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AMENDMENT 1
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Information technology — High efficiency coding and media delivery in heterogeneous environments —

Part 2: High efficiency video coding

AMENDMENT 1: Additional colour representation code point

Technologies de l'information — Codage à haute efficacité et livraison des medias dans des environnements hétérogènes —

Partie 2: Codage vidéo à haute efficacité

AMENDEMENT 1: Point de codage de représentation de couleur supplémentaire

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 29, *Coding of audio, picture, multimedia and hypermedia information* in collaboration with ITU-T. A technically aligned twin text is published as ITU-T H.265.

A list of all parts in the ISO/IEC 23008 series can be found on the ISO website.

Information technology — High efficiency coding and media delivery in heterogeneous environments —

Part 2: High efficiency video coding

AMENDMENT 1: Additional colour representation code point

Page 19, Clause 4: Abbreviated terms

Add the following additional items (interspersed with the existing items in alphabetical order):

FCC Federal Communications Commission (of the United States)

NTSC National Television System Committee (of the United States)

SMPTE Society of Motion Picture and Television Engineers

Page 446, Annex E

In E.3.1, replace the semantics of video_full_range_flag, colour_description_present_flag, colour_primaries, transfer_characteristics, and matrix_coeffs, including Tables E.3, E.4, and E.5, with the following.

video_full_range_flag indicates the black level and range of the luma and chroma signals as derived from E'_Y, E'_{PB}, and E'_{PR} or E'_R, E'_G, and E'_B real-valued component signals.

When the video_full_range_flag syntax element is not present, the value of video_full_range_flag is inferred to be equal to 0.

colour_description_present_flag equal to 1 specifies that colour_primaries, transfer_characteristics, and matrix_coeffs are present. colour_description_present_flag equal to 0 specifies that colour_primaries, transfer_characteristics, and matrix_coeffs are not present.

colour_primaries indicates the chromaticity coordinates of the source primaries as specified in Table E.3 in terms of the CIE 1931 definition of x and y as specified in ISO 11664-1.

When the colour_primaries syntax element is not present, the value of colour_primaries is inferred to be equal to 2 (the chromaticity is unspecified or is determined by the application). Values of colour_primaries that are identified as reserved in Table E.3 are reserved for future use by ITU-T | ISO/IEC and shall not be present in bitstreams conforming to this version of this document. Decoders shall interpret reserved values of colour_primaries as equivalent to the value 2.

Table E.3 — Colour primaries interpretation using the colour_primaries syntax element

Value	Primaries			Informative remark
0	Reserved			For future use by ITU-T | ISO/IEC
1	primary	x	y	Rec. ITU-R BT.709–6
	green	0.300	0.600	Rec. ITU-R BT.1361–0 conventional colour gamut system and extended colour gamut system (historical)
	blue	0.150	0.060	IEC 61966-2-1 sRGB or sYCC
	red	0.640	0.330	IEC 61966-2-4
	white D65	0.312 7	0.329 0	SMPTE RP 177 (1993) Annex B
2	Unspecified			Image characteristics are unknown or are determined by the application.
3	Reserved			For future use by ITU-T | ISO/IEC
4	primary	x	y	Rec. ITU-R BT.470–6 System M (historical)
	green	0.21	0.71	NTSC Recommendation for transmission standards for colour television (1953)
	blue	0.14	0.08	FCC Title 47 Code of Federal Regulations (2003) 73.682 (a) (20)
	red	0.67	0.33	
	white C	0.310	0.316	
5	primary	x	y	Rec. ITU-R BT.470–6 System B, G (historical)
	green	0.29	0.60	Rec. ITU-R BT.601–7 625
	blue	0.15	0.06	Rec. ITU-R BT.1358–0 625 (historical)
	red	0.64	0.33	Rec. ITU-R BT.1700–0 625 PAL and 625 SECAM
	white D65	0.312 7	0.329 0	
6	primary	x	y	Rec. ITU-R BT.601–7 525
	green	0.310	0.595	Rec. ITU-R BT.1358–1 525 or 625 (historical)
	blue	0.155	0.070	Rec. ITU-R BT.1700–0 NTSC
	red	0.630	0.340	SMPTE ST 170 (2004)
	white D65	0.312 7	0.329 0	(functionally the same as the value 7)
7	primary	x	y	SMPTE ST 240 (1999, historical)
	green	0.310	0.595	(functionally the same as the value 6)
	blue	0.155	0.070	
	red	0.630	0.340	
	white D65	0.312 7	0.329 0	
8	primary	x	y	Generic film (colour filters using Illuminant C)
	green	0.243	0.692 (Wratten 58)	
	blue	0.145	0.049 (Wratten 47)	
	red	0.681	0.319 (Wratten 25)	
	white C	0.310	0.316	
9	primary	x	y	Rec. ITU-R BT.2020–2
	green	0.170	0.797	Rec. ITU-R BT.2100–1
	blue	0.131	0.046	
	red	0.708	0.292	
	white D65	0.312 7	0.329 0	

