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| *Title:* | **Proposal to support UHDTV colorimetory** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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| *Source:* | Sony Corporation | | |

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# Abstract

This contribution proposes to support colorimetory of ITU-R UHDTV in HEVC. Proposed text is attached.

1. Annex E  
     
   Video usability information

(This annex forms an integral part of this Recommendation | International Standard)

This annex specifies syntax and semantics of the VUI parameters of the sequence parameter sets.

VUI parameters are not required for constructing the luma or chroma samples by the decoding process. Conforming decoders are not required to process this information for output order conformance to this Recommendation | International Standard (see Annex C for the specification of output order conformance). Some VUI parameters are required to check bitstream conformance and for output timing decoder conformance.

In Annex , specification for presence of VUI parameters is also satisfied when those parameters (or some subset of them) are conveyed to decoders (or to the HRD) by other means not specified by this Recommendation | International Standard. When present in the bitstream, VUI parameters shall follow the syntax and semantics specified in subclauses  and and this annex. When the content of VUI parameters is conveyed for the application by some means other than presence within the bitstream, the representation of the content of the VUI parameters is not required to use the same syntax specified in this annex. For the purpose of counting bits, only the appropriate bits that are actually present in the bitstream are counted.

* 1. VUI syntax
     1. VUI parameters syntax

|  |  |
| --- | --- |
| vui\_parameters( ) { | Descriptor |
| **aspect\_ratio\_info\_present\_flag** | u(1) |
| if( aspect\_ratio\_info\_present\_flag ) { |  |
| **aspect\_ratio\_idc** | u(8) |
| if( aspect\_ratio\_idc = = Extended\_SAR ) { |  |
| **sar\_width** | u(16) |
| **sar\_height** | u(16) |
| } |  |
| } |  |
| **overscan\_info\_present\_flag** | u(1) |
| if( overscan\_info\_present\_flag ) |  |
| **overscan\_appropriate\_flag** | u(1) |
| **video\_signal\_type\_present\_flag** | u(1) |
| if( video\_signal\_type\_present\_flag ) { |  |
| **video\_format** | u(3) |
| **video\_full\_range\_flag** | u(1) |
| **colour\_description\_present\_flag** | u(1) |
| if( colour\_description\_present\_flag ) { |  |
| **colour\_primaries** | u(8) |
| **transfer\_characteristics** | u(8) |
| **matrix\_coefficients** | u(8) |
| } |  |
| } |  |
| **chroma\_loc\_info\_present\_flag** | u(1) |
| if( chroma\_loc\_info\_present\_flag ) { |  |
| **chroma\_sample\_loc\_type\_top\_field** | ue(v) |
| **chroma\_sample\_loc\_type\_bottom\_field** | ue(v) |
| } |  |
| **neutral\_chroma\_indication\_flag** | u(1) |
| **field\_seq\_flag** | u(1) |
| **timing\_info\_present\_flag** | u(1) |
| if( timing\_info\_present\_flag ) { |  |
| **num\_units\_in\_tick** | u(32) |
| **time\_scale** | u(32) |
| **fixed\_pic\_rate\_flag** | u(1) |
| } |  |
| **nal\_hrd\_parameters\_present\_flag** | u(1) |
| if( nal\_hrd\_parameters\_present\_flag ) |  |
| hrd\_parameters( ) |  |
| **vcl\_hrd\_parameters\_present\_flag** | u(1) |
| if( vcl\_hrd\_parameters\_present\_flag ) |  |
| hrd\_parameters( ) |  |
| if( nal\_hrd\_parameters\_present\_flag | | vcl\_hrd\_parameters\_present\_flag ) |  |
| **low\_delay\_hrd\_flag** | u(1) |
| **sub\_pic\_cpb\_params\_present\_flag** | u(1) |
| if( sub\_pic\_cpb\_params\_present\_flag ) |  |
| **num\_units\_in\_sub\_tick** | u(32) |
| } |  |
| **bitstream\_restriction\_flag** | u(1) |
| if( bitstream\_restriction\_flag ) { |  |
| **tiles\_fixed\_structure\_flag** | u(1) |
| **motion\_vectors\_over\_pic\_boundaries\_flag** | u(1) |
| **max\_bytes\_per\_pic\_denom** | ue(v) |
| **max\_bits\_per\_mincu\_denom** | ue(v) |
| **log2\_max\_mv\_length\_horizontal** | ue(v) |
| **log2\_max\_mv\_length\_vertical** | ue(v) |
| } |  |
| } |  |

* + 1. HRD parameters syntax

|  |  |
| --- | --- |
| hrd\_parameters( ) { | Descriptor |
| **cpb\_cnt\_minus1** | ue(v) |
| **bit\_rate\_scale** | u(4) |
| **cpb\_size\_scale** | u(4) |
| for( SchedSelIdx = 0; SchedSelIdx <= cpb\_cnt\_minus1; SchedSelIdx++ ) { |  |
| **bit\_rate\_value\_minus1[** SchedSelIdx **]** | ue(v) |
| **cpb\_size\_value\_minus1[** SchedSelIdx **]** | ue(v) |
| **cbr\_flag[** SchedSelIdx **]** | u(1) |
| } |  |
| **initial\_cpb\_removal\_delay\_length\_minus1** | u(5) |
| **cpb\_removal\_delay\_length\_minus1** | u(5) |
| **dpb\_output\_delay\_length\_minus1** | u(5) |
| **time\_offset\_length** | u(5) |
| } |  |

* 1. VUI semantics
     1. VUI parameters semantics

**aspect\_ratio\_info\_present\_flag** equal to 1 specifies that aspect\_ratio\_idc is present. aspect\_ratio\_info\_present\_flag equal to 0 specifies that aspect\_ratio\_idc is not present.

