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**Information technology — Coding-  
independent code points —**

**Part 2:  
Video**

*Technologies de l'information — Points de code indépendants du  
codage —*

*Partie 2: Vidéo*





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## 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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives) or [www.iec.ch/members\\_experts/refdocs](http://www.iec.ch/members_experts/refdocs)).

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

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

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

This document was prepared by Joint Technical Committee ISO/IEC JTC1, *Information technology*, Subcommittee SC 29, *Coding of audio, picture, multimedia and hypermedia information*, in collaboration with ITU-T [as Rec. ITU-T H.273 (07/2021)].

This second edition cancels and replaces the first edition (ISO/IEC 23091-2:2019), which has been technically revised.

The main changes are as follows:

- the addition of a code point for chroma sampling grid alignment indication for the 4:2:0 colour format;
- correction of the range of values specification for sample aspect ratio indication;
- correction of the formulae for the  $IC_T C_P$  colour representation for the hybrid-log-gamma (HLG) transfer function specified in Rec. ITU-R BT.2100-2;
- correction of the formulae for the transfer function for the sYCC colour representation specified in IEC 61966-2-1.

A list of all parts in the ISO/IEC 23091 series can be found on the ISO and IEC websites.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at [www.iso.org/members.html](http://www.iso.org/members.html) and [www.iec.ch/national-committees](http://www.iec.ch/national-committees).

## Introduction

In a number of specifications, there is a need to identify some characteristics of video (or still image) media content that are logically independent of the compression format. These characteristics can include, for example, aspects that relate to the sourcing or presentation, or the role of the video (or still image) media component. These characteristics have typically been documented by fields that take an encoded value or item selected from an enumerated list, herein called code points.

These code points are typically defined in the specification of compression formats to document these characteristics of the media. In past practices, the definition of these fields has been copied from document to document, sometimes with new values being added in later documents (and sometimes with later amendments specified to add new entries to existing documents).

This past practice has raised a number of issues, including the following:

- a) A lack of a formal way to avoid conflicting assignments being made in different documents.
- b) Having additional values defined in later specifications that can be practically used with older compression formats, but without clear formal applicability of these new values to older documents.
- c) Any update or correction of code point semantics can incur significant effort to update all documents in which the code point is specified, instead of enabling a single central specification to apply across different referencing specifications.
- d) The choice of reference for other specifications (such as container or delivery formats) not being obvious; wherein a formal reference to a compression format document appears to favour that one format over others, and also appears to preclude definitions defined in other compression format specifications.
- e) Burdensome maintenance needs to ensure that a reference to material defined in a compression format specification is maintained appropriately over different revisions of the referenced format specification, as the content of a compression format specification can change over time and is ordinarily not intended as a point of reference for defining such code points.

This document provides a central definition of such code points for video and image applications to address these issues. This document can be used to provide universal descriptions to assist interpretation of video and image signals following decoding, or to describe the properties of these signals before they are encoded.



# Information technology — Coding-independent code points —

## Part 2: Video

### 1 Scope

This document defines various code points and fields that establish properties of a video (or still image) representation and are independent of the compression encoding and bit rate. These properties can describe the appropriate interpretation of decoded data or can, similarly, describe the characteristics of such a signal before the signal is compressed by an encoder that is suitable for compressing such an input signal.

### 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/CIE 11664-1, *Colorimetry — Part 1: CIE standard colorimetric observers*

### 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

#### 3.1 bottom field

assembly of the odd-numbered rows of samples of the *components* (3.3) of a video frame using a numbering of rows that starts with row number 0 as the top row

#### 3.2 chroma

sample array or single sample representing one of the two colour difference signals related to the primary colours, represented by the symbols Cb and Cr

Note 1 to entry: The term "chroma" is used rather than "chrominance" in order to avoid the implication of the use of linear light transfer characteristics that is often associated with "chrominance".

#### 3.3 component

array or single sample from one of the three arrays [*luma* (3.4) and two *chroma* (3.2)] that compose a *picture* (3.5) in 4:2:0, 4:2:2, or 4:4:4 colour format or the array or a single sample of the array that compose a *picture* in monochrome format

## 3.4

### **luma**

sample array or single sample representing the monochrome signal related to the primary colours, represented by the symbol or subscript Y or L

Note 1 to entry: The term "luma" is used rather than "luminance" in order to avoid the implication of the use of linear light transfer characteristics that is often associated with "luminance". The symbol L is sometimes used instead of the symbol Y to avoid confusion with the symbol y as used for vertical location.

## 3.5

### **picture**

array of *luma* (3.4) samples in monochrome format or array of *luma* samples and two corresponding arrays of *chroma* (3.2) samples in 4:2:0, 4:2:2, and 4:4:4 colour format

## 3.6

### **reserved**

values of a particular code point that are for future use by ITU-T | ISO/IEC

Note 1 to entry: These values shall not be used in identifiers conforming to this edition of this document. It is possible they will be used in a manner yet to be specified in some future extensions of this document by ITU-T | ISO/IEC.

## 3.7

### **top field**

assembly of the even-numbered rows of samples of a video frame using a numbering of rows that starts with row number 0 as the top row

## 3.8

### **unspecified**

values of a particular code point that have no specified meaning in this edition of this document and will not have a specified meaning in the future as an integral part of future editions of this document

## 4 Abbreviated terms

LSB      least significant bit

MSB      most significant bit

## 5 Conventions

NOTE      The mathematical operators used in this document are similar to those used in the C programming language. However, integer division and arithmetic shift operations are specifically defined. Numbering and counting conventions generally begin from 0.

### 5.1 Arithmetic operators

+          addition

–          subtraction (as a two-argument operator) or negation (as a unary prefix operator)

\*          multiplication, including matrix multiplication

$x^y$       exponentiation, x to the power of y (in other contexts, such notation may be used for superscripting not intended for interpretation as exponentiation)

/          integer division with truncation of the result toward zero (for example,  $7 / 4$  and  $(-7) / (-4)$  are truncated to 1 and  $(-7) / 4$  and  $7 / (-4)$  are truncated to -1)



$\div$	division in mathematical formulae where no truncation or rounding is intended
$\frac{x}{y}$	division in mathematical formulae where no truncation or rounding is intended
$\sum_{i=x}^y f(i)$	summation of $f(i)$ with $i$ taking all integer values from $x$ up to and including $y$
$x \% y$	modulus, remainder of $x$ divided by $y$ , defined only for integers $x$ and $y$ with $x \geq 0$ and $y > 0$

## 5.2 Bit-wise operators

$\&$	bit-wise "and" (when operating on integer arguments, operates on a two's complement representation of the integer value; when operating on a binary argument that contains fewer bits than another argument, the shorter argument is extended by adding more significant bits equal to 0)
$ $	bit-wise "or" (when operating on integer arguments, operates on a two's complement representation of the integer value; when operating on a binary argument that contains fewer bits than another argument, the shorter argument is extended by adding more significant bits equal to 0)
$\wedge$	bit-wise "exclusive or" (when operating on integer arguments, operates on a two's complement representation of the integer value; when operating on a binary argument that contains fewer bits than another argument, the shorter argument is extended by adding more significant bits equal to 0)
$x \gg y$	arithmetic right shift of a two's complement integer representation of $x$ by $y$ binary digits (defined only for non-negative integer values of $y$ ; bits shifted into the MSBs as a result of the right shift have a value equal to the MSB of $x$ prior to the shift operation)
$x \ll y$	arithmetic left shift of a two's complement integer representation of $x$ by $y$ binary digits (defined only for non-negative integer values of $y$ ; bits shifted into the LSBs as a result of the left shift have a value equal to 0)

## 5.3 Assignment operators

$=$	assignment operator
$++$	increment, i.e. $x++$ is equivalent to $x = x + 1$ ; when used in an array index, evaluates to the value of the variable prior to the increment operation
$--$	decrement, i.e. $x--$ is equivalent to $x = x - 1$ ; when used in an array index, evaluates to the value of the variable prior to the decrement operation
$+=$	increment by amount given, i.e. $x += 3$ is equivalent to $x = x + 3$ , and $x += (-3)$ is equivalent to $x = x + (-3)$
$-=$	decrement by amount given, i.e. $x -= 3$ is equivalent to $x = x - 3$ , and $x -= (-3)$ is equivalent to $x = x - (-3)$

## 5.4 Relational, logical, and other operators

$==$	equality operator
$!=$	not equal to operator

!x	logical negation "not"
>	larger than operator
<	smaller than operator
>=	larger than or equal to operator
<=	smaller than or equal to operator
&&	conditional/logical "and" operator, performs a logical "and" of its Boolean operators, but only evaluates the second operand when necessary
	conditional/logical "or" operator, performs a logical "or" of its Boolean operators, but only evaluates the second operand when necessary
a ? b : c	ternary conditional, if condition a is true, then the result is equal to b; otherwise the result is equal to c

NOTE When a relational operator is applied to a code point or variable that has been assigned the value "na" (not applicable), the value "na" is treated as a distinct value for the code point or variable. The value "na" is considered not to be equal to any other value.