Table E.3 *(continued)*

Value	Primaries			Informative remark
10	primary	x	y	SMPTE ST 428-1 (2006)
	green (Y)	0.0	1.0	(CIE 1931 XYZ)
	blue (Z)	0.0	0.0	
	red (X)	1.0	0.0	
	centre white	1 ÷ 3	1 ÷ 3	
11	primary	x	y	SMPTE RP 431-2 (2011)
	green	0.265	0.690	
	blue	0.150	0.060	
	red	0.680	0.320	
	white	0.314	0.351	
12	primary	x	y	SMPTE EG 432-1 (2010)
	green	0.265	0.690	
	blue	0.150	0.060	
	red	0.680	0.320	
	white D65	0.312 7	0.329 0	
13...21	Reserved			For future use by ITU-T | ISO/IEC
22	primary	x	y	EBU Tech. 3213-E (1975)
	green	0.295	0.605	
	blue	0.155	0.077	
	red	0.630	0.340	
	white D65	0.312 7	0.329 0	
23...255	Reserved			For future use by ITU-T | ISO/IEC

transfer_characteristics, as specified in Table E.4, either indicates the reference opto-electronic transfer characteristic function of the source picture as a function of a source input linear optical intensity L_C with a nominal real-valued range of 0 to 1 or indicates the inverse of the reference electro-optical transfer characteristic function as a function of an output linear optical intensity L_O with a nominal real-valued range of 0 to 1. For interpretation of entries in Table E.4 that are expressed in terms of multiple curve segments parameterized by the variable α over a region bounded by the variable β or by the variables β and γ, the values of α and β are defined to be the positive constants necessary for the curve segments that meet at the value β to have continuity of value and continuity of slope at the value β, and the value of γ, when applicable, is defined to be the positive constant necessary for the associated curve segments to meet at the value γ. For example, for transfer_characteristics equal to 1, 6, 11, 14, or 15, α has the value $1 + 5.5 * \beta = 1.099\ 296\ 826\ 809\ 442...$ and β has the value 0.018 053 968 510 807....

When the transfer_characteristics syntax element is not present, the value of transfer_characteristics is inferred to be equal to 2 (the transfer characteristics are unspecified or are determined by the application). Values of transfer_characteristics that are identified as reserved in Table E.4 are reserved for future use by ITU-T | ISO/IEC and shall not be present in bitstreams conforming to this version of this document. Decoders shall interpret reserved values of transfer_characteristics as equivalent to the value 2.

NOTE 5 As indicated in Table E.4, some values of transfer_characteristics are defined in terms of a reference opto-electronic transfer characteristic function and others are defined in terms of a reference electro-optical transfer characteristic function, according to the convention that has been applied in other documents. In the cases of Rec. ITU-R BT.709-6 and Rec. ITU-R BT.2020-2 (which could be indicated by transfer_characteristics equal to 1, 6, 14, or 15), although the value is defined in terms of a reference opto-electronic transfer characteristic function, a suggested corresponding reference electro-optical transfer characteristic function for flat panel displays used in HDTV studio production has been specified in Rec. ITU-R BT.1886-0.

