

Eighth edition
2014-09-01

AMENDMENT 1
2015-11-15

**Information technology — Coding of
audio-visual objects —**

Part 10:

Advanced Video Coding

**AMENDMENT 1: Multi-Resolution frame
compatible stereoscopic video with
depth maps, additional supplemental
enhancement information and video
usability information**

*Technologies de l'information — Codage des objets audiovisuels —
Partie 10: Codage visuel avancé*

*AMENDEMENT 1: Vidéo stéréoscopique multi-résolution à cadre
compatible avec cartes de profondeur, information additionnelle
d'amélioration supplémentaire et information relative à
l'utilisabilité de la vidéo*

Reference number
ISO/IEC 14496-10:2014/Amd.1:2015(E)





COPYRIGHT PROTECTED DOCUMENT

© ISO/IEC 2015, Published in Switzerland

All rights reserved. Unless otherwise specified, 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
Ch. de Blandonnet 8 • CP 401
CH-1214 Vernier, Geneva, Switzerland
Tel. +41 22 749 01 11
Fax +41 22 749 09 47
copyright@iso.org
www.iso.org

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).

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).

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 meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: [Foreword - Supplementary information](#)

The committee responsible for this document is ISO/IEC JTC 1, *Information technology*, Subcommittee SC 29, *Coding of audio, picture, multimedia and hypermedia information*.

STANDARDSISO.COM : Click to view the full PDF of ISO/IEC 14496-10:2014/Amd 1:2015

Information technology — Coding of audio-visual objects —

Part 10: Advanced Video Coding

AMENDMENT 1: Multi-Resolution frame compatible stereoscopic video with depth maps, additional supplemental enhancement information and video usability information

Page xvi, 0.4

At the end of 0.4, add the following:

Rec. ITU T H.264 | ISO/IEC 14496-10 version 23 (the current Specification) refers to the integrated version 22 text after its amendment to specify multi-resolution frame-compatible (MFC) stereoscopic video with depth maps, including the specification of an additional profile, the MFC Depth High profile, and the mastering display colour volume SEI message, additional colour-related video usability information codepoint identifiers, and miscellaneous minor corrections and clarifications.

Page xx, 0.7

Replace the sentence

Subclause I.10 specifies one profile for MVCD (Multiview and Depth).

with

Subclause I.10 specifies two profiles for MVCD (Multiview Depth High, and MFC Depth High).

Page 42, 7.3.2.1.1

Replace the syntax table with the following:

seq_parameter_set_data() {	C	Descriptor
profile_idc	0	u(8)
constraint_set0_flag	0	u(1)
constraint_set1_flag	0	u(1)
constraint_set2_flag	0	u(1)
constraint_set3_flag	0	u(1)
constraint_set4_flag	0	u(1)
constraint_set5_flag	0	u(1)
reserved_zero_2bits /* equal to 0 */	0	u(2)
level_idc	0	u(8)
seq_parameter_set_id	0	ue(v)

if(profile_idc == 100 profile_idc == 110 profile_idc == 122 profile_idc == 244 profile_idc == 44 profile_idc == 83 profile_idc == 86 profile_idc == 118 profile_idc == 128 profile_idc == 138 profile_idc == 139 profile_idc == 134 profile_idc == 135) {		
chroma_format_idc	0	ue(v)
if(chroma_format_idc == 3)		
separate_colour_plane_flag	0	u(1)
bit_depth_luma_minus8	0	ue(v)
bit_depth_chroma_minus8	0	ue(v)
qpprime_y_zero_transform_bypass_flag	0	u(1)
seq_scaling_matrix_present_flag	0	u(1)
if(seq_scaling_matrix_present_flag)		
for (i = 0; i < ((chroma_format_idc != 3) ? 8 : 12); i++) {		
seq_scaling_list_present_flag[i]	0	u(1)
if(seq_scaling_list_present_flag[i])		
if(i < 6)		
scaling_list(ScalingList4x4[i], 16, UseDefaultScalingMatrix4x4Flag[i])	0	
else		
scaling_list(ScalingList8x8[i - 6], 64, UseDefaultScalingMatrix8x8Flag[i - 6])	0	
}		
}		
log2_max_frame_num_minus4	0	ue(v)
pic_order_cnt_type	0	ue(v)
if(pic_order_cnt_type == 0)		
log2_max_pic_order_cnt_lsb_minus4	0	ue(v)
else if(pic_order_cnt_type == 1) {		
delta_pic_order_always_zero_flag	0	u(1)
offset_for_non_ref_pic	0	se(v)
offset_for_top_to_bottom_field	0	se(v)
num_ref_frames_in_pic_order_cnt_cycle	0	ue(v)
for(i = 0; i < num_ref_frames_in_pic_order_cnt_cycle; i++)		
offset_for_ref_frame[i]	0	se(v)
}		
max_num_ref_frames	0	ue(v)
gaps_in_frame_num_value_allowed_flag	0	u(1)
pic_width_in_mbs_minus1	0	ue(v)
pic_height_in_map_units_minus1	0	ue(v)
frame_mbs_only_flag	0	u(1)
if(!frame_mbs_only_flag)		
mb_adaptive_frame_field_flag	0	u(1)