## 5.5 Mathematical functions

[Formulae \(1\) to \(11\)](#) define functions for use in mathematical expressions within this document.

$$\text{Abs}(x) = \begin{cases} x & ; \quad x \geq 0 \\ -x & ; \quad x < 0 \end{cases} \quad (1)$$

$$\text{Ceil}(x) \text{ the smallest integer greater than or equal to } x. \quad (2)$$

$$\text{Clip1}_Y(x) = \text{Clip3}(0, (1 \ll \text{BitDepth}_Y) - 1, x), \quad (3)$$

where  $\text{BitDepth}_Y$  is the representation bit depth of the corresponding luma colour component signal.

$$\text{Clip1}_C(x) = \text{Clip3}(0, (1 \ll \text{BitDepth}_C) - 1, x), \quad (4)$$

where  $\text{BitDepth}_C$  is the representation bit depth of the corresponding chroma colour component signal C. In general,  $\text{BitDepth}_C$  may be distinct for different chroma colour components signals C – e.g. for C corresponding to Cb or Cr.

$$\text{Clip3}(x, y, z) = \begin{cases} x & ; \quad z < x \\ y & ; \quad z > y \\ z & ; \quad \text{otherwise} \end{cases} \quad (5)$$

$$\text{Floor}(x) \text{ the largest integer less than or equal to } x. \quad (6)$$

$$\text{Ln}(x) \text{ the natural logarithm of } x. \quad (7)$$

$$\text{Log10}(x) \text{ the base-10 logarithm of } x. \quad (8)$$

$$\text{Round}(x) = \text{Sign}(x) * \text{Floor}(\text{Abs}(x) + 0.5). \quad (9)$$

$$\text{Sign}(x) = \begin{cases} 1 & ; x > 0 \\ 0 & ; x == 0 \\ -1 & ; x < 0 \end{cases} \quad (10)$$

$$\text{Sqrt}(x) \text{ the square root of } x. \quad (11)$$

## 5.6 Order of operations

When order of precedence in an expression is not indicated explicitly by use of parentheses, the following rules apply:

- Operations of a higher precedence are evaluated before any operation of a lower precedence.
- Operations of the same precedence are evaluated sequentially from left to right.

[Table 1](#) specifies the precedence of operations from highest to lowest; a higher position in the table indicates a higher precedence.

NOTE For those operators that are also used in the C programming language, the order of precedence used in this document is the same as used in the C programming language.

**Table 1 — Operation precedence from highest (at top of table) to lowest (at bottom of table)**

Operations (with operands x, y, and z)
"x+", "x-"
"!x", "-x" (as a unary prefix operator)
"x <sup>y</sup> "
"x * y", "x / y", "x ÷ y", " $\frac{x}{y}$ ", "x % y"
"x + y", "x - y" (as a two-argument operator), " $\sum_{i=x}^y f(i)$ "
"x << y", "x >> y"
"x < y", "x <= y", "x > y", "x >= y"
"x = y", "x != y"
"x & y"
"x   y"
"x && y"
"x    y"
"x ? y : z"
"x.y"
"x = y", "x += y", "x -= y"

6 Specified code points

This clause identifies the code points defined in this document, as listed in [Table 2](#) with cross-references to the subclause in which each is specified.

Table 2 — List of code point definitions

Name	Abstract	Subclause
ColourPrimaries	Video colour primaries	<a href="#">8.1</a>
TransferCharacteristics	Video colour transfer characteristics	<a href="#">8.2</a>
MatrixCoefficients and VideoFullRangeFlag	Video matrix colour coefficients	<a href="#">8.3</a>
VideoFramePackingType and QuincunxSamplingFlag	Video frame packing	<a href="#">8.4</a>
PackedContentInterpretationType	Interpretation of packed video frames	<a href="#">8.5</a>
SampleAspectRatio, SarWidth, and SarHeight	Sample aspect ratio of video	<a href="#">8.6</a>
Chroma420SampleLocType	Chroma sampling grid alignment for video fields or frames having the 4:2:0 colour format	<a href="#">8.7</a>

7 Principles for definition and referencing of code points

7.1 Application usage

This document specifies code points for coding-independent description of video and image signal type characteristics. These signal type identifiers can be used to provide universal descriptions to assist the interpretation of signals following decoding or to describe properties of the signals prior to encoding.

An example of the usage of the code point identifiers specified in this document is illustrated in [Figure 1](#). The signal type identifier may be represented within the video elementary stream produced by an encoder. Alternatively, or additionally, the signal type identifier may be carried outside of a video elementary stream by other means, such as in a file storage format, in a system multiplex format, or in a streaming system protocol.

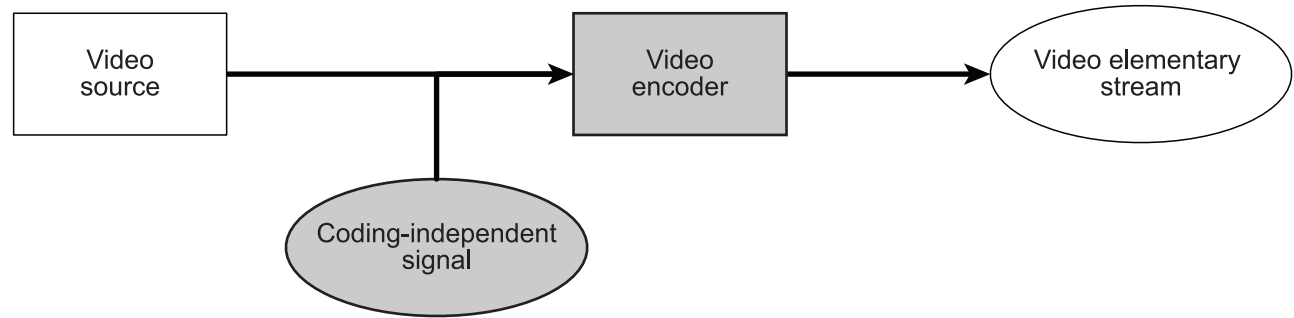


Figure 1 — Example usage

7.2 Code point encoding and defaults

The code points defined herein may be specified as a value or a label of an enumerated list. The definition of their encoding and representation (e.g. as a binary number) is the responsibility of the specification using the code point, as is the identification of any applicable default value not specified herein. It is also possible for external specifications to use a mapping to values defined here, if they wish to preserve identical semantics but different code point assignments.

Guidance is given for each code point as to a suitable type (e.g. unsigned integer) and a suitable value range (e.g. 0–63) for assistance in writing derived specifications. In some instances, default flag values

are provided that are suggested to be inferred for code point parameters with associated flags that might not be explicitly signalled or specified in derived specifications.

### 7.3 Externally defined values

If the external specification permits values not defined by this document to be identified in the same field that carries values defined by this document, then that other specification shall identify how values defined herein can be distinguished from values not defined herein.

### 7.4 Reference format

References to code points in this document should use only the code point name (i.e. a "Name" from [Table 2](#)) and specification title, and not use subclause numbers or any other "fragile" reference such as a table number. For example, for a hypothetical code point named "**ChocolateDensity**", a document can refer to "**ChocolateDensity** as defined in ISO/IEC 23091-2".

### 7.5 Uniform resource name format

ISO/IEC 23091-1 specifies a uniform resource name format that may be used for the code points specified in this document.

## 8 Video code points

### 8.1 Colour primaries

*Type: Unsigned integer, enumeration*

*Range: 0 – 255*

**ColourPrimaries** indicates the chromaticity coordinates of the source colour primaries as specified in [Table 3](#) in terms of the CIE 1931 definition of x and y, which shall be interpreted as specified by ISO/CIE 11664-1.

An 8-bit field should be adequate for representation of the ColourPrimaries code point.