**aspect\_ratio\_idc** specifies the value of the sample aspect ratio of the luma samples. shows the meaning of the code. When aspect\_ratio\_idc indicates Extended\_SAR, the sample aspect ratio is represented by sar\_width : sar\_height. When the aspect\_ratio\_idc syntax element is not present, aspect\_ratio\_idc value is inferred to be equal to 0.

Table E‑10‑8 – Meaning of sample aspect ratio indicator

|  |  |  |
| --- | --- | --- |
| **aspect\_ratio\_idc** | **Sample aspect ratio** | **(informative) Examples of use** |
| 0 | Unspecified |  |
| 1 | 1:1 ("square") | 1280x720 16:9 frame without horizontal overscan 1920x1080 16:9 frame without horizontal overscan (cropped from 1920x1088) 640x480 4:3 frame without horizontal overscan  3840x2160 16:9 frame without horizontal overscan 7680x4320 16:9 frame without horizontal overscan |
| 2 | 12:11 | 720x576 4:3 frame with horizontal overscan 352x288 4:3 frame without horizontal overscan |
| 3 | 10:11 | 720x480 4:3 frame with horizontal overscan 352x240 4:3 frame without horizontal overscan |
| 4 | 16:11 | 720x576 16:9 frame with horizontal overscan 528x576 4:3 frame without horizontal overscan |
| 5 | 40:33 | 720x480 16:9 frame with horizontal overscan 528x480 4:3 frame without horizontal overscan |
| 6 | 24:11 | 352x576 4:3 frame without horizontal overscan 480x576 16:9 frame with horizontal overscan |
| 7 | 20:11 | 352x480 4:3 frame without horizontal overscan 480x480 16:9 frame with horizontal overscan |
| 8 | 32:11 | 352x576 16:9 frame without horizontal overscan |
| 9 | 80:33 | 352x480 16:9 frame without horizontal overscan |
| 10 | 18:11 | 480x576 4:3 frame with horizontal overscan |
| 11 | 15:11 | 480x480 4:3 frame with horizontal overscan |
| 12 | 64:33 | 528x576 16:9 frame without horizontal overscan |
| 13 | 160:99 | 528x480 16:9 frame without horizontal overscan |
| 14 | 4:3 | 1440x1080 16:9 frame without horizontal overscan |
| 15 | 3:2 | 1280x1080 16:9 frame without horizontal overscan |
| 16 | 2:1 | 960x1080 16:9 frame without horizontal overscan |
| 17..254 | Reserved |  |
| 255 | Extended\_SAR |  |

NOTE 1 – For the examples in , the term "without horizontal overscan" refers to display processes in which the display area matches the area of the cropped decoded pictures and the term "with horizontal overscan" refers to display processes in which some parts near the left and/or right border of the cropped decoded pictures are not visible in the display area. As an example, the entry "720x576 4:3 frame with horizontal overscan" for aspect\_ratio\_idc equal to 2 refers to having an area of 704x576 luma samples (which has an aspect ratio of 4:3) of the cropped decoded frame (720x576 luma samples) that is visible in the display area.

**sar\_width** indicates the horizontal size of the sample aspect ratio (in arbitrary units).

**sar\_height** indicates the vertical size of the sample aspect ratio (in the same arbitrary units as sar\_width).

sar\_width and sar\_height shall be relatively prime or equal to 0. When aspect\_ratio\_idc is equal to 0 or sar\_width is equal to 0 or sar\_height is equal to 0, the sample aspect ratio shall be considered unspecified by this Recommendation | International Standard.

**overscan\_info\_present\_flag** equal to 1 specifies that the overscan\_appropriate\_flag is present. When overscan\_info\_present\_flag is equal to 0 or is not present, the preferred display method for the video signal is unspecified.

**overscan\_appropriate\_flag** equal to 1 indicates that the cropped decoded pictures output are suitable for display using overscan. overscan\_appropriate\_flag equal to 0 indicates that the cropped decoded pictures output contain visually important information in the entire region out to the edges of the cropping rectangle of the picture, such that the cropped decoded pictures output should not be displayed using overscan. Instead, they should be displayed using either an exact match between the display area and the cropping rectangle, or using underscan. As used in this paragraph, the term "overscan" refers to display processes in which some parts near the borders of the cropped decoded pictures are not visible in the display area. The term "underscan" describes display processes in which the entire cropped decoded pictures are visible in the display area, but they do not cover the entire display area. For display processes that neither use overscan nor underscan, the display area exactly matches the area of the cropped decoded pictures.

NOTE 2 – For example, overscan\_appropriate\_flag equal to 1 might be used for entertainment television programming, or for a live view of people in a videoconference, and overscan\_appropriate\_flag equal to 0 might be used for computer screen capture or security camera content.

**video\_signal\_type\_present\_flag** equal to 1 specifies that video\_format, video\_full\_range\_flag and colour\_description\_present\_flag are present. video\_signal\_type\_present\_flag equal to 0, specify that video\_format, video\_full\_range\_flag and colour\_description\_present\_flag are not present.

**video\_format** indicates the representation of the pictures as specified in , before being coded in accordance with this Recommendation | International Standard. When the video\_format syntax element is not present, video\_format value is inferred to be equal to 5.

Table E‑10‑9 – 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 61966-2-4  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) |
| 9 | primary x y  green 0.170 0.797  blue 0.131 0.046  red 0.708 0.292  white D65 0.3127 0.3290 | Rec. ITU-R BT.[IMAGE-UHDTV] |
| 10..255 | Reserved | For future use by ITU‑T | ISO/IEC |

[Ed. The formal recommendation number of ITU-R BT.[IMAGE-UHDTV] is assigned in Aug. 2012. The informal reference to ITU-R UHDTV needs to be updated]

**transfer\_characteristics** indicates the opto-electronic transfer characteristic of the source picture as specified in as a function of a linear optical intensity input Lc with a nominal real-valued range of 0 to 1.