Table E.4 — Transfer characteristics interpretation using the transfer_characteristics syntax element

Value	Transfer characteristics		Informative remark
0	Reserved		For future use by ITU-T | ISO/IEC
1	$V = \alpha * L_c^{0.45} - (\alpha - 1)$ $V = 4.500 * L_c$	for $1 >= L_c >= \beta$ for $\beta > L_c >= 0$	Rec. ITU-R BT.709–6 Rec. ITU-R BT.1361–0 conventional colour gamut system (historical) (functionally the same as the values 6, 14, and 15)
2	Unspecified		Image characteristics are unknown or are determined by the application.
3	Reserved		For future use by ITU-T | ISO/IEC
4	Assumed display gamma 2.2		Rec. ITU-R BT.470–6 System M (historical) NTSC Recommendation for transmission standards for colour television (1953) FCC Title 47 Code of Federal Regulations (2003) 73.682 (a) (20)
5	Assumed display gamma 2.8		Rec. ITU-R BT.470–6 System B, G (historical) Rec. ITU-R BT.1700–0 625 PAL and 625 SECAM
6	$V = \alpha * L_c^{0.45} - (\alpha - 1)$ $V = 4.500 * L_c$	for $1 >= L_c >= \beta$ for $\beta > L_c >= 0$	Rec. ITU-R BT.601–7 525 or 625 Rec. ITU-R BT.1358–1 525 or 625 (historical) Rec. ITU-R BT.1700–0 NTSC SMPTE ST 170 (2004) (functionally the same as the values 1, 14, and 15)
7	$V = \alpha * L_c^{0.45} - (\alpha - 1)$ $V = 4.0 * L_c$	for $1 >= L_c >= \beta$ for $\beta > L_c >= 0$	SMPTE ST 240 (1999, historical)
8	$V = L_c$	for all values of L_c	Linear transfer characteristics
9	$V = 1.0 + \mathrm{Log10}(L_c) \div 2$ $V = 0.0$	for $1 >= L_c >= 0.01$ for $0.01 > L_c >= 0$	Logarithmic transfer characteristic (100:1 range)
10	$V = 1.0 + \mathrm{Log10}(L_c) \div 2.5$ $V = 0.0$	for $1 >= L_c >= \mathrm{Sqrt}(10) \div 1\,000$ for $\mathrm{Sqrt}(10) \div 1\,000 > L_c >= 0$	Logarithmic transfer characteristic (100 * Sqrt(10) : 1 range)
11	$V = \alpha * L_c^{0.45} - (\alpha - 1)$ $V = 4.500 * L_c$ $V = -\alpha * (-L_c)^{0.45} + (\alpha - 1)$	for $L_c >= \beta$ for $\beta > L_c >- \beta$ for $-\beta >= L_c$	IEC 61966-2-4
12	$V = \alpha * L_c^{0.45} - (\alpha - 1)$ $V = 4.500 * L_c$ $V = -[\alpha * (-4 * L_c)^{0.45} - (\alpha - 1)] \div 4$	for $1{,}33 > L_c > = \beta$ for $\beta > L_c >= -\gamma$ for $-\gamma > L_c >= -0.25$	Rec. ITU-R BT.1361–0 extended colour gamut system (historical)
13	$V = \alpha * L_c^{(1 \div 2.4)} - (\alpha - 1)$ $V = 12.92 * L_c$	for $1 > = L_c >= \beta$ for $\beta > L_c >= 0$	IEC 61966-2-1 sRGB or sYCC