**Table 3 — Interpretation of colour primaries (ColourPrimaries) value**

Value	Colour primaries			Informative remarks
0	Reserved			For future use by ITU-T   ISO/IEC
1	primary	x	y	Rec. ITU-R BT.709-6
	green	0.300	0.600	Rec. ITU-R BT.1361-0 conventional colour gamut system and extended colour gamut system (historical)
	blue	0.150	0.060	IEC 61966-2-1 sRGB or sYCC
	red	0.640	0.330	IEC 61966-2-4
	white D65	0.3127	0.3290	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

Table 3 (continued)

Value	Colour primaries			Informative remarks
4	primary	x	y	Rec. ITU-R BT.470-6 System M (historical)
	green	0.21	0.71	United States National Television System Committee 1953 Recommendation for transmission standards for colour television
	blue	0.14	0.08	
	red	0.67	0.33	United States Federal Communications Commission Title 47 Code of Federal Regulations (2003) 73.682 (a) (20)
	white C	0.310	0.316	
5	primary	x	y	Rec. ITU-R BT.470-6 System B, G (historical)
	green	0.29	0.60	Rec. ITU-R BT.601-7 625
	blue	0.15	0.06	Rec. ITU-R BT.1358-0 625 (historical)
	red	0.64	0.33	Rec. ITU-R BT.1700-0 625 PAL and 625 SECAM
	white D65	0.3127	0.3290	
6	primary	x	y	Rec. ITU-R BT.601-7 525
	green	0.310	0.595	Rec. ITU-R BT.1358-1 525 or 625 (historical)
	blue	0.155	0.070	Rec. ITU-R BT.1700-0 NTSC
	red	0.630	0.340	Society of Motion Picture and Television Engineers ST 170 (2004)
	white D65	0.3127	0.3290	(functionally the same as the value 7)
7	primary	x	y	Society of Motion Picture and Television Engineers ST 240 (1999)
	green	0.310	0.595	(functionally the same as the value 6)
	blue	0.155	0.070	
	red	0.630	0.340	
	white D65	0.3127	0.3290	
8	primary	x	y	Generic film (colour filters using Illuminant C)
	green	0.243	0.692 (Wratten 58)	
	blue	0.145	0.049 (Wratten 47)	
	red	0.681	0.319 (Wratten 25)	
	white C	0.310	0.316	
9	primary	x	y	Rec. ITU-R BT.2020-2
	green	0.170	0.797	Rec. ITU-R BT.2100-2
	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 (2019)
	green (Y)	0.0	1.0	(CIE 1931 XYZ as in ISO/CIE 11664-1)
	blue (Z)	0.0	0.0	
	red (X)	1.0	0.0	
	centre white	1 ÷ 3	1 ÷ 3	
11	primary	x	y	Society of Motion Picture and Television Engineers RP 431-2 (2011)
	green	0.265	0.690	
	blue	0.150	0.060	
	red	0.680	0.320	
	white	0.314	0.351	

Table 3 (continued)

Value	Colour primaries			Informative remarks
12	primary	x	y	Society of Motion Picture and Television Engineers EG 432-1 (2010)
	green	0.265	0.690	
	blue	0.150	0.060	
	red	0.680	0.320	
	white D65	0.3127	0.3290	
13–21	Reserved			For future use by ITU-T   ISO/IEC
22	primary	x	y	No corresponding industry specification identified
	green	0.295	0.605	
	blue	0.155	0.077	
	red	0.630	0.340	
	white D65	0.3127	0.3290	
23–255	Reserved			For future use by ITU-T   ISO/IEC

## 8.2 Transfer characteristics

Type: Unsigned integer, enumeration

Range: 0 – 255

**TransferCharacteristics**, as specified in Table 4, either indicates the reference opto-electronic transfer characteristic function of the source picture as a function of a source input linear optical intensity input  $L_c$  with a nominal real-valued range of 0 to 1 or indicates the inverse of the reference electro-optical transfer characteristic function as a function of an output linear optical intensity  $L_o$  with a nominal real-valued range of 0 to 1. For interpretation of entries in Table 4 that are expressed in terms of multiple curve segments parameterized by the variable  $\alpha$  over a region bounded by the variable  $\beta$  or by the variables  $\beta$  and  $\gamma$ , the values of  $\alpha$  and  $\beta$  are defined to be the positive constants necessary for the curve segments that meet at the value  $\beta$  to have continuity of both value and slope at the value  $\beta$ . The value of  $\gamma$ , when applicable, is defined to be the positive constant necessary for the associated curve segments to meet at the value  $\gamma$ . For example, for TransferCharacteristics equal to 1, 6, 14, or 15,  $\alpha$  has the value  $1 + 5.5 * \beta = 1.099\ 296\ 826\ 809\ 442\dots$  and  $\beta$  has the value 0.018 053 968 510 807...

An 8-bit field should be adequate for representation of the TransferCharacteristics code point.

NOTE 1 As indicated in Table 4, some values of TransferCharacteristics are defined in terms of a reference opto-electronic transfer characteristic function and others are defined in terms of a reference electro-optical transfer characteristic function, according to the convention that has been applied in other documents. In the cases of Rec. ITU-R BT.709-6 and Rec. ITU-R BT.2020-2 (as can be indicated by TransferCharacteristics equal to 1, 6, 14, or 15), although the value is defined in terms of a reference opto-electronic transfer characteristic function, a corresponding reference electro-optical transfer characteristic function for flat panel displays used in HDTV studio production has been specified in Rec. ITU-R BT.1886-0.

Depending on the application and for proper functioning of the formulae specified in this document, it is possible that certain combinations of TransferCharacteristics, VideoFullRangeFlag, BitDepth<sub>y</sub>, and BitDepth<sub>c</sub> will not be permitted.

**Table 4 — Interpretation of transfer characteristics (TransferCharacteristics) value**

Value	Transfer characteristics	Informative remarks
0	Reserved	For future use by ITU-T   ISO/IEC
1	$V = \alpha * L_c^{0.45} - (\alpha - 1)$ for $1 \geq L_c \geq \beta$ $V = 4.500 * L_c$ for $\beta > L_c \geq 0$	Rec. ITU-R BT.709-6 Rec. ITU-R BT.1361-0 conventional colour gamut system (historical) (functionally the same as the values 6, 14, and 15)
2	Unspecified	Image characteristics are unknown or are determined by the application.
3	Reserved	For future use by ITU-T   ISO/IEC
4	Assumed display gamma 2.2	Rec. ITU-R BT.470-6 System M (historical) 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.1700-0 625 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.601-7 525 or 625 Rec. ITU-R BT.1358-1 525 or 625 (historical) Rec. ITU-R BT.1700-0 NTSC Society of Motion Picture and Television Engineers ST 170 (2004) (functionally the same as the values 1, 14, and 15)
7	$V = \alpha * L_c^{0.45} - (\alpha - 1)$ for $1 \geq L_c \geq \beta$ $V = 4.0 * L_c$ for $\beta > L_c \geq 0$	Society of Motion Picture and Television Engineers ST 240 (1999)
8	$V = L_c$ for $1 > L_c \geq 0$	Linear transfer characteristics
9	$V = 1.0 + \text{Log10}(L_c) \div 2$ 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	$V = 1.0 + \text{Log10}(L_c) \div 2.5$ for $1 \geq L_c \geq \text{Sqrt}(10) \div 1000$ $V = 0.0$ for $\text{Sqrt}(10) \div 1000 > L_c \geq 0$	Logarithmic transfer characteristic ( $100 * \text{Sqrt}(10) : 1$ 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



Table 4 (continued)