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).

Table E‑10‑10 – Transfer characteristics

| Value | Transfer Characteristic | Informative Remark |
| --- | --- | --- |
| 0 | Reserved | For future use by ITU‑T | ISO/IEC |
| 1 | V = 1.099 \* Lc0.45 − 0.099 for 1 >= Lc >= 0.018  V = 4.500 \* Lc for 0.018 > Lc >= 0 | Rec. ITU‑R BT.709-5  Rec. ITU‑R BT.1361 conventional colour gamut system  (functionally the same as the value 6) |
| 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 = 1.099 \* Lc0.45 − 0.099 for 1 >= Lc >= 0.018  V = 4.500 \* Lc for 0.018 > Lc >= 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 value 1) |
| 7 | V = 1.1115 \* Lc0.45 − 0.1115 for 1 >= Lc >= 0.0228  V = 4.0 \* Lc for 0.0228 > Lc >= 0 | Society of Motion Picture and Television Engineers 240M (1999) |
| 8 | V = Lc for 1 > Lc >= 0 | Linear transfer characteristics |
| 9 | V = 1.0 + Log10( Lc ) ÷ 2 for 1 >= Lc >= 0.01  V = 0.0 for 0.01 > Lc >= 0 | Logarithmic transfer characteristic (100:1 range) |
| 10 | V = 1.0 + Log10( Lc ) ÷ 2.5 for 1 >= Lc >= Sqrt( 10 ) ÷ 1000  V = 0.0 for Sqrt( 10 ) ÷ 1000 > Lc >= 0 | Logarithmic transfer characteristic (100 \* Sqrt( 10 ) : 1 range) |
| 11 | V = 1.099 \* Lc0.45 − 0.099 for Lc >= 0.018  V = 4.500 \* Lc for 0.018 > Lc > −0.018  V = −1.099 \* ( −Lc )0.45 + 0.099 for −0.018 >= Lc | IEC 61966-2-4 |
| 12 | V = 1.099 \* Lc0.45 − 0.099 for 1.33 > Lc >= 0.018  V = 4.500 \* Lc for 0.018 > Lc >= −0.0045  V = −( 1.099 \* ( −4 \* Lc )0.45 − 0.099 ) ÷ 4 for −0.0045 > Lc >= −0.25 | Rec. ITU‑R BT.1361 extended colour gamut system |
| 13 | V =1.099\* Lc0.45 – 0.099 for 1 >= Lc >=0.018  V = 4.500 \* Lc for 0.018> Lc >= 0 | Rec. ITU-R BT.[IMAGE-UHDTV] |
| 14 | V =1.0993\* Lc0.45 – 0.0993 for 1 >= Lc >=0.0181  V = 4.500 \* Lc for 0.0181> Lc >= 0 | Rec. ITU-R BT.[IMAGE-UHDTV] |
| 14..255 | Reserved | For future use by ITU‑T | ISO/IEC |

[Ed. The formal recommendation number of ITU-R BT.[IMAGE-UHDTV] is assigned in Aug. 2012. The informal reference to ITU-R UHDTV needs to be updated]

**matrix\_coefficients** describes the matrix coefficients used in deriving luma and chroma signals from the green, blue, and red primaries, as specified in .

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

– BitDepthC is equal to BitDepthY,

– 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 or more of the following conditions are true:

– BitDepthC is equal to BitDepthY,

– BitDepthC is equal to BitDepthY + 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).

For the interpretation of matrix\_coefficients, the following is specified:

– 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.

– 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 Recommendation.

– 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 or 10, the following equations apply:

Y = Clip1Y( Round( ( 1 << ( BitDepthY − 8 ) ) \* ( 219 \* E′Y + 16 ) ) ) (E‑1)

Cb = Clip1C( Round( ( 1 << ( BitDepthC − 8 ) ) \* ( 224 \* E′PB + 128 ) ) ) (E‑2)

Cr = Clip1C( Round( ( 1 << ( BitDepthC − 8 ) ) \* ( 224 \* E′PR + 128 ) ) ) (E‑3)

– Otherwise, if matrix\_coefficients is equal to 0 or 8, the following equations apply:

R = Clip1Y( ( 1 << ( BitDepthY − 8 ) ) \* ( 219 \* E′R + 16 ) ) (E‑4)

G = Clip1Y( ( 1 << ( BitDepthY − 8 ) ) \* ( 219 \* E′G + 16 ) ) (E‑5)

B = Clip1Y( ( 1 << ( BitDepthY − 8 ) ) \* ( 219 \* E′B + 16 ) ) (E‑6)

– 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 or 10), 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 or 10, the following equations apply:

Y = Clip1Y( Round( ( ( 1 << BitDepthY ) − 1 ) \* E′Y ) ) (E‑7)

Cb = Clip1C( Round( ( ( 1 << BitDepthC ) − 1 ) \* E′PB + ( 1 << ( BitDepthC − 1 ) ) ) ) (E‑8)

Cr = Clip1C( Round( ( ( 1 << BitDepthC ) − 1 ) \* E′PR + ( 1 << ( BitDepthC − 1 ) ) ) ) (E‑9)

– Otherwise, if matrix\_coefficients is equal to 0 or 8, the following equations apply:

R = Clip1Y( ( ( 1 << BitDepthY ) − 1 ) \* E′R ) (E‑10)

G = Clip1Y( ( ( 1 << BitDepthY ) − 1 ) \* E′G ) (E‑11)

B = Clip1Y( ( ( 1 << BitDepthY ) − 1 ) \* E′B ) (E‑12)

– 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 or 10), the interpretation of the matrix\_coefficients syntax element is reserved for future definition by ITU‑T | ISO/IEC.

