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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

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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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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*.

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:

subset_seq_parameter_set_rbsp( ) {	C	Descriptor
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.

Page 411, Table E-3

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 green blue red white D65	x 0.300 0.150 0.640 0.3127	y 0.600 0.060 0.330 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 green blue red white C	x 0.21 0.14 0.67 0.310	y 0.71 0.08 0.33 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 green blue red white D65	x 0.29 0.15 0.64 0.3127	y 0.60 0.06 0.33 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 green blue red white D65	x 0.310 0.155 0.630 0.3127	y 0.595 0.070 0.340 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 green blue red white D65	x 0.310 0.155 0.630 0.3127	y 0.595 0.070 0.340 0.3290	Society of Motion Picture and Television Engineers 240M (1999) (functionally the same as the value 6)
8	primary green blue red white C	x 0.243 0.145 0.681 0.310	y 0.692 (Wratten 58) 0.049 (Wratten 47) 0.319 (Wratten 25) 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 $1 + 5.5 * \beta = 1.099\,296\,826\,809\,442...$ 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 Specification. Decoders shall interpret reserved values of transfer_characteristics as equivalent to the value 2.

Page 413, Table E-4

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	$V = \alpha * L_c^{0.45} - (\alpha - 1)$ $V = 4.500 * L_c$	for $1 >= L_c >= \beta$ for $\beta > L_c >= 0$	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	$V = \alpha * L_c^{0.45} - (\alpha - 1)$ $V = 4.500 * L_c$	for $1 >= L_c >= \beta$ for $\beta > L_c >= 0$	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	$V = \alpha * L_c^{0.45} - (\alpha - 1)$ $V = 4.000 * L_c$	for $1 >= L_c >= \beta$ for $\beta > L_c >= 0$	Society of Motion Picture and Television Engineers 240M (1999)
8	$V = L_c$	for all values of L_c	Linear transfer characteristics
9	$V = 1.0 + \text{Log10}(L_c) \div 2$ $V = 0.0$	for $1 >= L_c >= 0.01$ for $0.01 > L_c >= 0$	Logarithmic transfer characteristic (100:1 range)
10	$V = 1.0 + \text{Log10}(L_c) \div 2.5$ $V = 0.0$	for $1 >= L_c >= \text{Sqrt}(10) \div 1\,000$ for $\text{Sqrt}(10) \div 1\,000 > L_c >= 0$	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

Value	Transfer characteristic		Informative remark
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 extended colour gamut system
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)
14	$V = \alpha * L_c^{0.45} - (\alpha - 1)$ $V = 4.500 * L_c$	for $1 >= L_c >= \beta$ $V = 4.500 * L_c$ for $\beta > L_c >= 0$	Rec. ITU-R BT.2020 (functionally the same as the values 1, 6, and 15)
15	$V = \alpha * L_c^{0.45} - (\alpha - 1)$ $V = 4.500 * L_c$	for $1 >= L_c >= \beta$ for $\beta > L_c >= 0$	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.

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

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

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

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

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

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

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

  — 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.

$$Y = Clip1_Y(Round(((1 << BitDepth_Y) - 1) * E'_Y)) \quad (E\text{-}10)$$

$$Cb = Clip1_C(Round(((1 << BitDepth_C) - 1) * E'_{PB} + (1 << (BitDepth_C - 1)))) \quad (E\text{-}11)$$

$$Cr = Clip1_C(Round(((1 << BitDepth_C) - 1) * E'_{PR} + (1 << (BitDepth_C - 1)))) \quad (E\text{-}12)$$

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

$$R = Clip1_Y(((1 << BitDepth_Y) - 1) * E'_R) \quad (E\text{-}13)$$

$$G = Clip1_Y(((1 << BitDepth_Y) - 1) * E'_G) \quad (E\text{-}14)$$

$$B = Clip1_Y(((1 << BitDepth_Y) - 1) * E'_B) \quad (E\text{-}15)$$

— 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.

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

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

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

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.

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

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

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

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

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

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

$$Cb = Round(0.5 * G - 0.25 * (R + B)) + (1 << (BitDepth_C - 1)) \quad \text{(E-23)}$$

$$Cr = Round(0.5 * (R - B)) + (1 << (BitDepth_C - 1)) \quad \text{(E-24)}$$

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:

$$t = Y - (Cb - (1 << (BitDepth_C - 1))) \quad \text{(E-25)}$$

$$G = Clip1_Y(Y + (Cb - (1 << (BitDepth_C - 1)))) \quad \text{(E-26)}$$

$$B = Clip1_Y(t - (Cr - (1 << (BitDepth_C - 1)))) \quad \text{(E-27)}$$

$$R = Clip1_Y(t + (Cr - (1 << (BitDepth_C - 1)))) \quad \text{(E-28)}$$

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

$$Cr = Round(R) - Round(B) + (1 << (BitDepth_C - 1)) \quad \text{(E-29)}$$

$$t = Round(B) + ((Cr - (1 << (BitDepth_C - 1))) >> 1) \quad \text{(E-30)}$$

$$Cb = Round(G) - t + (1 << (BitDepth_C - 1)) \quad \text{(E-31)}$$

$$Y = t + ((Cb - (1 << (BitDepth_C - 1))) >> 1) \quad \text{(E-32)}$$

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:

$$t = Y - ((Cb - (1 << (BitDepth_C - 1))) >> 1) \quad \text{(E-33)}$$

$$G = Clip1_Y(t + (Cb - (1 << (BitDepth_C - 1)))) \quad \text{(E-34)}$$

$$B = Clip1_Y(t - ((Cr - (1 << (BitDepth_C - 1))) >> 1)) \quad \text{(E-35)}$$

$$R = Clip1_Y(B + (Cr - (1 << (BitDepth_C - 1)))) \quad \text{(E-36)}$$

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

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

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

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.

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

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

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

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

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.

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

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

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

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

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

$$E'_Y = E'_G \quad \text{(E-47)}$$

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

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

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.

Page 417, Table E-5

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)