Value	Transfer characteristics	Informative remarks
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 $-\gamma \geq L_c \geq -0.25$	Rec. ITU-R BT.1361-0 extended colour gamut system (historical)
13	<p>– If MatrixCoefficients is equal to 0 for <math>1 &gt; L_c \geq \beta</math>  <math>V = \alpha * L_c^{(1 \div 2.4)} - (\alpha - 1)</math> for <math>\beta &gt; L_c \geq 0</math>  <math>V = 12.92 * L_c</math> for <math>L_c \geq \beta</math></p> <p>– Otherwise for <math>\beta &gt; L_c &gt; -\beta</math>  <math>V = \alpha * L_c^{(1 \div 2.4)} - (\alpha - 1)</math> for <math>-\beta \geq L_c</math>  <math>V = 12.92 * L_c</math>  <math>V = -\alpha * (-L_c)^{(1 \div 2.4)} + (\alpha - 1)</math></p>	<p>IEC 61966-2-1 sRGB (with MatrixCoefficients equal to 0)</p> <p>IEC 61966-2-1 sYCC (with MatrixCoefficients equal to 5)</p>
14	$V = \alpha * L_c^{0.45} - (\alpha - 1)$ for $1 \geq L_c \geq \beta$ $V = 4.500 * L_c$ for $\beta > L_c \geq 0$	Rec. ITU-R BT.2020-2 (functionally the same as the values 1, 6, and 15)
15	$V = \alpha * L_c^{0.45} - (\alpha - 1)$ for $1 \geq L_c \geq \beta$ $V = 4.500 * L_c$ for $\beta > L_c \geq 0$	Rec. ITU-R BT.2020-2 (functionally the same as the values 1, 6, and 14)
16	$V = ((c_1 + c_2 * L_o^n) \div (1 + c_3 * L_o^n))^m$ for all values of $L_o$ $c_1 = c_3 - c_2 + 1 = 107 \div 128 = 0.835\ 937\ 5$ $c_2 = 2413 \div 128 = 18.851\ 562\ 5$ $c_3 = 2392 \div 128 = 18.687\ 5$ $m = 2523 \div 32 = 78.843\ 75$ $n = 653 \div 4096 = 0.159\ 301\ 757\ 812\ 5$ for which $L_o$ equal to 1 for peak white is ordinarily intended to correspond to a reference output luminance level of 10 000 candelas per square metre	<p>Society of Motion Picture and Television Engineers ST 2084 (2014) for 10, 12, 14, and 16-bit systems</p> <p>Rec. ITU-R BT.2100-2 perceptual quantization (PQ) system</p>
17	$V = (48 * L_o \div 52.37)^{(1 \div 2.6)}$ for all values of $L_o$ for which $L_o$ equal to 1 for peak white is ordinarily intended to correspond to a reference output luminance level of 48 candelas per square metre	Society of Motion Picture and Television Engineers ST 428-1 (2019)
18	$V = a * \text{Ln}(12 * L_c - b) + c$ for $1 \geq L_c > 1 \div 12$ $V = \text{Sqrt}(3) * L_c^{0.5}$ for $1 \div 12 \geq L_c \geq 0$ $a = 0.178\ 832\ 77$ $b = 0.284\ 668\ 92$ $c = 0.559\ 910\ 73$	<p>Association of Radio Industries and Businesses (ARIB) STD-B67 (2018)</p> <p>Rec. ITU-R BT.2100-2 hybrid log-gamma (HLG) system</p>
19–255	Reserved	For future use by ITU-T   ISO/IEC

NOTE 2 For TransferCharacteristics equal to 13, the formulae given in Table 4 for interpretation with MatrixCoefficients equal to 0 were specified as applying to all values of MatrixCoefficients in a previous edition of this document. Closer study later determined that IEC 61966-2-1 had specified a wider range of values for  $L_c$  in the context of sYCC usage corresponding to MatrixCoefficients equal to 5. This document was therefore revised to provide a specification of TransferCharacteristics interpretation that depends on the value of MatrixCoefficients to address this deficiency in the previous edition of the document.

NOTE 3 For TransferCharacteristics equal to 18, the formulae given in Table 4 are normalized for a source input linear optical intensity  $L_c$  with a nominal real-valued range of 0 to 1. An alternative scaling that is mathematically equivalent is used in ARIB STD-B67 (2018) with the source input linear optical intensity having a nominal real-valued range of 0 to 12.

### 8.3 Matrix coefficients

Type: Unsigned integer, enumeration

Range: 0 – 255, plus associated flag

**MatrixCoefficients** describes the matrix coefficients used in deriving luma and chroma signals from the green, blue, and red, or X, Y, and Z primaries, as specified in [Table 5](#) and the formulae below.

A flag, VideoFullRangeFlag, may be supplied with this code point (see below).

**VideoFullRangeFlag** specifies the scaling and offset values applied in association with the MatrixCoefficients. When not present or not specified, the value 0 for VideoFullRangeFlag would ordinarily be inferred as the default value for video imagery.

An 8-bit field should be adequate for representation of the MatrixCoefficients code point.

Certain values of MatrixCoefficients may be disallowed, depending on the application and the characteristics and format of the signal, e.g. with regard to combinations of the chroma format sampling structure and the values of BitDepth<sub>Y</sub> and BitDepth<sub>C</sub>.

The interpretation of MatrixCoefficients is specified by the following formulae.  $E_R$ ,  $E_G$ , and  $E_B$  are defined as "linear-domain" real-valued signals based on the indicated colour primaries (see [8.1](#)) before applying the transfer characteristics (see [8.2](#)).

For purposes of the YZX representation when MatrixCoefficients is equal to 0, the symbols R, G, and B are substituted for X, Y, and Z, respectively, in the following descriptions of [Formulae \(12\) to \(14\)](#), [Formulae \(15\) to \(17\)](#), [Formulae \(21\) to \(23\)](#), and [Formulae \(27\) to \(29\)](#).

Nominal peak white is specified as having  $E_R$  equal to 1,  $E_G$  equal to 1, and  $E_B$  equal to 1.

Nominal black is specified as having  $E_R$  equal to 0,  $E_G$  equal to 0, and  $E_B$  equal to 0.

The application of the transfer characteristics function is denoted by  $(x)'$  for an argument  $x$ .

- If MatrixCoefficients is not equal to 14, the signals  $E'_R$ ,  $E'_G$ , and  $E'_B$  are determined by application of the transfer characteristics function as per [Formulae \(12\) to \(14\)](#):

$$E'_R = (E_R)' \quad (12)$$

$$E'_G = (E_G)' \quad (13)$$

$$E'_B = (E_B)' \quad (14)$$

In this case, the range of  $E'_R$ ,  $E'_G$ , and  $E'_B$  is specified as follows:

- If TransferCharacteristics 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 (TransferCharacteristics is equal to 11 (IEC 61966-2-4) or 12 (Rec. ITU-R BT.1361-0 extended colour gamut system)),  $E'_R$ ,  $E'_G$  and  $E'_B$  are real numbers with a larger range not specified in this document.
- Otherwise (MatrixCoefficients is equal to 14), the "linear-domain" real-valued signals  $E_L$ ,  $E_M$ , and  $E_S$  are determined as per [Formulae \(15\) to \(17\)](#):

$$E_L = (1688 * E_R + 2146 * E_G + 262 * E_B) \div 4096 \quad (15)$$

$$E_M = (683 * E_R + 2951 * E_G + 462 * E_B) \div 4096 \quad (16)$$

$$E_S = (99 * E_R + 309 * E_G + 3688 * E_B) \div 4096 \quad (17)$$

In this case, the signals  $E'_L$ ,  $E'_M$ , and  $E'_S$  are determined by application of the transfer characteristics function as per [Formulae \(18\)](#) to [\(20\)](#):

$$E'_L = (E_L)' \quad (18)$$

$$E'_M = (E_M)' \quad (19)$$

$$E'_S = (E_S)' \quad (20)$$

The interpretation of MatrixCoefficients is specified as follows.

— If VideoFullRangeFlag is equal to 0, the following applies:

— If MatrixCoefficients is equal to 0 or 8, [Formulae \(21\)](#) to [\(23\)](#) apply:

$$R = \text{Clip1}_Y ( (1 \ll (\text{BitDepth}_Y - 8)) * (219 * E'_R + 16) ) \quad (21)$$

$$G = \text{Clip1}_Y ( (1 \ll (\text{BitDepth}_Y - 8)) * (219 * E'_G + 16) ) \quad (22)$$

$$B = \text{Clip1}_Y ( (1 \ll (\text{BitDepth}_Y - 8)) * (219 * E'_B + 16) ) \quad (23)$$

— Otherwise, if MatrixCoefficients is equal to 1, 4, 5, 6, 7, 9, 10, 11, 12, 13, or 14, [Formulae \(24\)](#) to [\(26\)](#) apply:

$$Y = \text{Clip1}_Y ( \text{Round} ( (1 \ll (\text{BitDepth}_Y - 8)) * (219 * E'_Y + 16) ) ) \quad (24)$$

$$Cb = \text{Clip1}_C ( \text{Round} ( (1 \ll (\text{BitDepth}_C - 8)) * (224 * E'_{PB} + 128) ) ) \quad (25)$$

$$Cr = \text{Clip1}_C ( \text{Round} ( (1 \ll (\text{BitDepth}_C - 8)) * (224 * E'_{PR} + 128) ) ) \quad (26)$$

— Otherwise, if MatrixCoefficients is equal to 2, the interpretation of the MatrixCoefficients code point is unknown or is determined by the application.