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 or 10, the following equations apply:

E′Y = KR \* E′R + ( 1 − KR − KB ) \* E′G + KB \* E′B (E‑13)

E′PB = 0.5 \* ( E′B − E′Y ) ÷ ( 1 − KB ) (E‑14)

E′PR = 0.5 \* ( E′R − E′Y ) ÷ ( 1 − KR ) (E‑15)

NOTE 3 – 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. 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. 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 Recommendation.

– Otherwise if matrix\_coefficients is equal to 10, the following equations apply:

E′Y = KR \* E′R + ( 1 − KR − KB ) \* E′G + KB \* E′B (E‑13)

NOTE 3bis – EY, ER, EG, and EB are the “linear” signals before applying the transfer characteristics.

E′Y is then derived by applying the transfer characteristics (transfer\_characteristics is equal to 13) to EY.

E′PB = ( E′B − E′Y ) ÷ 1.9404 for -0.9702 <= E′B − E′Y <= 0 (E‑14)

E′PB = ( E′B − E′Y ) ÷ 1.5816 for 0 < E′B − E′Y <= 0.7908 (E‑14)

E′PR = ( E′R − E′Y ) ÷ 1.7184 for -0.8592 <= E′R − E′Y  <=0 (E‑15)

E′PR = ( E′R − E′Y ) ÷ 0.9936 for 0 < E′R − E′Y  <= 0.4968 (E‑15)

– Otherwise, if matrix\_coefficients is equal to 0, the following equations apply:

Y = Round( G ) (E‑16)

Cb = Round( B ) (E‑17)

Cr = Round( R ) (E‑18)

– Otherwise (matrix\_coefficients is equal to 8), the following applies:

– If BitDepthC is equal to BitDepthY, the following equations apply:

Y = Round( 0.5 \* G + 0.25 \* ( R + B ) ) (E‑19)

Cb = Round( 0.5 \* G − 0.25 \* ( R + B ) ) + ( 1 << ( BitDepthC − 1 ) ) (E‑20)

Cr = Round( 0.5 \* (R − B ) ) + ( 1 << ( BitDepthC − 1 ) ) (E‑21)

NOTE 4 – For purposes of the YCgCo nomenclature used in , Cb and Cr of Equations  and may be referred to as Cg and Co, respectively. The inverse conversion for the above three equations should be computed as:

t = Y − ( Cb − ( 1 << ( BitDepthC − 1 ) ) ) (E‑22)

G = Clip1Y( Y + ( Cb − ( 1 << ( BitDepthC − 1 ) ) ) ) (E‑23)

B = Clip1Y( t − ( Cr − ( 1 << ( BitDepthC − 1 ) ) ) ) (E‑24)

R = Clip1Y( t + ( Cr − ( 1 << ( BitDepthC − 1 ) ) ) ) (E‑25)

– Otherwise (BitDepthC is not equal to BitDepthY), the following equations apply:

Cr = Round( R ) − Round( B ) + ( 1 << ( BitDepthC − 1 ) ) (E‑26)

t = Round( B ) + ( ( Cr − ( 1 << ( BitDepthC − 1 ) ) ) >> 1 ) (E‑27)

Cb = Round( G ) − t + ( 1 << ( BitDepthC − 1 ) ) (E‑28)

Y = t + ( ( Cb − ( 1 << ( BitDepthC − 1 ) ) ) >> 1 ) (E‑29)

NOTE 5 – For purposes of the YCgCo nomenclature used in , Cb and Cr of Equations  and may be referred to as Cg and Co, respectively. The inverse conversion for the above four equations should be computed as.

t = Y − ( ( Cb − ( 1 << ( BitDepthC − 1 ) ) ) >> 1 ) (E‑30)

G = Clip1Y( t + ( Cb − ( 1 << ( BitDepthC − 1 ) ) ) ) (E‑31)

B = Clip1Y( t − ( ( Cr − ( 1 << ( BitDepthC − 1 ) ) ) >> 1 ) ) (E‑32)

R = Clip1Y( B + ( Cr − ( 1 << ( BitDepthC − 1 ) ) ) ) (E‑33)

Table E‑10‑11 – Matrix coefficients

|  |  |  |
| --- | --- | --- |
| Value | Matrix | Informative remark |
| 0 | GBR | Typically referred to as RGB; see Equations  to |
| 1 | KR = 0.2126; KB = 0.0722 | ITU‑R Rec. BT.709-5  ITU‑R Rec. BT.1361 conventional colour gamut system and extended colour gamut system  IEC 61966-2-4 xvYCC709  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 | KR = 0.30; KB = 0.11 | United States Federal Communications Commission Title 47 Code of Federal Regulations (2003) 73.682 (a) (20) |
| 5 | KR = 0.299; KB = 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 xvYCC601  (functionally the same as the value 6) |
| 6 | KR = 0.299; KB = 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) |
| 7 | KR = 0.212; KB = 0.087 | Society of Motion Picture and Television Engineers 240M (1999) |
| 8 | YCgCo | See Equations  to |
| 9 | KR = 0.2627; KB = 0.0593 | ITU-R Rec. BT.[IMAGE-UHDTV] (non-constant luminance) |
| 10 | KR = 0.2627; KB = 0.0593 | ITU-R Rec. BT.[IMAGE-UHDTV] (constant luminance) |
| 11..255 | Reserved | For future use by ITU‑T | ISO/IEC |

[Ed. The formal recommendation number of ITU-R BT.[IMAGE-UHDTV] is assigned in Aug. 2012. The informal reference to ITU-R UHDTV needs to be updated]

**chroma\_loc\_info\_present\_flag** equal to 1 specifies that chroma\_sample\_loc\_type\_top\_field and chroma\_sample\_loc\_type\_bottom\_field are present. chroma\_loc\_info\_present\_flag equal to 0 specifies that chroma\_sample\_loc\_type\_top\_field and chroma\_sample\_loc\_type\_bottom\_field are not present.