Table E.4 *(continued)*

Value	Transfer characteristics	Informative remark
14	$V = \alpha * L_C^{0.45} - (\alpha - 1)$ for $1 >= L_C >= \beta$ $V = 4.500 * L_C$ for $\beta > L_C >= 0$	Rec. ITU-R BT.2020–2 (functionally the same as the values 1, 6, and 15)
15	$V = \alpha * L_C^{0.45} - (\alpha - 1)$ for $1 >= L_C >= \beta$ $V = 4.500 * L_C$ for $\beta > L_C >= 0$	Rec. ITU-R BT.2020–2 (functionally the same as the values 1, 6, and 14)
16	$V = ((c_1 + c_2 * L_o^n) \div (1 + c_3 * L_o^n))^m$ for all values of L_o $c_1 = c_3 - c_2 + 1 = 3\,424 \div 4\,096 = 0.835\,937\,5$ $c_2 = 32 * 2\,413 \div 4\,096 = 18.851\,562\,5$ $c_3 = 32 * 2\,392 \div 4\,096 = 18.687\,5$ $m = 128 * 2\,523 \div 4\,096 = 78.843\,75$ $n = 0.25 * 2\,610 \div 4\,096 = 0.159\,301\,757\,812\,5$ for which L_o equal to 1 for peak white is ordinarily intended to correspond to a reference output luminance level of 10 000 cd/m^2	SMPTE ST 2084 (2014) for 10, 12, 14, and 16-bit systems Rec. ITU-R BT.2100–1 perceptual quantization (PQ) system
17	$V = (48 * L_o \div 52.37)^{(1 \div 2.6)}$ for all values of L_o for which L_o equal to 1 for peak white is ordinarily intended to correspond to a reference output luminance level of 48 cd/m^2	SMPTE ST 428-1 (2006)
18	$V = a * Ln(12 * L_C - b) + c$ for $1 >= L_C > 1 \div 12$ $V = Sqrt(3) * L_C^{0.5}$ for $1 \div 12 >= L_C >= 0$ $a = 0.178\,832\,77$, $b = 0.284\,668\,92$, $c = 0.559\,910\,73$	Association of Radio Industries and Businesses (ARIB) STD-B67 Rec. ITU-R BT.2100–1 hybrid log-gamma (HLG) system
19..255	Reserved	For future use by ITU-T | ISO/IEC

NOTE 6 For transfer_characteristics equal to 18, the formulae given in Table E.4 are normalized for a source input linear optical intensity L_C with a nominal real-valued range of 0 to 1. An alternative scaling that is mathematically equivalent is used in ARIB STD-B67 with the source input linear optical intensity having a nominal real-valued range of 0 to 12.

matrix_coeffs describes the matrix coefficients used in deriving luma and chroma signals from the green, blue, and red, or Y, Z, and X primaries, as specified in Table E.5.

matrix_coeffs shall not be equal to 0 unless one or more of the following conditions are true:

— $BitDepth_C$ is equal to $BitDepth_Y$.

— chroma_format_idc is equal to 3 (the 4:4:4 chroma format).

The specification of the use of matrix_coeffs equal to 0 under all other conditions is reserved for future use by ITU-T | ISO/IEC.

matrix_coeffs shall not be equal to 8 unless one of the following conditions is true:

— $BitDepth_C$ is equal to $BitDepth_Y$,

— $BitDepth_C$ is equal to $BitDepth_Y + 1$ and chroma_format_idc is equal to 3 (the 4:4:4 chroma format).

The specification of the use of matrix_coeffs equal to 8 under all other conditions is reserved for future use by ITU-T | ISO/IEC.

When the matrix_coeffs syntax element is not present, the value of matrix_coeffs is inferred to be equal to 2 (unspecified).

The interpretation of matrix_coeffs, together with colour_primaries and transfer_characteristics, is specified by the formulae below.

NOTE 7 For purposes of YZX representation when matrix_coeffs is equal to 0, the symbols R, G, and B are substituted for X, Y, and Z, respectively, in the descriptions of Formulae (E.1) to (E.3), (E.13) to (E.15), (E.19) to (E.21) and (E.31) to (E.33).