direct_8x8_inference_flag	0	u(1)
frame_cropping_flag	0	u(1)
if(frame_cropping_flag) {		
frame_crop_left_offset	0	ue(v)
frame_crop_right_offset	0	ue(v)
frame_crop_top_offset	0	ue(v)
frame_crop_bottom_offset	0	ue(v)
}		
vui_parameters_present_flag	0	u(1)
if(vui_parameters_present_flag)		
vui_parameters	0	
}		

Page 45, 7.3.2.1.3

Replace the syntax table with the following:

	C	Descriptor
subset_seq_parameter_set_rbsp() {		
seq_parameter_set_data()	0	
if(profile_idc == 83 profile_idc == 86) {		
seq_parameter_set_svc_extension() /* specified in Annex G */	0	
svc_vui_parameters_present_flag	0	u(1)
if(svc_vui_parameters_present_flag == 1)		
svc_vui_parameters_extension() /* specified in Annex G */	0	
} else if(profile_idc == 118 profile_idc == 128 profile_idc == 134) {		
bit_equal_to_one /* equal to 1 */	0	f(1)
seq_parameter_set_mvc_extension() /* specified in Annex H */	0	
mvc_vui_parameters_present_flag	0	u(1)
if(mvc_vui_parameters_present_flag == 1)		
mvc_vui_parameters_extension() /* specified in Annex H */	0	
} else if(profile_idc == 138 profile_idc == 135) {		
bit_equal_to_one /* equal to 1 */	0	f(1)
seq_parameter_set_mvcd_extension() /* specified in Annex I */		
} else if(profile_idc == 139) {		
bit_equal_to_one /* equal to 1 */	0	f(1)
seq_parameter_set_mvcd_extension() /* specified in Annex I */		
seq_parameter_set_3davc_extension() /* specified in Annex J */	0	
}		
additional_extension2_flag	0	u(1)
if(additional_extension2_flag == 1)		
while(more_rbsp_data())		
additional_extension2_data_flag	0	u(1)
rbsp_trailing_bits()	0	
}		

Page 346, D.1

Insert the following before the row containing only “else”:

else if(payloadType == 137)		
mastering_display_colour_volume(payloadSize)	5	

Page 360, D.1.27

Renumber D.1.27 as D.1.28.

Add the following new subclause as D.1.27:

D.1.27 Mastering display colour volume SEI message syntax

mastering_display_colour_volume(payloadSize) {	C	Descriptor
for(c = 0; c < 3; c++) {		
display primaries_x[c]	5	u(16)
display primaries_y[c]	5	u(16)
}		
white_point_x	5	u(16)
white_point_y	5	u(16)
max_display_mastering_luminance	5	u(32)
min_display_mastering_luminance	5	u(32)
}		

Page 405, D.2.27

Renumber D.2.27 as D.2.28.

Add the following new subclause as D.2.27:

D.2.27 Mastering display colour volume SEI message semantics

This SEI message identifies the colour volume (the colour primaries, white point, and luminance range) of a display considered to be the mastering display for the associated video content, e.g. the colour volume of a display that was used for viewing while authoring the video content. The described mastering display is a three-colour additive display system that has been configured to use the indicated mastering colour volume.

This SEI message does not specify the measurement methodologies and procedures used for determining the indicated values or any description of the mastering environment. It also does not provide information on colour transformations that would be appropriate to preserve creative intent on displays with colour volumes different from that of the described mastering display.

The information conveyed in this SEI message is intended to be adequate for purposes corresponding to the use of Society of Motion Picture and Television Engineers ST 2086.