When chroma\_format\_idc is not equal to 1, chroma\_loc\_info\_present\_flag should be equal to 0.

**chroma\_sample\_loc\_type\_top\_field** and **chroma\_sample\_loc\_type\_bottom\_field** specify the location of chroma samples as follows:

– If chroma\_format\_idc is equal to 1 (4:2:0 chroma format), chroma\_sample\_loc\_type\_top\_field and chroma\_sample\_loc\_type\_bottom\_field specify the location of chroma samples for the top field and the bottom field, respectively, as shown in .

– Otherwise (chroma\_format\_idc is not equal to 1), the values of the syntax elements chroma\_sample\_loc\_type\_top\_field and chroma\_sample\_loc\_type\_bottom\_field shall be ignored. When chroma\_format\_idc is equal to 2 (4:2:2 chroma format) or 3 (4:4:4 chroma format), the location of chroma samples is specified in subclause . When chroma\_format\_idc is equal to 0, there is no chroma sample array.

The value of chroma\_sample\_loc\_type\_top\_field and chroma\_sample\_loc\_type\_bottom\_field shall be in the range of 0 to 5, inclusive. When the chroma\_sample\_loc\_type\_top\_field and chroma\_sample\_loc\_type\_bottom\_field are not present, the values of chroma\_sample\_loc\_type\_top\_field and chroma\_sample\_loc\_type\_bottom\_field is inferred to be equal to 0.

NOTE 6 – When coding progressive source material, chroma\_sample\_loc\_type\_top\_field and chroma\_sample\_loc\_type\_bottom\_field should have the same value.



Figure E‑1 – Location of chroma samples for top and bottom fields for chroma\_format\_idc equal to 1 (4:2:0 chroma format) as a function of chroma\_sample\_loc\_type\_top\_field and chroma\_sample\_loc\_type\_bottom\_field

**neutral\_chroma\_indication\_flag** equal to 1 indicates that the value of all decoded chroma samples is equal to 1 << ( BitDepthC − 1 ). neutral\_chroma\_indication\_flag equal to 0 provides no indication of decoded chroma sample values. When neutral\_chroma\_indication\_flag is equal to 1, it is a requirement of bitstream conformance that the value of all decoded chroma samples produced by the decoding process shall be equal to  1 << ( BitDepthC − 1 ). When neutral\_chroma\_indication\_flag is not present, it is inferred to be equal to 0.

NOTE 7 – When neutral\_chroma\_indication\_flag is equal to 1, it is not necessary for the decoder to apply the specified decoding process in order to determine the value of the decoded chroma samples.

**field\_seq\_flag** equal to 1 indicates that the coded video sequence conveys pictures that represent fields, and specifies that a field indication SEI message shall be present in every access unit of the current coded video sequence. field\_seq\_flag equal to 0 indicates that the coded video sequence conveys pictures that represent frames and that a field indication SEI message may or may not be present in any access unit of the current coded video sequence. When field\_seq\_flag is not present, it is inferred to be equal to 0.

NOTE 8 – The specified decoding process does not treat access units conveying pictures that represent fields or frames differently. A sequence of pictures that represent fields would therefore be coded with the picture dimensions of an individual field. For example, access units containing pictures that represent 1080i fields would commonly have cropped output dimensions of 1920x540, while the sequence picture rate would commonly express the rate of the source fields (typically between 50 and 60 Hz), instead of the source frame rate (typically between 25 and 30 Hz).

**timing\_info\_present\_flag** equal to 1 specifies that num\_units\_in\_tick, time\_scale and fixed\_pic\_rate\_flag are present in the bitstream. timing\_info\_present\_flag equal to 0 specifies that num\_units\_in\_tick, time\_scale and fixed\_pic\_rate\_flag are not present in the bitstream.

**num\_units\_in\_tick** is the number of time units of a clock operating at the frequency time\_scale Hz that corresponds to one increment (called a clock tick) of a clock tick counter. num\_units\_in\_tick shall be greater than 0. A clock tick is the minimum interval of time that can be represented in the coded data when sub\_pic\_cpb\_params\_present\_flag is equal to 0. For example, when the picture rate of a video signal is 30 000 ÷ 1001 Hz, time\_scale may be equal to 60 000 and num\_units\_in\_tick may be equal to 1001. See Equation .

**time\_scale** is the number of time units that pass in one second. For example, a time coordinate system that measures time using a 27 MHz clock has a time\_scale of 27 000 000. time\_scale shall be greater than 0.

**fixed\_pic\_rate\_flag** equal to 1 indicates that the temporal distance between the HRD output times of any two consecutive pictures in output order is constrained as follows. fixed\_pic\_rate\_flag equal to 0 indicates that no such constraints apply to the temporal distance between the HRD output times of any two consecutive pictures in output order.

When fixed\_pic\_rate\_flag is not present, it is inferred to be equal to 0.