E_R, E_G, and E_B are defined as "linear-domain" real-valued signals based on the indicated colour primaries before application of the transfer characteristics function.

Nominal peak white is specified as having E_R equal to 1, E_G equal to 1, and E_B equal to 1.

Nominal black is specified as having E_R equal to 0, E_G equal to 0, and E_B equal to 0,

The application of the transfer characteristics function is denoted by $(x)'$ for an argument x.

— If matrix_coeffs is not equal to 14, the signals E'_R, E'_G, and E'_B are determined by application of the transfer characteristics function as follows:

$$E'_R = (E_R)' \tag{E.1}$$

$$E'_G = (E_G)' \tag{E.2}$$

$$E'_B = (E_B)' \tag{E.3}$$

In this case, the range of E'_R, E'_G, and E'_B is specified as follows:

— If transfer_characteristics is not equal to 11 or 12, E'_R, E'_G, and E'_B are real numbers with values in the range of 0 to 1, inclusive.

— Otherwise, (transfer_characteristics is equal to 11 or 12), E'_R, E'_G and E'_B are real numbers with a larger range not specified in this document.

— Otherwise (matrix_coeffs is equal to 14), the "linear-domain" real-valued signals E_L, E_M, and E_S are determined as follows:

$$E_L = (1\,688 * E_R + 2\,146 * E_G + 262 * E_B) \div 4\,096 \tag{E.4}$$

$$E_M = (683 * E_R + 2\,951 * E_G + 462 * E_B) \div 4\,096 \tag{E.5}$$

$$E_S = (99 * E_R + 309 * E_G + 3688 * E_B) \div 4\,096 \tag{E.6}$$

In this case, the signals E'_L, E'_M, and E'_S are determined by application of the transfer characteristics function as follows:

$$E'_L = (E_L)' \tag{E.7}$$

$$E'_M = (E_M)' \tag{E.8}$$

$$E'_S = (E_S)' \tag{E.9}$$

The interpretation of matrix_coeffs is specified as follows:

— If video_full_range_flag is equal to 0, the following applies:

— If matrix_coeffs is equal to 1, 4, 5, 6, 7, 9, 10, 11, 12, 13, or 14, the following formulae apply:

$$Y = \mathrm{Clip1}_Y(\mathrm{Round}((1 << (\mathrm{BitDepth}_Y - 8)) * (219 * E'_Y + 16))) \quad \text{(E.10)}$$

$$Cb = \mathrm{Clip1}_C(\mathrm{Round}((1 << (\mathrm{BitDepth}_C - 8)) * (224 * E'_{PB} + 128))) \quad \text{(E.11)}$$

$$Cr = \mathrm{Clip1}_C(\mathrm{Round}((1 << (\mathrm{BitDepth}_C - 8)) * (224 * E'_{PR} + 128))) \quad \text{(E.12)}$$

— Otherwise, if matrix_coeffs is equal to 0 or 8, the following formulae apply:

$$R = \mathrm{Clip1}_Y((1 << (\mathrm{BitDepth}_Y - 8)) * (219 * E'_R + 16)) \quad \text{(E.13)}$$

$$G = \mathrm{Clip1}_Y((1 << (\mathrm{BitDepth}_Y - 8)) * (219 * E'_G + 16)) \quad \text{(E.14)}$$

$$B = \mathrm{Clip1}_Y((1 << (\mathrm{BitDepth}_Y - 8)) * (219 * E'_B + 16)) \quad \text{(E.15)}$$

— Otherwise, if matrix_coeffs is equal to 2, the interpretation of the matrix_coeffs syntax element is unknown or is determined by the application.

— Otherwise (matrix_coeffs is not equal to 0, 1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, or 14), the interpretation of the matrix_coeffs syntax element is reserved for future definition by ITU-T | ISO/IEC.