The following constraints apply for the presence of mastering display colour volume SEI messages in IDR access units:

- when a mastering display colour volume SEI message is present in any access unit of a coded video sequence and the mastering display colour volume SEI message is not contained within any other SEI message, a mastering display colour volume SEI message that is not contained within any other SEI message shall be present in the IDR access unit that is the first access unit of the coded video sequence;
- when a mastering display colour volume SEI message is present in any access unit of a coded video sequence and the mastering display colour volume SEI message is contained in a scalable

nesting SEI message applying to dependency_id dId, quality_id qId, and temporal_id tId, a mastering display colour volume SEI message that is contained in a scalable nesting SEI message applying to dependency_id equal to dId, quality_id equal to qId, and temporal_id equal to tId shall be present in the IDR access unit that is the first access unit of the coded video sequence;

- when a mastering display colour volume SEI message is present in any access unit of a coded video sequence and the mastering display colour volume SEI message is contained in an MVC scalable nesting SEI message applying to view_id vId and temporal_id tId, a mastering display colour volume SEI message that is contained in an MVC scalable nesting SEI message applying to view_id equal to vId and temporal_id equal to tId shall be present in the IDR access unit that is the first access unit of the coded video sequence;
- when a mastering display colour volume SEI message is present in any access unit of a coded video sequence and the mastering display colour volume SEI message is contained in an MVCD scalable nesting SEI message applying to texture views with view_id vId and temporal_id tId, a mastering display colour volume SEI message that is contained in an MVCD scalable nesting SEI message applying to texture views with view_id equal to vId and temporal_id equal to tId shall be present in the IDR access unit that is the first access unit of the coded video sequence.

The mastering display colour volume SEI message persists in decoding order from the current access unit until the end of the coded video sequence.

When a mastering display colour volume SEI message is not contained within any other SEI message, it pertains only to VCL NAL units with nal_unit_type in the range of 1 to 5, inclusive.

NOTE When the bitstream is a scalable video bitstream according to Annex G, a mastering display colour volume SEI message that is not contained within any other SEI message applies only to the base layer bitstream. When the bitstream is a multiview video bitstream according to Annex H, a mastering display colour volume SEI message that is not contained within any other SEI message applies only to the base layer bitstream. When the bitstream is a multiview video bitstream with depth according to Annex I or Annex J, a mastering display colour volume SEI message that is not contained within any other SEI message applies only to the base texture view.

The following constraints apply for the content of mastering display colour volume SEI messages:

- all mastering display colour volume SEI messages that apply to the same coded video sequence and are not contained within any other SEI message shall have the same content;
- all mastering display colour volume SEI messages that apply to the same coded video sequence and are contained in a scalable nesting SEI message applying to particular values of dependency_id, quality_id, and temporal_id shall have the same content;
- all mastering display colour volume SEI messages that apply to the same coded video sequence and are contained in an MVC scalable nesting SEI message applying to particular values of view_id and temporal_id shall have the same content;
- all mastering display colour volume SEI messages that apply to the same coded video sequence and are contained in an MVCD scalable nesting SEI message applying to texture views with particular values of view_id and temporal_id shall have the same content.

display primaries_x[c] and **display primaries_y[c]** specify the normalized x and y chromaticity coordinates, respectively, of the colour primary component c of the mastering display in increments of 0.00002, according to the CIE 1931 definition of x and y as specified in ISO 11664-1 (see also ISO 11664-3 and CIE 15). For describing mastering displays that use red, green, and blue colour primaries, it is suggested that index value c equal to 0 should correspond to the green primary, c equal to 1 should correspond to the blue primary, and c equal to 2 should correspond to the red colour primary (see also Annex E and Table E-3). The values of display primaries_x[c] and display primaries_y[c] shall be in the range of 0 to 50 000, inclusive.

white_point_x and **white_point_y** specify the normalized x and y chromaticity coordinates, respectively, of the white point of the mastering display in normalized increments of 0.00002, according

to the CIE 1931 definition of x and y as specified in ISO 11664-1 (see also ISO 11664-3 and CIE 15). The values of `white_point_x` and `white_point_y` shall be in the range of 0 to 50 000.

max_display_mastering_luminance and **min_display_mastering_luminance** specify the nominal maximum and minimum display luminance, respectively, of the mastering display in units of 0.0001 candelas per square metre. `min_display_mastering_luminance` shall be less than `max_display_mastering_luminance`.

At minimum luminance, the mastering display is considered to have the same nominal chromaticity as the white point.