When fixed\_pic\_rate\_flag is equal to 1 for a coded video sequence containing picture n, the value computed for Δto,dpb( n ) as specified in Equation  shall be equal to tc as specified in Equation  (using the value of tc for the coded video sequence containing picture n) when one or more of the following conditions are true for the following picture nn that is specified for use in Equation :

– picture nn is in the same coded video sequence as picture n.

– picture nn is in a different coded video sequence and fixed\_pic\_rate\_flag is equal to 1 in the coded video sequence containing picture nn and the value of num\_units\_in\_tick ÷ time\_scale is the same for both coded video sequences.

**nal\_hrd\_parameters\_present\_flag** equal to 1 specifies that NAL HRD parameters (pertaining to Type II bitstream conformance) are present. nal\_hrd\_parameters\_present\_flag equal to 0 specifies that NAL HRD parameters are not present.

NOTE 9 – When nal\_hrd\_parameters\_present\_flag is equal to 0, the conformance of the bitstream cannot be verified without provision of the NAL HRD parameters and all buffering period and picture timing SEI messages, by some means not specified in this Recommendation | International Standard.

When nal\_hrd\_parameters\_present\_flag is equal to 1, NAL HRD parameters (subclauses  and ) immediately follow the flag.

The variable NalHrdBpPresentFlag is derived as follows:

– If any of the following is true, the value of NalHrdBpPresentFlag shall be set equal to 1:

– nal\_hrd\_parameters\_present\_flag is present in the bitstream and is equal to 1,

– the need for presence of buffering periods for NAL HRD operation to be present in the bitstream in buffering period SEI messages is determined by the application, by some means not specified in this Recommendation | International Standard.

– Otherwise, the value of NalHrdBpPresentFlag shall be set equal to 0.

**vcl\_hrd\_parameters\_present\_flag** equal to 1 specifies that VCL HRD parameters (pertaining to all bitstream conformance) are present. vcl\_hrd\_parameters\_present\_flag equal to 0 specifies that VCL HRD parameters are not present.

NOTE 10 – When vcl\_hrd\_parameters\_present\_flag is equal to 0, the conformance of the bitstream cannot be verified without provision of the VCL HRD parameters and all buffering period and picture timing SEI messages, by some means not specified in this Recommendation | International Standard.

When vcl\_hrd\_parameters\_present\_flag is equal to 1, VCL HRD parameters (subclauses  and ) immediately follow the flag.

The variable VclHrdBpPresentFlag is derived as follows:

– If any of the following is true, the value of VclHrdBpPresentFlag shall be set equal to 1:

– vcl\_hrd\_parameters\_present\_flag is present in the bitstream and is equal to 1,

– the need for presence of buffering periods for VCL HRD operation to be present in the bitstream in buffering period SEI messages is determined by the application, by some means not specified in this Recommendation | International Standard.

– Otherwise, the value of VclHrdBpPresentFlag shall be set equal to 0.

The variable CpbDpbDelaysPresentFlag is derived as follows:

– If any of the following is true, the value of CpbDpbDelaysPresentFlag shall be set equal to 1:

– nal\_hrd\_parameters\_present\_flag is present in the bitstream and is equal to 1,

– vcl\_hrd\_parameters\_present\_flag is present in the bitstream and is equal to 1,

– the need for presence of CPB and DPB output delays to be present in the bitstream in picture timing SEI messages is determined by the application, by some means not specified in this Recommendation | International Standard.

– Otherwise, the value of CpbDpbDelaysPresentFlag shall be set equal to 0.

**low\_delay\_hrd\_flag** specifies the HRD operational mode as specified in Annex . When fixed\_pic\_rate\_flag is equal to 1, low\_delay\_hrd\_flag shall be equal to 0. When low\_delay\_hrd\_flag is not present, its value is inferred to be equal to 1 − fixed\_pic\_rate\_flag.

NOTE 11 – When low\_delay\_hrd\_flag is equal to 1, "big pictures" that violate the nominal CPB removal times due to the number of bits used by an access unit are permitted. It is expected, but not required, that such "big pictures" occur only occasionally.

**sub\_pic\_cpb\_params\_present\_flag** equal to 1 specifies that sub-picture level CPB removal delay parameters are present and the CPB may operate at access unit level or sub-picture level. sub\_pic\_cpb\_params\_present\_flag equal to 0 specifies that sub-picture level CPB removal delay parameters are not present and the CPB operates at access unit level. When sub\_pic\_cpb\_params\_present\_flag is not present, its value is inferred to be equal to 0.

**num\_units\_in\_sub\_tick** is the number of time units of a clock operating at the frequency time\_scale Hz that corresponds to one increment (called a sub-picture clock tick) of a sub-picture clock tick counter. num\_units\_in\_sub\_tick shall be greater than 0. A sub-picture clock tick is the minimum interval of time that can be represented in the coded data when sub\_pic\_cpb\_params\_present\_flag is equal to 1.

**bitstream\_restriction\_flag** equal to 1, specifies that the following coded video sequence bitstream restriction parameters are present. bitstream\_restriction\_flag equal to 0, specifies that the following coded video sequence bitstream restriction parameters are not present.

**tiles\_fixed\_structure\_flag** equal to 1 indicates that each picture parameter set that is active in the coded video sequence has the same value of the syntax elements num\_tile\_columns\_minus1, num\_tile\_rows\_minus1, uniform\_spacing\_flag, column\_width[ i ], row\_height[ i ] and loop\_filter\_across\_tiles\_enabled\_flag, when present. tiles\_fixed\_structure\_flag equal to 0 indicates that tiles syntax elements in different picture parameter sets may or may not have the same value. When the tiles\_fixed\_structure\_flag syntax element is not present, it is inferred to be equal to 0.