— Otherwise (MatrixCoefficients is not equal to 0, 1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, or 14), the interpretation of the MatrixCoefficients code point is reserved for future definition by ITU-T | ISO/IEC.

— Otherwise (VideoFullRangeFlag is equal to 1), the following formulae apply:

— If MatrixCoefficients is equal to 0 or 8, [Formulae \(27\)](#) to [\(29\)](#) apply:

$$R = \text{Clip1}_Y ( (1 \ll \text{BitDepth}_Y) - 1 ) * E'_R \quad (27)$$

$$G = \text{Clip1}_Y ( (1 \ll \text{BitDepth}_Y) - 1 ) * E'_G \quad (28)$$

$$B = \text{Clip1}_Y ( (1 \ll \text{BitDepth}_Y) - 1 ) * E'_B \quad (29)$$

- Otherwise, if MatrixCoefficients is equal to 1, 4, 5, 6, 7, 9, 10, 11, 12, 13, or 14, [Formulae \(30\)](#) to [\(32\)](#) apply:

$$Y = \text{Clip1}_Y( \text{Round}( ( ( 1 \ll \text{BitDepth}_Y ) - 1 ) * E'_Y ) ) \quad (30)$$

$$Cb = \text{Clip1}_C( \text{Round}( ( ( 1 \ll \text{BitDepth}_C ) - 1 ) * E'_{PB} + ( 1 \ll ( \text{BitDepth}_C - 1 ) ) ) ) \quad (31)$$

$$Cr = \text{Clip1}_C( \text{Round}( ( ( 1 \ll \text{BitDepth}_C ) - 1 ) * E'_{PR} + ( 1 \ll ( \text{BitDepth}_C - 1 ) ) ) ) \quad (32)$$

- Otherwise, if MatrixCoefficients is equal to 2, the interpretation of the MatrixCoefficients code point is unknown or is determined by the application.
- Otherwise (MatrixCoefficients is not equal to 0, 1, 2, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, or 14), the interpretation of the MatrixCoefficients code point is reserved for future definition by ITU-T | ISO/IEC.

When MatrixCoefficients is equal to 1, 4, 5, 6, 7, 9, 10, 11, 12, or 13, the constants  $K_R$  and  $K_B$  are specified as follows:

- If MatrixCoefficients is not equal to 12 or 13, the constants  $K_R$  and  $K_B$  are specified in [Table 5](#).
- Otherwise (MatrixCoefficients is equal to 12 or 13), the constants  $K_R$  and  $K_B$  are computed as follows, using the chromaticity coordinates  $(x_R, y_R)$ ,  $(x_G, y_G)$ ,  $(x_B, y_B)$ , and  $(x_W, y_W)$  specified by [Table 3](#) for the ColourPrimaries code point for the red, green, blue, and white colour primaries, respectively:

$$K_R = \frac{y_R * (x_W * (y_G * z_B - y_B * z_G) + y_W * (x_B * z_G - x_G * z_B) + z_W * (x_G * y_B - x_B * y_G))}{y_W * (x_R * (y_G * z_B - y_B * z_G) + x_G * (y_B * z_R - y_R * z_B) + x_B * (y_R * z_G - y_G * z_R))} \quad (33)$$

$$K_B = \frac{y_B * (x_W * (y_R * z_G - y_G * z_R) + y_W * (x_G * z_R - x_R * z_G) + z_W * (x_R * y_G - x_G * y_R))}{y_W * (x_R * (y_G * z_B - y_B * z_G) + x_G * (y_B * z_R - y_R * z_B) + x_B * (y_R * z_G - y_G * z_R))} \quad (34)$$

where the values of  $z_R$ ,  $z_G$ ,  $z_B$ , and  $z_W$ , are given by [Formulae \(35\)](#) to [\(38\)](#):

$$z_R = 1 - (x_R + y_R) \quad (35)$$

$$z_G = 1 - (x_G + y_G) \quad (36)$$

$$z_B = 1 - (x_B + y_B) \quad (37)$$

$$z_W = 1 - (x_W + y_W) \quad (38)$$

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

- If MatrixCoefficients is not equal to 0, 8, 10, 11, 13, or 14, [Formulae \(39\)](#) to [\(41\)](#) apply:

$$E'_Y = K_R * E'_R + (1 - K_R - K_B) * E'_G + K_B * E'_B \quad (39)$$

$$E'_{PB} = 0.5 * (E'_B - E'_Y) \div (1 - K_B) \quad (40)$$

$$E'_{PR} = 0.5 * (E'_R - E'_Y) \div (1 - K_R) \quad (41)$$

$E'_Y$  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 TransferCharacteristics is not equal to 11 or 12,  $E'_Y$  is a real number with values in the range of 0 to 1. When TransferCharacteristics 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 TransferCharacteristics is equal to 11 (IEC 61966-2-4), or 12 (Rec. ITU-R BT.1361-0 extended colour gamut system),  $E'_Y$ ,  $E'_{PB}$ , and  $E'_{PR}$  are real numbers with a larger range not specified in this document.

- Otherwise, if MatrixCoefficients is equal to 0, [Formulae \(42\)](#) to [\(44\)](#) apply:

$$Y = \text{Round}(G) \quad (42)$$

$$Cb = \text{Round}(B) \quad (43)$$

$$Cr = \text{Round}(R) \quad (44)$$

- Otherwise, if MatrixCoefficients is equal to 8, the following applies:

- If BitDepth<sub>C</sub> is equal to BitDepth<sub>Y</sub>, [Formulae \(45\)](#) to [\(47\)](#) apply:

$$Y = \text{Round}(0.5 * G + 0.25 * (R + B)) \quad (45)$$

$$Cb = \text{Round}(0.5 * G - 0.25 * (R + B)) + (1 \ll (\text{BitDepth}_C - 1)) \quad (46)$$

$$Cr = \text{Round}(0.5 * (R - B)) + (1 \ll (\text{BitDepth}_C - 1)) \quad (47)$$

For purposes of the YCgCo nomenclature used in [Table 5](#), Cb and Cr of [Formulae \(46\)](#) and [\(47\)](#) may be referred to as Cg and Co, respectively. An appropriate inverse conversion for the above three formulae is given in [Formulae \(48\)](#) to [\(51\)](#):

$$t = Y - (Cb - (1 \ll (\text{BitDepth}_C - 1))) \quad (48)$$

$$G = \text{Clip1}_Y(Y + (Cb - (1 \ll (\text{BitDepth}_C - 1)))) \quad (49)$$

$$B = \text{Clip1}_Y(t - (Cr - (1 \ll (\text{BitDepth}_C - 1)))) \quad (50)$$

$$R = \text{Clip1}_Y(t + (Cr - (1 \ll (\text{BitDepth}_C - 1)))) \quad (51)$$

- Otherwise (BitDepth<sub>C</sub> is not equal to BitDepth<sub>Y</sub>), [Formulae \(52\)](#) to [\(55\)](#) apply:

$$Cr = \text{Round}(R) - \text{Round}(B) + (1 \ll (\text{BitDepth}_C - 1)) \quad (52)$$

$$t = \text{Round}(B) + ((Cr - (1 \ll (\text{BitDepth}_C - 1))) \gg 1) \quad (53)$$

$$Cb = \text{Round}(G) - t + (1 \ll (\text{BitDepth}_C - 1)) \quad (54)$$

$$Y = t + ((Cb - (1 \ll (\text{BitDepth}_C - 1))) \gg 1) \quad (55)$$

For purposes of the YCgCo nomenclature used in [Table 5](#), Cb and Cr of [Formulae \(54\)](#) and [\(52\)](#) may be referred to as Cg and Co, respectively. An appropriate inverse conversion for the above four formulae is given in [Formulae \(56\)](#) to [\(59\)](#):

$$t = Y - ( (Cb - (1 \ll (\text{BitDepth}_C - 1))) \gg 1 ) \quad (56)$$

$$G = \text{Clip1}_Y(t + (Cb - (1 \ll (\text{BitDepth}_C - 1)))) \quad (57)$$

$$B = \text{Clip1}_Y(t - ( (Cr - (1 \ll (\text{BitDepth}_C - 1))) \gg 1 )) \quad (58)$$

$$R = \text{Clip1}_Y(B + (Cr - (1 \ll (\text{BitDepth}_C - 1)))) \quad (59)$$

- Otherwise, if MatrixCoefficients is equal to 10 or 13, the signal  $E'_Y$  is determined by application of the transfer characteristics function as given in [Formulae \(60\)](#) and [\(61\)](#), and [Formulae \(62\)](#) and [\(69\)](#) apply for specification of the signals  $E'_{PB}$  and  $E'_{PR}$ :

$$E_Y = K_R * E_R + (1 - K_R - K_B) * E_G + K_B * E_B \quad (60)$$

$$E'_Y = (E_Y)' \quad (61)$$

In this case,  $E_Y$  is defined from the "linear-domain" signals for  $E_R$ ,  $E_G$ , and  $E_B$ , prior to application of the transfer characteristics function, which is then applied to produce the signal  $E'_Y$ .  $E_Y$  and  $E'_Y$  are real values with the value 0 associated with nominal black and the value 1 associated with nominal white.