STANDARDSISO.COM : Click to view the full PDF of ISO/IEC 14496-10:2014/Amd 1:2015

Replace Table E-3 with the following:

Table E-3 — Colour primaries

Value	Primaries	Informative remark
0	Reserved	For future use by ITU-T ISO/IEC
1	primary x y green 0.300 0.600 blue 0.150 0.060 red 0.640 0.330 white D65 0.3127 0.3290	Rec. ITU-R BT.709-5 Rec. ITU-R BT.1361 conventional colour gamut system and extended colour gamut system IEC 61966-2-1 (sRGB or sYCC) IEC 61966-2-4 Society of Motion Picture and Television Engineers 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 green 0.21 0.71 blue 0.14 0.08 red 0.67 0.33 white C 0.310 0.316	Rec. ITU-R BT.470-6 System M (historical) United States National Television System Committee 1953 Recommendation for transmission standards for colour television United States Federal Communications Commission Title 47 Code of Federal Regulations (2003) 73.682 (a) (20)
5	primary x y green 0.29 0.60 blue 0.15 0.06 red 0.64 0.33 white D65 0.3127 0.3290	Rec. ITU-R BT.470-6 System B, G (historical) Rec. ITU-R BT.601-6 625 Rec. ITU-R BT.1358 625 Rec. ITU-R BT.1700 625 PAL and 625 SECAM
6	primary x y green 0.310 0.595 blue 0.155 0.070 red 0.630 0.340 white D65 0.3127 0.3290	Rec. ITU-R BT.601-6 525 Rec. ITU-R BT.1358 525 Rec. ITU-R BT.1700 NTSC Society of Motion Picture and Television Engineers 170M (2004) (functionally the same as the value 7)
7	primary x y green 0.310 0.595 blue 0.155 0.070 red 0.630 0.340 white D65 0.3127 0.3290	Society of Motion Picture and Television Engineers 240M (1999) (functionally the same as the value 6)
8	primary x y 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	Generic film (colour filters using Illuminant C)

Value	Primaries			Informative remark
9	primary	x	y	Rec. ITU-R BT.2020
	green	0.170	0.797	
	blue	0.131	0.046	
	red	0.708	0.292	
	white D65	0.3127	0.3290	
10	primary	x	y	Society of Motion Picture and Television Engineers ST 428-1 (CIE 1931 XYZ)
	Y	0.0	1.0	
	Z	0.0	0.0	
	X	1.0	0.0	
	centre white	1 ÷ 3	1 ÷ 3	
11	primary	x	y	Society of Motion Picture and Television Engineers ST 431-2 (DCI P3)
	green	0.264	0.690	
	blue	0.150	0.060	
	red	0.680	0.320	
	white DCI	0.314	0.351	
12	primary	x	y	Society of Motion Picture and Television Engineers ST 432-1 (P3 D65)
	green	0.264	0.690	
	blue	0.150	0.060	
	red	0.680	0.320	
	white D65	0.3127	0.3290	
13..255	Reserved			For future use by ITU-T ISO/IEC

Page 408, E.2

Replace the semantics of transfer_characteristics with the following:

transfer_characteristics indicates the opto-electronic transfer characteristic of the source picture as specified in Table E-4 as a function of a linear optical intensity input L_c 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, 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 Specification. Decoders shall interpret reserved values of transfer_characteristics as equivalent to the value 2.

Replace Table E-4 with the following:

Table E-4 — Transfer characteristics

Value	Transfer characteristic	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.709-5 Rec. ITU-R BT.1361 conventional colour gamut system (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) United States National Television System Committee 1953 Recommendation for transmission standards for colour television United States Federal Communications Commission Title 47 Code of Federal Regulations (2003) 73.682 (a) (20) Rec. ITU-R BT.1700 (2007 revision) 625 PAL and 625 SECAM
5	Assumed display gamma 2.8	Rec. ITU-R BT.470-6 System B, G (historical)
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.601-6 525 or 625 Rec. ITU-R BT.1358 525 or 625 Rec. ITU-R BT.1700 NTSC Society of Motion Picture and Television Engineers 170M (2004) (functionally the same as the values 1, 14, and 15)
7	$V = \alpha * L_c^{0.45} - (\alpha - 1)$ for $1 \geq L_c \geq \beta$ $V = 4.000 * L_c$ for $\beta > L_c \geq 0$	Society of Motion Picture and Television Engineers 240M (1999)
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