NOTE 12 – The signalling of tiles\_fixed\_structure\_flag equal to 1 is a guarantee to a decoder that each picture in the coded video sequence has the same number of tiles distributed in the same way which might be useful for workload allocation in the case of multi-threaded decoding.

**motion\_vectors\_over\_pic\_boundaries\_flag** equal to 0 indicates that no sample outside the picture boundaries and no sample at a fractional sample position for which the sample value is derived using one or more samples outside the picture boundaries is used for inter prediction of any sample. motion\_vectors\_over\_pic\_boundaries\_flag equal to 1 indicates that one or more samples outside picture boundaries may be used in inter prediction. When the motion\_vectors\_over\_pic\_boundaries\_flag syntax element is not present, motion\_vectors\_over\_pic\_boundaries\_flag value is inferred to be equal to 1.

**max\_bytes\_per\_pic\_denom** indicates a number of bytes not exceeded by the sum of the sizes of the VCL NAL units associated with any coded picture in the coded video sequence.

The number of bytes that represent a picture in the NAL unit stream is specified for this purpose as the total number of bytes of VCL NAL unit data (i.e., the total of the NumBytesInNALunit variables for the VCL NAL units) for the picture. The value of max\_bytes\_per\_pic\_denom shall be in the range of 0 to 16, inclusive.

Depending on max\_bytes\_per\_pic\_denom the following applies:

– If max\_bytes\_per\_pic\_denom is equal to 0, no limits are indicated.

– Otherwise (max\_bytes\_per\_pic\_denom is not equal to 0), it is a requirement of bitstream conformance that no coded picture shall be represented in the coded video sequence by more than the following number of bytes.

( PicSizeInMinCbs \* RawMinCUBits ) ÷ ( 8 \* max\_bytes\_per\_pic\_denom ) (E‑34)

When the max\_bytes\_per\_pic\_denom syntax element is not present, the value of max\_bytes\_per\_pic\_denom is inferred to be equal to 2.

**max\_bits\_per\_mincu\_denom** indicates an upper bound for the number of coded bits of coding\_unit( ) data for any coding block in any picture of the coded video sequence. The value of max\_bits\_per\_mincu\_denom shall be in the range of 0 to 16, inclusive.

Depending on max\_bits\_per\_mincu\_denom the following applies:

– If max\_bits\_per\_mincu\_denom is equal to 0, no limit is specified by this syntax element.

– Otherwise (max\_bits\_per\_mincu\_denom is not equal to 0), it is a requirement of bitstream conformance that no coded coding\_unit( ) shall be represented in the bitstream by more than the following number of bits.

( 128 + RawMinCUBits ) ÷ max\_bits\_per\_mincu\_denom \* ( 2 << log2CbSize − log2MinCbSize ) (E‑35)

where log2CbSize is the value of log2CbSize for the given coding block and the number of bits of coding\_unit( ) data for the same coding block is given by the number of times read\_bits( 1 ) is called in subclauses 9.3.3.2.2 and 9.3.3.2.3.

When the max\_bits\_per\_mincu\_denom is not present,thevalue of max\_bits\_per\_mincu\_denom is inferred to be equal to 1.

**log2\_max\_mv\_length\_horizontal** and **log2\_max\_mv\_length\_vertical** indicate the maximum absolute value of a decoded horizontal and vertical motion vector component, respectively, in ¼ luma sample units, for all pictures in the coded video sequence. A value of n asserts that no value of a motion vector component shall exceed the range from −2n to 2n − 1, inclusive, in units of ¼ luma sample displacement. The value of log2\_max\_mv\_length\_horizontal shall be in the range of 0 to 16, inclusive. The value of log2\_max\_mv\_length\_vertical shall be in the range of 0 to 16, inclusive. When log2\_max\_mv\_length\_horizontal is not present, the values of log2\_max\_mv\_length\_horizontal and log2\_max\_mv\_length\_vertical is inferred to be equal to 16.

NOTE 13 – The maximum absolute value of a decoded vertical or horizontal motion vector component is also constrained by profile and level limits as specified in Annex A.

* + 1. HRD parameters semantics

**cpb\_cnt\_minus1** plus 1 specifies the number of alternative CPB specifications in the bitstream. The value of cpb\_cnt\_minus1 shall be in the range of 0 to 31, inclusive. When low\_delay\_hrd\_flag is equal to 1, cpb\_cnt\_minus1 shall be equal to 0. When cpb\_cnt\_minus1 is not present, it is inferred to be equal to 0.

**bit\_rate\_scale** (together with bit\_rate\_value\_minus1[ SchedSelIdx ]) specifies the maximum input bit rate of the SchedSelIdx-th CPB.

**cpb\_size\_scale** (together with cpb\_size\_value\_minus1[ SchedSelIdx ]) specifies the CPB size of the SchedSelIdx-th CPB.

**bit\_rate\_value\_minus1[** SchedSelIdx **]** (together with bit\_rate\_scale) specifies the maximum input bit rate for the SchedSelIdx‑th CPB. bit\_rate\_value\_minus1[ SchedSelIdx ] shall be in the range of 0 to 232 − 2, inclusive. For any SchedSelIdx > 0, bit\_rate\_value\_minus1[ SchedSelIdx ] shall be greater than bit\_rate\_value\_minus1[ SchedSelIdx − 1 ]. The bit rate in bits per second is given by

BitRate[ SchedSelIdx ] = ( bit\_rate\_value\_minus1[ SchedSelIdx ] + 1 ) \* 2(6 + bit\_rate\_scale) (E‑36)

When the bit\_rate\_value\_minus1[ SchedSelIdx ] syntax element is not present, the value of BitRate[ SchedSelIdx ] is inferred as follows:

– If profile\_idc is equal to 100, BitRate[ SchedSelIdx ] is inferred to be equal to 1000 \* MaxBR for VCL HRD parameters and to be equal to 1200 \* MaxBR for NAL HRD parameters, where MaxBR is specified in subclause .