$$E'_{PB} = (E'_B - E'_Y) \div (2 * N_B) \text{ for } -N_B \leq E'_B - E'_Y \leq 0 \quad (62)$$

$$E'_{PB} = (E'_B - E'_Y) \div (2 * P_B) \text{ for } 0 < E'_B - E'_Y \leq P_B \quad (63)$$

$$E'_{PR} = (E'_R - E'_Y) \div (2 * N_R) \text{ for } -N_R \leq E'_R - E'_Y \leq 0 \quad (64)$$

$$E'_{PR} = (E'_R - E'_Y) \div (2 * P_R) \text{ for } 0 < E'_R - E'_Y \leq P_R \quad (65)$$

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 given in [Formulae \(66\)](#) to [\(69\)](#):

$$N_B = (1 - K_B)' \quad (66)$$

$$P_B = 1 - (K_B)' \quad (67)$$

$$N_R = (1 - K_R)' \quad (68)$$

$$P_R = 1 - (K_R)' \quad (69)$$

- Otherwise, if MatrixCoefficients is equal to 11, [Formulae \(70\)](#) to [\(72\)](#) apply:

$$E'_Y = E'_G \quad (70)$$

$$E'_{PB} = (0.986\ 566 * E'_B - E'_Y) \div 2.0 \quad (71)$$

$$E'_{PR} = (0.991\,902 * E'_Y) \div 2.0 \quad (72)$$

In this case, for purposes of the  $Y'D'_ZD'_X$  nomenclature used in [Table 5](#),  $E'_{PB}$  may be referred to as  $D'_Z$  and  $E'_{PR}$  may be referred to as  $D'_X$ .

— Otherwise (MatrixCoefficients is equal to 14), the following applies:

— If TransferCharacteristics is not equal to 18, [Formulae \(73\) to \(75\)](#) apply:

$$E'_Y = 0.5 * (E'_L + E'_M) \quad (73)$$

$$E'_{PB} = (6\,610 * E'_L - 13\,613 * E'_M + 7\,003 * E'_S) \div 4\,096 \quad (74)$$

$$E'_{PR} = (17\,933 * E'_L - 17\,390 * E'_M - 543 * E'_S) \div 4\,096 \quad (75)$$

— Otherwise, [Formulae \(76\) to \(78\)](#) apply:

$$E'_Y = 0.5 * (E'_L + E'_M) \quad (76)$$

$$E'_{PB} = (3\,625 * E'_L - 7\,465 * E'_M + 3\,840 * E'_S) \div 4\,096 \quad (77)$$

$$E'_{PR} = (9\,500 * E'_L - 9\,212 * E'_M - 288 * E'_S) \div 4\,096 \quad (78)$$

In these cases, for purposes of the  $IC_T C_P$  nomenclature used in [Table 5](#),  $E'_Y$ ,  $E'_{PB}$ , and  $E'_{PR}$  of [Formulae \(73\), \(74\), and \(75\)](#) or [Formulae \(76\), \(77\), and \(78\)](#) may be referred to as  $I$ ,  $C_T$ , and  $C_P$ , respectively. [Formulae \(73\), \(74\), and \(75\)](#) were designed specifically for use with TransferCharacteristics equal to 16 (PQ), and [Formulae \(76\), \(77\), and \(78\)](#) were designed specifically for use with TransferCharacteristics equal to 18 (HLG).

**Table 5 — Interpretation of matrix coefficients (MatrixCoefficients) value**

Value	Matrix coefficients	Informative remarks
0	Identity	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 (2019) See <a href="#">Formulae (42) to (44)</a>
1	$K_R = 0.2126$ ; $K_B = 0.0722$	Rec. ITU-R BT.709-6 Rec. ITU-R BT.1361-0 conventional colour gamut system and extended colour gamut system (historical) IEC 61966-2-4 xvYCC <sub>709</sub> Society of Motion Picture and Television Engineers RP 177 (1993) Annex B See <a href="#">Formulae (39) to (41)</a>
2	Unspecified	Image characteristics are unknown or are determined by the application
3	Reserved	For future use by ITU-T   ISO/IEC

**Table 5** (continued)

Value	Matrix coefficients	Informative remarks
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 <a href="#">Formulae (39) to (41)</a>
5	$K_R = 0.299; K_B = 0.114$	Rec. ITU-R BT.470-6 System B, G (historical) Rec. ITU-R BT.601-7 625 Rec. ITU-R BT.1358-0 625 (historical) Rec. ITU-R BT.1700-0 625 PAL and 625 SECAM IEC 61966-2-1 sYCC IEC 61966-2-4 xvYCC <sub>601</sub> (functionally the same as the value 6) See <a href="#">Formulae (39) to (41)</a>
6	$K_R = 0.299; K_B = 0.114$	Rec. ITU-R BT.601-7 525 Rec. ITU-R BT.1358-1 525 or 625 (historical) Rec. ITU-R BT.1700-0 NTSC Society of Motion Picture and Television Engineers ST 170 (2004) (functionally the same as the value 5) See <a href="#">Formulae (39) to (41)</a>
7	$K_R = 0.212; K_B = 0.087$	Society of Motion Picture and Television Engineers ST 240 (1999) See <a href="#">Formulae (39) to (41)</a>
8	YCgCo	See <a href="#">Formulae (45) to (59)</a>
9	$K_R = 0.2627; K_B = 0.0593$	Rec. ITU-R BT.2020-2 (non-constant luminance) Rec. ITU-R BT.2100-2 Y'CbCr See <a href="#">Formulae (39) to (41)</a>
10	$K_R = 0.2627; K_B = 0.0593$	Rec. ITU-R BT.2020-2 (constant luminance) See <a href="#">Formulae (60) to (69)</a>
11	$Y'D'_ZD'_X$	Society of Motion Picture and Television Engineers ST 2 085 (2015) See <a href="#">Formulae (70) to (72)</a>
12	See <a href="#">Formulae (39) to (44)</a>	Chromaticity-derived non-constant luminance system See <a href="#">Formulae (39) to (41)</a>
13	See <a href="#">Formulae (39) to (44)</a>	Chromaticity-derived constant luminance system See <a href="#">Formulae (60) to (69)</a>
14	$IC_T C_P$	Rec. ITU-R BT.2100-2 $IC_T C_P$ See <a href="#">Formulae (73) to (75)</a> for TransferCharacteristics value 16 (PQ) See <a href="#">Formulae (76) to (78)</a> for TransferCharacteristics value 18 (HLG)
15–255	Reserved	For future use by ITU-T   ISO/IEC

NOTE In a previous edition of this document, the IEC 61966-2-1 sYCC representation was identified as corresponding to MatrixCoefficients equal to 1. Closer study later determined that this representation should correspond to MatrixCoefficients equal to 5 instead (which is functionally the same as the value 6). This document was therefore revised to correct the error.

## 8.4 Video frame packing type

Type: Unsigned integer, enumeration



Range: 0 – 15, plus associated flag

**VideoFramePackingType** indicates the type of packing arrangement used in video frames as specified in [Table 6](#). A flag, **QuincunxSamplingFlag**, may be supplied with this code point (see below).

**QuincunxSamplingFlag** indicates whether a quincunx sampling structure is used in the frame packed video representation. When not present or not specified, the value 0 for **QuincunxSamplingFlag** would ordinarily be inferred as the default value for packed video imagery.