Value	Transfer characteristic	Informative remark
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 extended colour gamut system
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)
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 (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 (functionally the same as the values 1, 6, and 14)
16	$V = [(c_1 + c_2 * L_c^n) \div (1 + c_3 * L_c^n)]^m$ for all values of L_c $c_1 = c_3 - c_2 + 1 = 3\,424 \div 4\,096 = 0.8359375$ $c_2 = 32 * 2\,413 \div 4\,096 = 18.8515625$ $c_3 = 32 * 2\,392 \div 4\,096 = 18.6875$ $m = 128 * 2\,523 \div 4\,096 = 78.84375$ $n = 0.25 * 2\,610 \div 4\,096 = 0.1593017578125$ 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	Society of Motion Picture and Television Engineers ST 2084 for 10, 12, 14, and 16-bit systems
17	$V = (48 * L_c \div 52.37)^{(1 \div 2.6)}$ 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	Society of Motion Picture and Television Engineers ST 428-1
18..255	Reserved	For future use by ITU-T ISO/IEC

Page 408, E.2.1

Replace the semantics of matrix_coefficients with the following:

matrix_coefficients 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_coefficients 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 (4:4:4).

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

matrix_coefficients 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 (4:4:4).

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

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

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

NOTE 3 For purposes of YZX representation when `matrix_coefficients` is equal to 0, the symbols R, G, and B are substituted for X, Y, and Z, respectively, in the following descriptions of Formulae (E-1) to (E-3), (E-7) to (E-9), (E-13) to (E-15), and (E-19) to (E-21).

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. The application of the transfer characteristics function is denoted by $(x)'$ for an argument x . The signals E'_R , E'_G , and E'_B are determined by application of the transfer characteristics function as follows:

$$E'_R = (E_R)' \quad (\text{E-1})$$

$$E'_G = (E_G)' \quad (\text{E-2})$$

$$E'_B = (E_B)' \quad (\text{E-3})$$

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 (IEC 61966-2-4) or 12 (Rec. ITU-R BT.1361 extended colour gamut system)], E'_R , E'_G and E'_B are real numbers with a larger range not specified in this specification.

Nominal 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 interpretation of `matrix_coefficients` is specified as follows.

- If `video_full_range_flag` is equal to 0, the following applies.
 - If `matrix_coefficients` is equal to 1, 4, 5, 6, 7, 9, 10 or 11, the following formulae apply.

$$Y = \text{Clip1}_Y(\text{Round}((1 \ll (\text{BitDepth}_Y - 8)) * (219 * E'_Y + 16))) \quad (\text{E-4})$$

$$C_b = \text{Clip1}_C(\text{Round}((1 \ll (\text{BitDepth}_C - 8)) * (224 * E'_{PB} + 128))) \quad (\text{E-5})$$

$$C_r = \text{Clip1}_C(\text{Round}((1 \ll (\text{BitDepth}_C - 8)) * (224 * E'_{PR} + 128))) \quad (\text{E-6})$$

- Otherwise, if `matrix_coefficients` is equal to 0 or 8, the following formulae apply.

$$R = \text{Clip1}_Y((1 \ll (\text{BitDepth}_Y - 8)) * (219 * E'_R + 16)) \quad (\text{E-7})$$

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

$$B = \text{Clip1}_Y((1 \ll (\text{BitDepth}_Y - 8)) * (219 * E'_B + 16)) \quad (\text{E-9})$$

- Otherwise, if `matrix_coefficients` is equal to 2, the interpretation of the `matrix_coefficients` syntax element is unknown or is determined by the application.

- Otherwise (matrix_coefficients is not equal to 0, 1, 2, 4, 5, 6, 7, 8, 9, 10 or 11), the interpretation of the matrix_coefficients 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_coefficients is equal to 1, 4, 5, 6, 7, 9, 10 or 11, the following formulae apply.

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

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

$$Cr = \text{Clip1}_C(\text{Round}(((1 \ll \text{BitDepth}_C) - 1) * E'_{PR} + (1 \ll (\text{BitDepth}_C - 1)))) \quad (\text{E-12})$$
 - Otherwise, if matrix_coefficients is equal to 0 or 8, the following formulae apply.