– Otherwise, BitRate[ SchedSelIdx ] is inferred to be equal to cpbBrVclFactor \* MaxBR for VCL HRD parameters and to be equal to cpbBrNalFactor \* MaxBR for NAL HRD parameters, where MaxBR, cpbBrVclFactor and cpbBrNalFactor are specified in subclause .

**cpb\_size\_value\_minus1[** SchedSelIdx **]** is used together with cpb\_size\_scale to specify the SchedSelIdx-th CPB size. cpb\_size\_value\_minus1[ SchedSelIdx ] shall be in the range of 0 to 232 − 2, inclusive. For any SchedSelIdx greater than 0, cpb\_size\_value\_minus1[ SchedSelIdx ] shall be less than or equal to cpb\_size\_value\_minus1[ SchedSelIdx −1 ].

The CPB size in bits is given by

CpbSize[ SchedSelIdx ] = ( cpb\_size\_value\_minus1[ SchedSelIdx ] + 1 ) \* 2(4 + cpb\_size\_scale) (E‑)

When the cpb\_size\_value\_minus1[ SchedSelIdx ] syntax element is not present, the value of CpbSize[ SchedSelIdx ] is inferred as follows:

– If profile\_idc is equal to 100, CpbSize[ SchedSelIdx ] is inferred to be equal to 1000 \* MaxCPB for VCL HRD parameters and to be equal to 1200 \* MaxCPB for NAL HRD parameters, where MaxCPB is specified in subclause . [Ed. (GJS): Looks wrong, and why are there two items here? Why not just let Annex A take care of this?]

– Otherwise, CpbSize[ SchedSelIdx ] is inferred to be equal to cpbBrVclFactor \* MaxCPB for VCL HRD parameters and to be equal to cpbBrNalFactor \* MaxCPB for NAL HRD parameters, where MaxCPB, cpbBrVclFactor and cpbBrNalFactor are specified in subclause .

**cbr\_flag[** SchedSelIdx **]** equal to 0 specifies that to decode this bitstream by the HRD using the SchedSelIdx-th CPB specification, the hypothetical stream delivery scheduler (HSS) operates in an intermittent bit rate mode. cbr\_flag[ SchedSelIdx ] equal to 1 specifies that the HSS operates in a constant bit rate (CBR) mode. When the cbr\_flag[ SchedSelIdx ] syntax element is not present, the value of cbr\_flag is inferred to be equal to 0.

**initial\_cpb\_removal\_delay\_length\_minus1** specifies the length in bits of the initial\_cpb\_removal\_delay[ SchedSelIdx ] and initial\_cpb\_removal\_delay\_offset[ SchedSelIdx ] syntax elements of the buffering period SEI message. The length of initial\_cpb\_removal\_delay[ SchedSelIdx ] and of initial\_cpb\_removal\_delay\_offset[ SchedSelIdx ] is initial\_cpb\_removal\_delay\_length\_minus1 + 1. When the initial\_cpb\_removal\_delay\_length\_minus1 syntax element is present in more than one hrd\_parameters( ) syntax structure within the VUI parameters syntax structure, the value of the initial\_cpb\_removal\_delay\_length\_minus1 parameters shall be equal in both hrd\_parameters( ) syntax structures. When the initial\_cpb\_removal\_delay\_length\_minus1 syntax element is not present, it is inferred to be equal to 23.

**cpb\_removal\_delay\_length\_minus1** specifies the length in bits of the cpb\_removal\_delay syntax element. The length of the cpb\_removal\_delay syntax element of the picture timing SEI message is cpb\_removal\_delay\_length\_minus1 + 1. When the cpb\_removal\_delay\_length\_minus1 syntax element is present in more than one hrd\_parameters( ) syntax structure within the VUI parameters syntax structure, the value of the cpb\_removal\_delay\_length\_minus1 parameters shall be equal in both hrd\_parameters( ) syntax structures. When the cpb\_removal\_delay\_length\_minus1 syntax element is not present, it is inferred to be equal to 23.

**dpb\_output\_delay\_length\_minus1** specifies the length in bits of the dpb\_output\_delay syntax element. The length of the dpb\_output\_delay syntax element of the picture timing SEI message is dpb\_output\_delay\_length\_minus1 + 1. When the dpb\_output\_delay\_length\_minus1 syntax element is present in more than one hrd\_parameters( ) syntax structure within the VUI parameters syntax structure, the value of the dpb\_output\_delay\_length\_minus1 parameters shall be equal in both hrd\_parameters( ) syntax structures. When the dpb\_output\_delay\_length\_minus1 syntax element is not present, it is inferred to be equal to 23.

**time\_offset\_length** greater than 0 specifies the length in bits of the time\_offset syntax element. time\_offset\_length equal to 0 specifies that the time\_offset syntax element is not present. When the time\_offset\_length syntax element is present in more than one hrd\_parameters( ) syntax structure within the VUI parameters syntax structure, the value of the time\_offset\_length parameters shall be equal in both hrd\_parameters( ) syntax structures. When the time\_offset\_length syntax element is not present, it is inferred to be equal to 24.

**Patent rights declaration(s)**

**Sony Corporation may have current or pending patent rights relating to the technology described in this contribution and, conditioned on reciprocity, is prepared to grant licenses under reasonable and non-discriminatory terms as necessary for implementation of the resulting ITU-T Recommendation | ISO/IEC International Standard (per box 2 of the ITU-T/ITU-R/ISO/IEC patent statement and licensing declaration form).**