0.5G + 0.25 R + B\right]$ $C_B = \text{round}\left[0.5G - 0.25 R + B\right] + 2^{n-1}$ $C_R = \text{round}\left[0.5 R - B\right] + 2^{n-1}$</p>
9	Rec. ITU-R BT.2020 non-constant luminance system (<i>only MPEG-4 AVC, MPEG-H HEVC</i>)	$Y' = 0.2627 R' + 0.6780 G' + 0.0593 B'$ $C'_B = \frac{B' - Y'}{1.8814}$ $C'_R = \frac{R' - Y'}{1.4746}$

TABLE 2.8 (END)

matrix_coefficients	Systems and standards	Matrix
10	Rec. ITU-R BT.2020 constant luminance system (<i>only MPEG-4 AVC, MPEG-H HEVC</i>)	$Y'_C = 0.2627 R + 0.6780 G + 0.0593 B'$ $C'_{BC} = \begin{cases} \frac{B' - Y'_C}{1.9404} & \text{for } -0.9702 \leq B' - Y'_C \leq 0 \\ \frac{B' - Y'_C}{1.5916} & \text{for } 0 < B' - Y'_C \leq 0,7908 \end{cases}$ $C'_{RC} = \begin{cases} \frac{R' - Y'_C}{1.7184} & \text{for } -0.8592 \leq B' - Y'_C \leq 0 \\ \frac{R' - Y'_C}{0.9936} & \text{for } 0 < B' - Y'_C \leq 0,4968 \end{cases}$
11-255		Reserved. For future use by ITU-T/ISO/IEC

- 7 Report ITU-R BT.2380-0:2015 *Television colorimetry elements*
- 8 Recommendation ITU-R BT.709-6:2015 *Parameter values for the HDTV standards for production and international programme exchange*
- 9 IEC 61966-2-1:1999 *Multimedia systems and equipment – Colour measurement and management – Part 2-1: Colour management – Default RGB colour space – sRGB*
- 10 IEC 61966-2-4:2006 *Multimedia systems and equipment – Colour management and colour measurement. Part 2-4: Colour management – Extended-gamut YCC colour space for video applications – xvYCC*
- 11 RP 177-1993 SMPTE Recommended Practice. *Derivation of Basic Television Colour Equations*
- 12 Recommendation ITU-R BT.470-7:2005 *Conventional analogue television systems*
- 13 Recommendation ITU-R BT.1700-07:2005 *Characteristics of composite video signals for conventional analogue television systems*
- 14 Recommendation ITU-R BT.601-07:2011 *Studio encoding parameters of digital television for standard 4:3 and wide screen 16:9 aspect ratios*
- 15 SMPTE ST 240M-1999 *SMPTE Television – 1125-Line High-Definition Production Systems – Signal Parameters*
- 16 Recommendation ITU-R BT.2020-2:2015 *Parameter values for ultra-high definition television systems for production and international programme exchange*
- 17 Recommendation ITU-R BT.2100-0:2016 *Image parameter values for high dynamic range television for use in production and international programme exchange*
- 18 SMPTE ST 428-1:2006 *D-Cinema Distribution Master — Image Characteristics.*
- 19 SMPTE RP 431-2:2011 *D-Cinema Quality — Reference Projector and Environment for the Display of DCDM in Review Rooms and Theaters*
- 20 SMPTE EG 432-1:2010 *Digital Source Processing — Color Processing for D-Cinema*
- 21 EBU TECH 3213:1975 *EBU Standard for Chromaticity Tolerances for Studio Monitors*
- 22 SMPTE ST 2084:2014 *Dynamic Range Electro-Optical Transfer Function of Mastering Reference Displays*
- 23 ARIB STD-B67:2015 *Essential parameter values for the Extended Image Dynamic Range Television (EIDRTV) system*