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

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

$$B = \text{Clip1}_Y(((1 \ll \text{BitDepth}_Y) - 1) * E'_B) \quad (\text{E-15})$$
 - Otherwise, if matrix_coefficients is equal to 2, the interpretation of the matrix_coefficients syntax element is unknown or is determined by the application.
 - Otherwise (matrix_coefficients is not equal to 0, 1, 2, 4, 5, 6, 7, 8, 9, 10 or 11), the interpretation of the matrix_coefficients syntax element is reserved for future definition by ITU-T | ISO/IEC. Reserved values for matrix_coefficients shall not be present in bitstreams conforming to this version of this specification. Decoders shall interpret reserved values of matrix_coefficients as equivalent to the value 2.

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

- If matrix_coefficients is not equal to 0, 8, 10, or 11, the following formulae apply.

$$E'_Y = K_R * E'_R + (1 - K_R - K_B) * E'_G + K_B * E'_B \quad (\text{E-16})$$

$$E'_{PB} = 0.5 * (E'_B - E'_Y) \div (1 - K_B) \quad (\text{E-17})$$

$$E'_{PR} = 0.5 * (E'_R - E'_Y) \div (1 - K_R) \quad (\text{E-18})$$

NOTE 4 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 (IEC 61966-2-4) or 12 (ITU-R BT.1361 extended colour gamut system), E'_Y , E'_{PB} and E'_{PR} are real numbers with a larger range not specified in this specification.

- Otherwise, if matrix_coefficients is equal to 0, the following formulae apply.

$$Y = \text{Round}(G) \quad (\text{E-19})$$

$$Cb = \text{Round}(B) \quad (\text{E-20})$$

$$C_r = \text{Round}(R) \quad (\text{E-21})$$

— Otherwise, if `matrix_coefficients` is equal to 8, the following applies.

— If `BitDepthC` is equal to `BitDepthY`, the following formulae apply.

$$Y = \text{Round}(0.5 * G + 0.25 * (R + B)) \quad (\text{E-22})$$

$$C_b = \text{Round}(0.5 * G - 0.25 * (R + B)) + (1 \ll (\text{BitDepth}_C - 1)) \quad (\text{E-23})$$

$$C_r = \text{Round}(0.5 * (R - B)) + (1 \ll (\text{BitDepth}_C - 1)) \quad (\text{E-24})$$

NOTE 5 For purposes of the YCgCo nomenclature used in Table E-5, `Cb` and `Cr` of Formula (E-23) and Formula (E-24) may be referred to as `Cg` and `Co`, respectively. The inverse conversion for the above three formulae should be computed as:

$$t = Y - (C_b - (1 \ll (\text{BitDepth}_C - 1))) \quad (\text{E-25})$$

$$G = \text{Clip1}_Y(Y + (C_b - (1 \ll (\text{BitDepth}_C - 1)))) \quad (\text{E-26})$$

$$B = \text{Clip1}_Y(t - (C_r - (1 \ll (\text{BitDepth}_C - 1)))) \quad (\text{E-27})$$

$$R = \text{Clip1}_Y(t + (C_r - (1 \ll (\text{BitDepth}_C - 1)))) \quad (\text{E-28})$$

— Otherwise (`BitDepthC` is not equal to `BitDepthY`), the following formulae apply.

$$C_r = \text{Round}(R) - \text{Round}(B) + (1 \ll (\text{BitDepth}_C - 1)) \quad (\text{E-29})$$

$$t = \text{Round}(B) + ((C_r - (1 \ll (\text{BitDepth}_C - 1))) \gg 1) \quad (\text{E-30})$$

$$C_b = \text{Round}(G) - t + (1 \ll (\text{BitDepth}_C - 1)) \quad (\text{E-31})$$

$$Y = t + ((C_b - (1 \ll (\text{BitDepth}_C - 1))) \gg 1) \quad (\text{E-32})$$

NOTE 6 For purposes of the YCgCo nomenclature used in Table E-5, `Cb` and `Cr` of Formula (E-31) and (E-29) may be referred to as `Cg` and `Co`, respectively. The inverse conversion for the above four formulae should be computed as:

$$t = Y - ((C_b - (1 \ll (\text{BitDepth}_C - 1))) \gg 1) \quad (\text{E-33})$$

$$G = \text{Clip1}_Y(t + (C_b - (1 \ll (\text{BitDepth}_C - 1)))) \quad (\text{E-34})$$

$$B = \text{Clip1}_Y(t - ((C_r - (1 \ll (\text{BitDepth}_C - 1))) \gg 1)) \quad (\text{E-35})$$

$$R = \text{Clip1}_Y(B + (C_r - (1 \ll (\text{BitDepth}_C - 1)))) \quad (\text{E-36})$$

