

Third edition  
2017-10-15

AMENDMENT 1  
2018-03

---

---

**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*



Reference number  
ISO/IEC 23008-2:2017/Amd.1:2018(E)

© ISO/IEC 2018

IECNORM.COM : Click to view the full PDF of ISO/IEC 23008-2:2017/Amd 1:2018



**COPYRIGHT PROTECTED DOCUMENT**

© ISO/IEC 2018

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office  
CP 401 • Ch. de Blandonnet 8  
CH-1214 Vernier, Geneva  
Phone: +41 22 749 01 11  
Fax: +41 22 749 09 47  
Email: [copyright@iso.org](mailto:copyright@iso.org)  
Website: [www.iso.org](http://www.iso.org)

Published in Switzerland

## Foreword

ISO (the International Organization for Standardization) and IEC (the International Electrotechnical Commission) form the specialized system for worldwide standardization. National bodies that are members of ISO or IEC participate in the development of International Standards through technical committees established by the respective organization to deal with particular fields of technical activity. ISO and IEC technical committees collaborate in fields of mutual interest. Other international organizations, governmental and non-governmental, in liaison with ISO and IEC, also take part in the work. In the field of information technology, ISO and IEC have established a joint technical committee, ISO/IEC JTC 1.

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](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO and IEC shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

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.

IECNORM.COM : Click to view the full PDF of ISO/IEC 23008-2:2017/Amd 1:2018

# 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  $\alpha$  over a region bounded by the variable  $\beta$  or by the variables  $\beta$  and  $\gamma$ , the values of  $\alpha$  and  $\beta$  are defined to be the positive constants necessary for the curve segments that meet at the value  $\beta$  to have continuity of value and continuity of slope at the value  $\beta$ , and the value of  $\gamma$ , when applicable, is defined to be the positive constant necessary for the associated curve segments to meet at the value  $\gamma$ . For example, for transfer\_characteristics equal to 1, 6, 11, 14, or 15,  $\alpha$  has the value  $1 + 5.5 * \beta = 1.099\ 296\ 826\ 809\ 442\dots$  and  $\beta$  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 <sup>2</sup>	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 <sup>2</sup>	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<sub>C</sub> is equal to BitDepth<sub>Y</sub>.
- 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<sub>C</sub> is equal to BitDepth<sub>Y</sub>,
- BitDepth<sub>C</sub> is equal to BitDepth<sub>Y</sub> + 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  $\text{BitDepth}_C$  is equal to  $\text{BitDepth}_Y$ , 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:

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

$$G = \text{Clip1}_Y(Y + (Cb - (1 \ll (\text{BitDepth}_C - 1)))) \quad (\text{E.38})$$

$$B = \text{Clip1}_Y(t - (Cr - (1 \ll (\text{BitDepth}_C - 1)))) \quad (\text{E.39})$$

$$R = \text{Clip1}_Y(t + (Cr - (1 \ll (\text{BitDepth}_C - 1)))) \quad (\text{E.40})$$

— Otherwise ( $\text{BitDepth}_C$  is not equal to  $\text{BitDepth}_Y$ ), 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:

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

$$G = \text{Clip1}_Y(t + (Cb - (1 \ll (\text{BitDepth}_C - 1)))) \quad (\text{E.46})$$

$$B = \text{Clip1}_Y(t - (((Cr - (1 \ll (\text{BitDepth}_C - 1)))) \gg 1)) \quad (\text{E.47})$$

$$R = \text{Clip1}_Y(B + (Cr - (1 \ll (\text{BitDepth}_C - 1)))) \quad (\text{E.48})$$

— 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.