**Table 6 — Definition of VideoFramePackingType**

Value	Interpretation
0	Each component plane of the decoded frames contains a "checkerboard" based interleaving of corresponding planes of two constituent frames as illustrated in <a href="#">Figure 2</a>
1	Each component plane of the decoded frames contains a column-based interleaving of corresponding planes of two constituent frames as illustrated in <a href="#">Figure 3</a>
2	Each component plane of the decoded frames contains a row-based interleaving of corresponding planes of two constituent frames as illustrated in <a href="#">Figure 4</a>
3	Each component plane of the decoded frames contains a side-by-side packing arrangement of corresponding planes of two constituent frames as illustrated in <a href="#">Figure 5</a> and <a href="#">Figure 7</a>
4	Each component plane of the decoded frames contains top-bottom packing arrangement of corresponding planes of two constituent frames as illustrated in <a href="#">Figure 6</a>
5	The component planes of the decoded frames in output order form a temporal interleaving of alternating first and second constituent frames as illustrated in <a href="#">Figure 8</a>
6	The decoded frame constitutes a complete 2D frame without any frame packing (see NOTE 4).

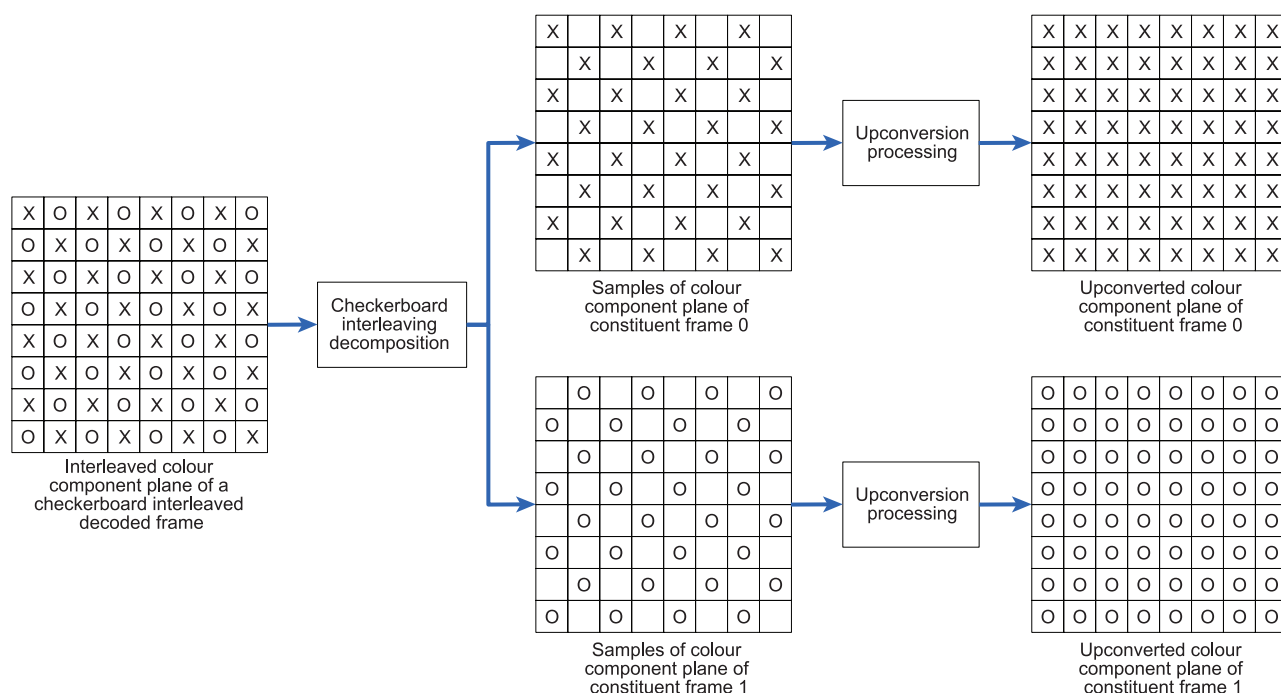
NOTE 1 [Figure 2](#) to [Figure 7](#) provide typical examples of rearrangement and upconversion processing for various packing arrangement schemes. In [Figure 2](#) to [Figure 7](#), an upconversion processing is performed on each constituent frame to produce frames having the same resolution as that of the decoded frame. An example of the upsampling method to be applied to a quincunx sampled frame as shown in [Figure 2](#) or [Figure 7](#) is to fill in missing positions with an average of the available spatially neighbouring samples (the average of the values of the available samples above, below, to the left and to the right of each sample to be generated). The actual upconversion process to be performed, if any, is outside the scope of this document.

NOTE 2 Sample aspect ratio (SAR) is expected to be signalled appropriately to describe the intended horizontal distance between the columns and the intended vertical distance between the rows of the luma sample array in the decoded frame. For the typical examples in [Figure 2](#) and [Figure 4](#) with an SAR of 1:1 for the upconverted colour plane, signalling an SAR of 1:1 is appropriate. For the typical examples in [Figure 5](#) and [Figure 7](#) with an SAR of 1:1 for the upconverted colour plane, signalling an SAR of 2:1 is appropriate. For the typical example in [Figure 6](#) with an SAR of 1:1 for the upconverted colour plane, signalling an SAR of 1:2 is appropriate.

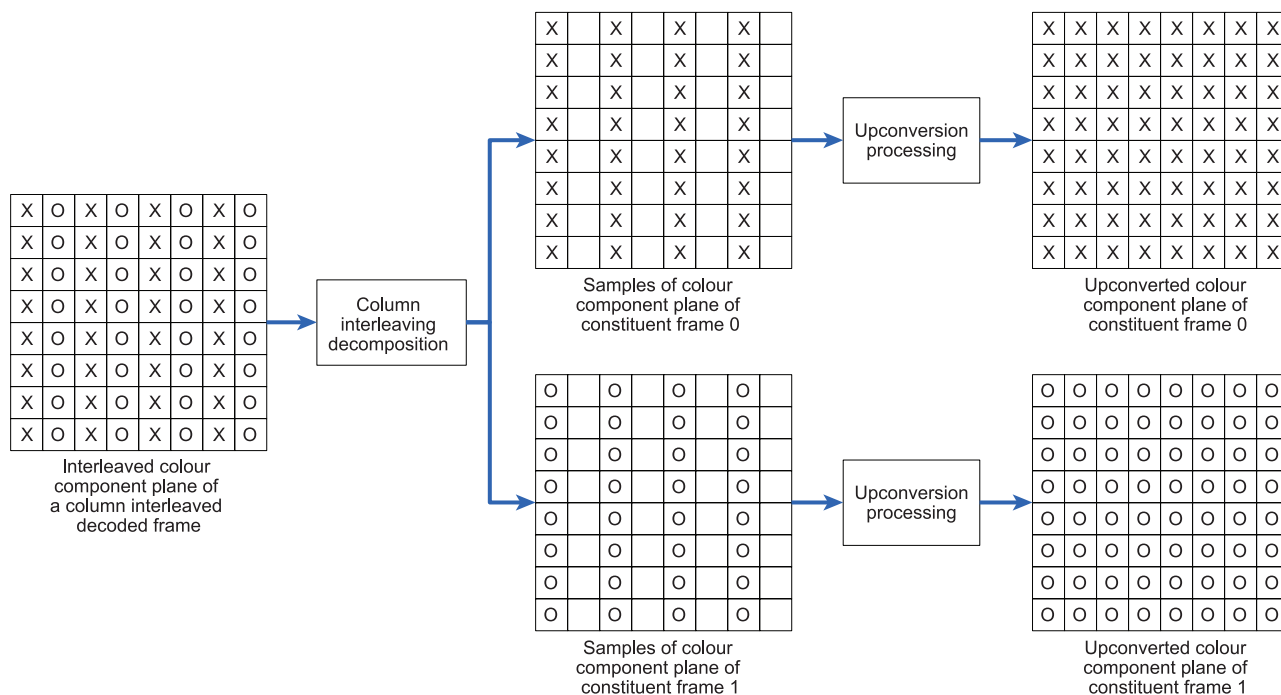
NOTE 3 **VideoFramePackingType** equal to 5 describes a temporal interleaving process of different frames.

NOTE 4 **VideoFramePackingType** equal to 6 is used to signal the presence of 2D content (that is not frame packed) in 3D services that use a mix of 2D and 3D content.