— Otherwise, if `matrix_coefficients` is equal to 10, the following applies.

$$E_Y = K_R * E_R + (1 - K_R - K_B) * E_G + K_B * E_B \quad (\text{E-37})$$

$$E'_Y = (E_Y)' \tag{E-38}$$

NOTE 7 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 analogue with the value 0 associated with nominal black and the value 1 associated with nominal white.

$$E'_{PB} = (E'_B - E'_Y) \div (2 * N_B) \quad \text{for } -N_B \leq E'_B - E'_Y \leq 0 \tag{E-39}$$

$$E'_{PB} = (E'_B - E'_Y) \div (2 * P_B) \quad \text{for } 0 < E'_B - E'_Y \leq P_B \tag{E-40}$$

$$E'_{PR} = (E'_R - E'_Y) \div (2 * N_R) \quad \text{for } -N_R \leq E'_R - E'_Y \leq 0 \tag{E-41}$$

$$E'_{PR} = (E'_R - E'_Y) \div (2 * P_R) \quad \text{for } 0 < E'_R - E'_Y \leq P_R \tag{E-42}$$

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.

$$N_B = (1 - K_B)' \tag{E-43}$$

$$P_B = 1 - (K_B)' \tag{E-44}$$

$$N_R = (1 - K_R)' \tag{E-45}$$

$$P_R = 1 - (K_R)' \tag{E-46}$$

— Otherwise (matrix_coefficients is equal to 11), the following formulae apply.

$$E'_Y = E'_G \tag{E-47}$$

$$E'_{PB} = (0.986\ 566 * E'_B - E'_Y) \div 2 \tag{E-48}$$

$$E'_{PR} = (E'_R - 0.991\ 902 * E'_Y) \div 2 \tag{E-49}$$

NOTE 8 For purposes of the $Y'D'_zD'_x$ nomenclature used in Table E-5, E'_{PB} and E'_{PR} of Formulae (E-48) and (E-49) may be referred to as D'_z and D'_x , respectively.

Replace Table E-5 with the following:

Table E-5 — Matrix coefficients

Value	Matrix	Informative remark
0	GBR	The identity matrix. Typically used for GBR (often referred to as RGB); however, may also be used for YZX (often referred to as XYZ) IEC 61966-2-1 (sRGB) Society of Motion Picture and Television Engineers ST 428-1 (XYZ) See Formula (E-19) to (E-21)
1	$K_R = 0.212\ 6; K_B = 0.072\ 2$	ITU-R Rec. BT.709-5 ITU-R Rec. BT.1361 conventional colour gamut system and extended colour gamut system IEC 61966-2-1 (sRGB) IEC 61966-2-4 xvYCC ₇₀₉ Society of Motion Picture and Television Engineers RP 177 (1993) Annex B See Formulae (E-16) to (E-18)
2	Unspecified	Image characteristics are unknown or are determined by the application.
3	Reserved	For future use by ITU-T ISO/IEC
4	$K_R = 0.30; K_B = 0.11$	United States Federal Communications Commission Title 47 Code of Federal Regulations (2003) 73.682 (a) (20) See Formulae (E-16) to (E-18)
5	$K_R = 0.299; K_B = 0.114$	ITU-R Rec. BT.470-6 System B, G (historical) ITU-R Rec. BT.601-6 625 ITU-R Rec. BT.1358 625 ITU-R Rec. BT.1700 625 PAL and 625 SECAM IEC 61966-2-4 xvYCC ₆₀₁ (functionally the same as the value 6) See Formulae (E-16) to (E-18)
6	$K_R = 0.299; K_B = 0.114$	ITU-R Rec. BT.601-6 525 ITU-R Rec. BT.1358 525 ITU-R Rec. BT.1700 NTSC Society of Motion Picture and Television Engineers 170M (2004) (functionally the same as the value 5) See Formulae (E-16) to (E-18)
7	$K_R = 0.212; K_B = 0.087$	Society of Motion Picture and Television Engineers 240M (1999) See Formulae (E-16) to (E-18)
8	YCgCo	See Formulae (E-22)to (E-36)
9	$K_R = 0.2627; K_B = 0.0593$	Rec. ITU-R BT.2020 non-constant luminance system See Formulae (E-16) to (E-18)