— Otherwise (video_full_range_flag is equal to 1), the following applies:

  — If matrix_coeffs is equal to 1, 4, 5, 6, 7, 9, 10, 11, 12, 13, or 14, the following applies:

$$Y = \mathrm{Clip1}_Y(\mathrm{Round}(((1 << \mathrm{BitDepth}_Y) - 1) * E'_Y)) \quad \text{(E.16)}$$

$$Cb = \mathrm{Clip1}_C(\mathrm{Round}(((1 << \mathrm{BitDepth}_C) - 1) * E'_{PB} + [1 << (\mathrm{BitDepth}_C - 1)])) \quad \text{(E.17)}$$

$$Cr = \mathrm{Clip1}_C(\mathrm{Round}(((1 << \mathrm{BitDepth}_C) - 1) * E'_{PR} + [1 << (\mathrm{BitDepth}_C - 1)])) \quad \text{(E.18)}$$

  — Otherwise, if matrix_coeffs is equal to 0 or 8, the following applies:

$$R = \mathrm{Clip1}_Y(((1 << \mathrm{BitDepth}_Y) - 1) * E'_R) \quad \text{(E.19)}$$

$$G = \mathrm{Clip1}_Y(((1 << \mathrm{BitDepth}_Y) - 1) * E'_G) \quad \text{(E.20)}$$

$$B = \mathrm{Clip1}_Y(((1 << \mathrm{BitDepth}_Y) - 1) * E'_B) \quad \text{(E.21)}$$

  — Otherwise, if matrix_coeffs is equal to 2, the interpretation of the matrix_coeffs syntax element is unknown or is determined by the application.

  — Otherwise (matrix_coeffs is not equal to 0, 1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, or 14), the interpretation of the matrix_coeffs syntax element is reserved for future definition by ITU-T | ISO/IEC. Reserved values for matrix_coeffs shall not be present in bitstreams conforming to this version of this document. Decoders shall interpret reserved values of matrix_coeffs as equivalent to the value 2.

It is a requirement of bitstream conformance to this version of this document that when colour_primaries is not equal to 1, 4, 5, 6, 7, 8, 9, 10, 11, 12, or 22, matrix_coeffs shall not be equal to 12 or 13.

When matrix_coeffs is equal to 1, 4, 5, 6, 7, 9, 10, 11, 12, or 13, the constants K_B and K_R are specified as follows:

— If matrix_coeffs is not equal to 12 or 13, the constants K_B and K_R are specified in Table E.5.

— Otherwise (matrix_coeffs is equal to 12 or 13), the constants K_R and K_B are computed as follows, using the chromaticity coordinates (x_R, y_R), (x_G, y_G), (x_B, y_B), and (x_W, y_W) specified by Table E.3 for the colour_primaries syntax element for the red, green, blue, and white colour primaries, respectively.

$$K_R = \frac{y_R * \left(x_W * \left(y_G * z_B - y_B * z_G\right) + y_W * \left(x_B * z_G - x_G * z_B\right) + z_W * \left(x_G * y_B - x_B * y_G\right)\right)}{y_W * \left(x_R * \left(y_G * z_B - y_B * z_G\right) + x_G * \left(y_B * z_R - y_R * z_B\right) + x_B * \left(y_R * z_G - y_G * z_R\right)\right)} \quad \text{(E.22)}$$

$$K_B = \frac{y_B * \left(x_W * \left(y_R * z_G - y_G * z_R\right) + y_W * \left(x_G * z_R - x_R * z_G\right) + z_W * \left(x_R * y_G - x_G * y_R\right)\right)}{y_W * \left(x_R * \left(y_G * z_B - y_B * z_G\right) + x_G * \left(y_B * z_R - y_R * z_B\right) + x_B * \left(y_R * z_G - y_G * z_R\right)\right)} \quad \text{(E.23)}$$

where the values of z_R, z_G, z_B, and z_W, are given by.

