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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 médias 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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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_coefs`, 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_coefs` are present. `colour_description_present_flag` equal to 0 specifies that `colour primaries`, `transfer_characteristics`, and `matrix_coefs` 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) (CIE 1931 XYZ)
	green (Y)	0.0	1.0	
	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 $1 + 5.5 * \beta = 1.099\ 296\ 826\ 809\ 442\dots$ and β has the value $0.018\ 053\ 968\ 510\ 807\dots$

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	$V = \alpha * L_c^{0.45} - (\alpha - 1)$ for $1 \geq L_c \geq \beta$ $V = 4.500 * L_c$ for $\beta > L_c \geq 0$	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	$V = \alpha * L_c^{0.45} - (\alpha - 1)$ for $1 \geq L_c \geq \beta$ $V = 4.500 * L_c$ for $\beta > L_c \geq 0$	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	$V = \alpha * L_c^{0.45} - (\alpha - 1)$ for $1 \geq L_c \geq \beta$ $V = 4.0 * L_c$ for $\beta > L_c \geq 0$	SMPTE ST 240 (1999, historical)
8	$V = L_c$ for all values of L_c	Linear transfer characteristics
9	$V = 1.0 + \text{Log}_{10}(L_c) \div 2$ for $1 \geq L_c \geq 0.01$ $V = 0.0$ for $0.01 > L_c \geq 0$	Logarithmic transfer characteristic (100:1 range)
10	$V = 1.0 + \text{Log}_{10}(L_c) \div 2.5$ for $1 \geq L_c \geq \text{Sqrt}(10) \div 1\ 000$ $V = 0.0$ for $\text{Sqrt}(10) \div 1\ 000 > L_c \geq 0$	Logarithmic transfer characteristic (100 * Sqrt(10) : 1 range)
11	$V = \alpha * L_c^{0.45} - (\alpha - 1)$ for $L_c \geq \beta$ $V = 4.500 * L_c$ for $\beta > L_c > -\beta$ $V = -\alpha * (-L_c)^{0.45} + (\alpha - 1)$ for $-\beta \geq L_c$	IEC 61966-2-4
12	$V = \alpha * L_c^{0.45} - (\alpha - 1)$ for $1,33 > L_c \geq \beta$ $V = 4.500 * L_c$ for $\beta > L_c \geq -\gamma$ $V = -[\alpha * (-4 * L_c)^{0.45} - (\alpha - 1)] \div 4$ for $-\gamma > L_c \geq -0.25$	Rec. ITU-R BT.1361-0 extended colour gamut system (historical)
13	$V = \alpha * L_c^{(1 \div 2.4)} - (\alpha - 1)$ for $1 \geq L_c \geq \beta$ $V = 12.92 * L_c$ for $\beta > L_c \geq 0$	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 $1 \geq L_c \geq \beta$ $V = 4.500 * L_c$ for $\beta > L_c \geq 0$	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 $1 \geq L_c \geq \beta$ $V = 4.500 * L_c$ for $\beta > L_c \geq 0$	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	$V = a * \text{Ln}(12 * L_c - b) + c$ for $1 \geq L_c > 1 \div 12$ $V = \text{Sqrt}(3) * L_c^{0.5}$ for $1 \div 12 \geq L_c \geq 0$ $a = 0.178\,832\,77, b = 0.284\,668\,92, c = 0.559\,910\,73$	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:

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

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

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

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

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

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

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

— 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:

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

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

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

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

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

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

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

— 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.

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

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

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

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

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

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

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

The variables E'_Y , E'_{PB} , and E'_{PR} (for matrix_coeffs not equal to 0 or 8) or Y , C_b , and C_r (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:

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

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

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

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:

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

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

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

- Otherwise, if `matrix_coeffs` is equal to 8, the following applies:
 - If `BitDepthC` is equal to `BitDepthY`, the following formulae apply:

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

$$Cb = \text{Round}(0.5 * G - 0.25 * (R + B)) + (1 \ll (\text{BitDepth}_C - 1)) \quad (\text{E.35})$$

$$Cr = \text{Round}(0.5 * (R - B)) + (1 \ll (\text{BitDepth}_C - 1)) \quad (\text{E.36})$$

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:

$$t = Y - (Cb - (1 \ll (\text{BitDepth}_C - 1))) \quad (\text{E.37})$$

$$G = \text{Clip}_{1Y}(Y + (Cb - (1 \ll (\text{BitDepth}_C - 1)))) \quad (\text{E.38})$$

$$B = \text{Clip}_{1Y}(t - (Cr - (1 \ll (\text{BitDepth}_C - 1)))) \quad (\text{E.39})$$

$$R = \text{Clip}_{1Y}(t + (Cr - (1 \ll (\text{BitDepth}_C - 1)))) \quad (\text{E.40})$$

- Otherwise (`BitDepthC` is not equal to `BitDepthY`), the following formulae apply:

$$Cr = \text{Round}(R) - \text{Round}(B) + (1 \ll (\text{BitDepth}_C - 1)) \quad (\text{E.41})$$

$$t = \text{Round}(B) + (((Cr - (1 \ll (\text{BitDepth}_C - 1)))) \gg 1) \quad (\text{E.42})$$

$$Cb = \text{Round}(G) - t + (1 \ll (\text{BitDepth}_C - 1)) \quad (\text{E.43})$$

$$Y = t + (((Cb - (1 \ll (\text{BitDepth}_C - 1)))) \gg 1) \quad (\text{E.44})$$

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:

$$t = Y - (((Cb - (1 \ll (\text{BitDepth}_C - 1)))) \gg 1) \quad (\text{E.45})$$

$$G = \text{Clip}_{1Y}(t + (Cb - (1 \ll (\text{BitDepth}_C - 1)))) \quad (\text{E.46})$$

$$B = \text{Clip}_{1Y}(t - (((Cr - (1 \ll (\text{BitDepth}_C - 1)))) \gg 1)) \quad (\text{E.47})$$

$$R = \text{Clip}_{1Y}(B + (Cr - (1 \ll (\text{BitDepth}_C - 1)))) \quad (\text{E.48})$$

- 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} :

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

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

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:

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

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

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

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

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:

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

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

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

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

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

$$E'_Y = E'_G \quad (\text{E.59})$$

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

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

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:

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

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

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

NOTE 13 In this case, for purposes of the $IC_T C_P$ 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.