$$z_R = 1 - (x_R + y_R) \quad \text{(E.24)}$$

$$z_G = 1 - (x_G + y_G) \quad \text{(E.25)}$$

$$z_B = 1 - (x_B + y_B) \quad \text{(E.26)}$$

$$z_W = 1 - (x_W + y_W) \quad \text{(E.27)}$$

The variables E'_Y, E'_{PB}, and E'_{PR} (for matrix_coeffs not equal to 0 or 8) or Y, Cb, and Cr (for matrix_coeffs equal to 0 or 8) are specified as follows:

— If matrix_coeffs is not equal to 0, 8, 10, 11, 13, or 14, the following formulae apply:

$$E'_Y = K_R * E'_R + (1 - K_R - K_B) * E'_G + K_B * E'_B \quad \text{(E.28)}$$

$$E'_{PB} = 0.5 * (E'_B - E'_Y) \div (1 - K_B) \quad \text{(E.29)}$$

$$E'_{PR} = 0.5 * (E'_R - E'_Y) \div (1 - K_R) \quad \text{(E.30)}$$

NOTE 8 E'_Y is a real number with the value 0 associated with nominal black and the value 1 associated with nominal white. E'_{PB} and E'_{PR} are real numbers with the value 0 associated with both nominal black and nominal white. When transfer_characteristics is not equal to 11 or 12, E'_Y is a real number with values in the range of 0 to 1 inclusive. When transfer_characteristics is not equal to 11 or 12, E'_{PB} and E'_{PR} are real numbers with values in the range of −0.5 to 0.5 inclusive. When transfer_characteristics is equal to 11 or 12, E'_Y, E'_{PB}, and E'_{PR} are real numbers with a larger range not specified in this document.

— Otherwise, if matrix_coeffs is equal to 0, the following formulae apply:

$$Y = \mathrm{Round}(G) \quad \text{(E.31)}$$

$$Cb = \mathrm{Round}(B) \quad \text{(E.32)}$$

$$Cr = \mathrm{Round}(R) \quad \text{(E.33)}$$

— Otherwise, if matrix_coeffs is equal to 8, the following applies:

— If $BitDepth_C$ is equal to $BitDepth_Y$, the following formulae apply:

$$Y = Round(0.5 * G + 0.25 * (R + B)) \tag{E.34}$$

$$Cb = Round(0.5 * G - 0.25 * (R + B)) + (1 << (BitDepth_C - 1)) \tag{E.35}$$

$$Cr = Round(0.5 * (R - B)) + (1 << (BitDepth_C - 1)) \tag{E.36}$$

NOTE 9 In this case, for purposes of the YCgCo nomenclature used in Table E.5, Cb, and Cr of Formulae (E.35) and (E.36) can be referred to as Cg and Co, respectively. An appropriate inverse conversion for Formulae (E.34) to (E.36) is as follows:

$$t = Y - (Cb - (1 << (BitDepth_C - 1))) \tag{E.37}$$

$$G = Clip1_Y(Y + (Cb - (1 << (BitDepth_C - 1)))) \tag{E.38}$$

$$B = Clip1_Y(t - (Cr - (1 << (BitDepth_C - 1)))) \tag{E.39}$$

$$R = Clip1_Y(t + (Cr - (1 << (BitDepth_C - 1)))) \tag{E.40}$$

— Otherwise ($BitDepth_C$ is not equal to $BitDepth_Y$), the following formulae apply:

$$Cr = Round(R) - Round(B) + (1 << (BitDepth_C - 1)) \tag{E.41}$$

$$t = Round(B) + ((Cr - (1 << (BitDepth_C - 1))) >> 1) \tag{E.42}$$

$$Cb = Round(G) - t + (1 << (BitDepth_C - 1)) \tag{E.43}$$

$$Y = t + ((Cb - (1 << (BitDepth_C - 1))) >> 1) \tag{E.44}$$

NOTE 10 In this case, for purposes of the YCgCo nomenclature used in Table E.5, Cb and Cr of Formulae (E.43) and (E.41) can be referred to as Cg and Co, respectively. An appropriate inverse conversion for Formulae (E.41) to (E.44) is as follows:

$$t = Y - ((Cb - (1 << (BitDepth_C - 1))) >> 1) \tag{E.45}$$

$$G = Clip1_Y(t + (Cb - (1 << (BitDepth_C - 1)))) \tag{E.46}$$

$$B = Clip1_Y(t - ((Cr - (1 << (BitDepth_C - 1))) >> 1)) \tag{E.47}$$

$$R = Clip1_Y(B + (Cr - (1 << (BitDepth_C - 1)))) \tag{E.48}$$

— Otherwise, if matrix_coeffs is equal to 10 or 13, the signal E'_Y is determined by application of the transfer characteristics function as follows and Formulae (E.51) to (E.54) apply for specification of the signals E'_{PB} and E'_{PR}:

$$E_Y = K_R * E_R + (1 - K_R - K_B) * E_G + K_B * E_B \tag{E.49}$$

$$E'_Y = (E_Y)' \tag{E.50}$$

NOTE 11 In this case, E_Y is defined from the "linear-domain" signals for E_R, E_G, and E_B, prior to application of the transfer characteristics function, which is then applied to produce the signal E'_Y. E_Y and E'_Y are real values with the value 0 associated with nominal black and the value 1 associated with nominal white.

while the signals E'_{PB} and E'_{PR} are determined as follows:

$$E'_{PB} = (E'_B - E'_Y) \div (2 * N_B) \quad \text{for } -N_B <= E'_B - E'_Y <= 0 \tag{E.51}$$

$$E'_{PB} = (E'_B - E'_Y) \div (2 * P_B) \quad \text{for } 0 < E'_B - E'_Y <= P_B \tag{E.52}$$

$$E'_{PR} = (E'_R - E'_Y) \div (2 * N_R) \quad \text{for } -N_R <= E'_R - E' <= 0 \tag{E.53}$$

$$E'_{PR} = (E'_R - E'_Y) \div (2 * P_R) \quad \text{for } 0 < E'_R - E'_Y <= P_R \tag{E.54}$$

where the constants N_B, P_B, N_R, and P_R are determined by application of the transfer characteristics function to expressions involving the constants K_B and K_R as follows:

$$N_B = (1 - K_B)' \tag{E.55}$$

$$P_B = 1 - (K_B)' \tag{E.56}$$

$$N_R = (1 - K_R)' \tag{E.57}$$

$$P_R = 1 - (K_R)' \tag{E.58}$$

— Otherwise, if matrix_coeffs is equal to 11, the following formulae apply:

$$E'_Y = E'_G \tag{E.59}$$

$$E'_{PB} = 0.5 * (0.986\,566 * E'_B - E'_Y) \tag{E.60}$$

$$E'_{PR} = 0.5 * (E'_R - 0.991\,902 * E'_Y) \tag{E.61}$$

NOTE 12 In this case, for purposes of the $Y'D'_ZD'_X$ nomenclature used in Table E.5, E'_{PB} can be referred to as D'_Z and E'_{PR} can be referred to as D'_X.

— Otherwise (matrix_coeffs is equal to 14), the following formulae apply:

$$E'_Y = 0.5 * (E'_L + E'_M) \tag{E.62}$$

$$E'_{PB} = (6\,610 * E'_L - 13\,613 * E'_M + 7\,003 * E'_S) \div 4\,096 \tag{E.63}$$

$$E'_{PR} = (17\,933 * E'_L - 17\,390 * E'_M - 543 * E'_S) \div 4\,096 \tag{E.64}$$

NOTE 13 In this case, for purposes of the IC_TC_P nomenclature used in Table E.5, E'_Y, E'_{PB}, and E'_{PR} of Formulae (E.62), (E.63), and (E.64) can be referred to as I, C_T, and C_P, respectively.