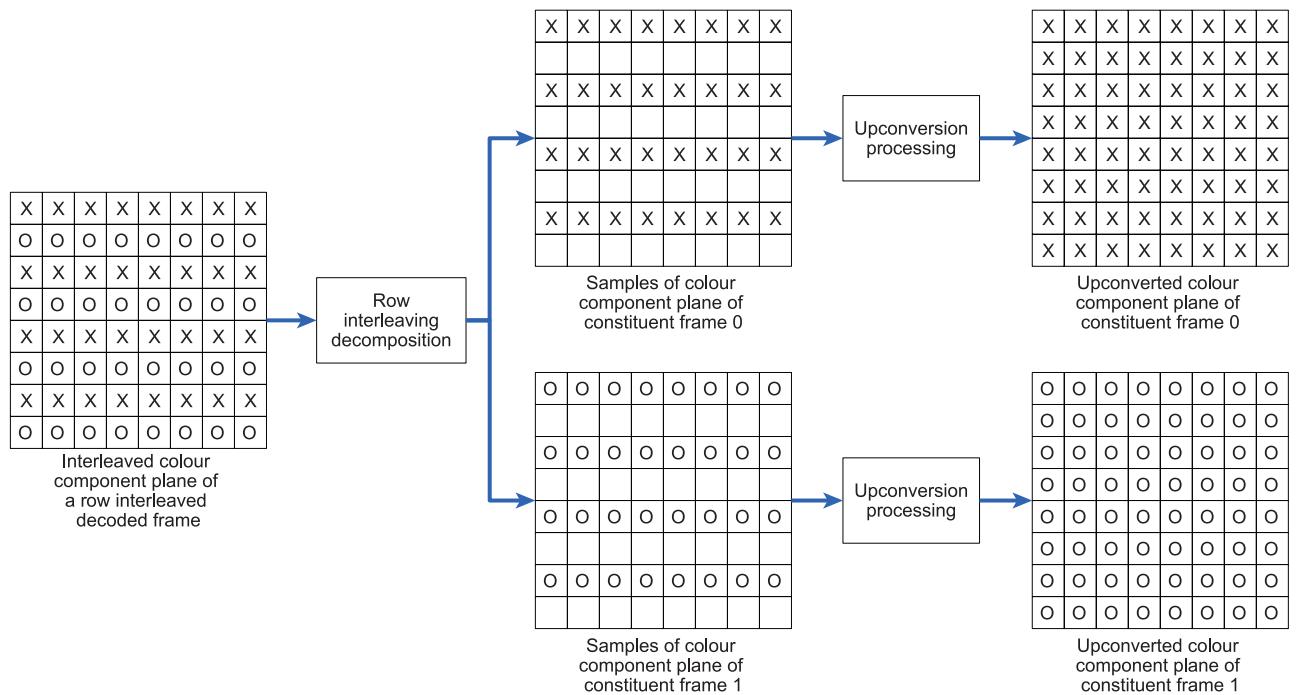
All other values of **VideoFramePackingType** are reserved for future use by ITU-T | ISO/IEC.



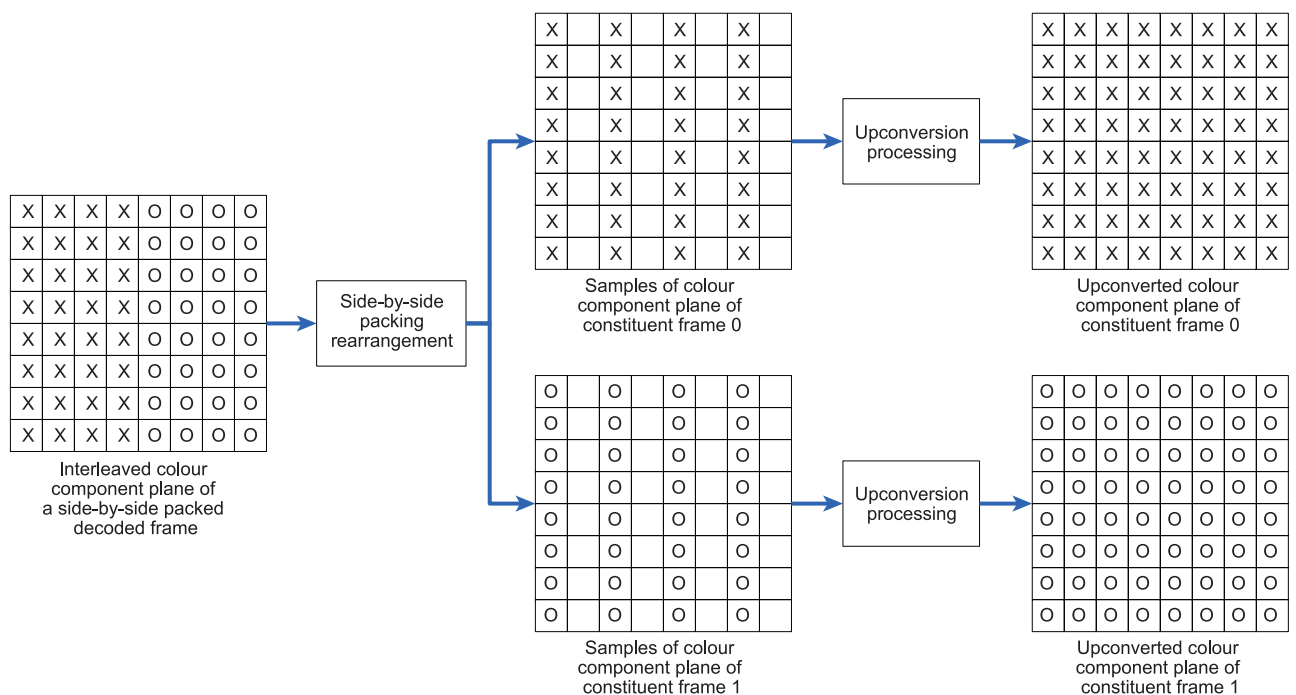
**Figure 2 — Rearrangement and upconversion flowchart for checkerboard interleaving (VideoFramePackingType equal to 0)**



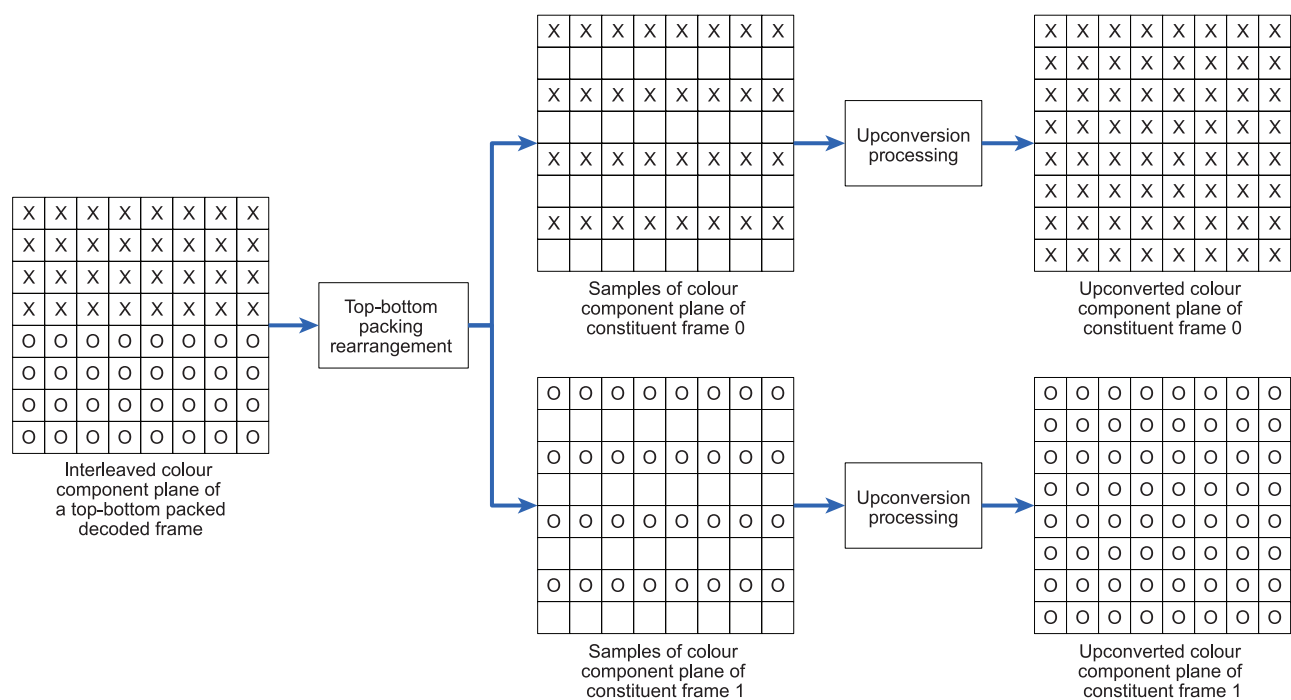
**Figure 3 — Rearrangement and upconversion flowchart for column interleaving (VideoFramePackingType equal to 1 with QuincunxSamplingFlag equal to 0)**



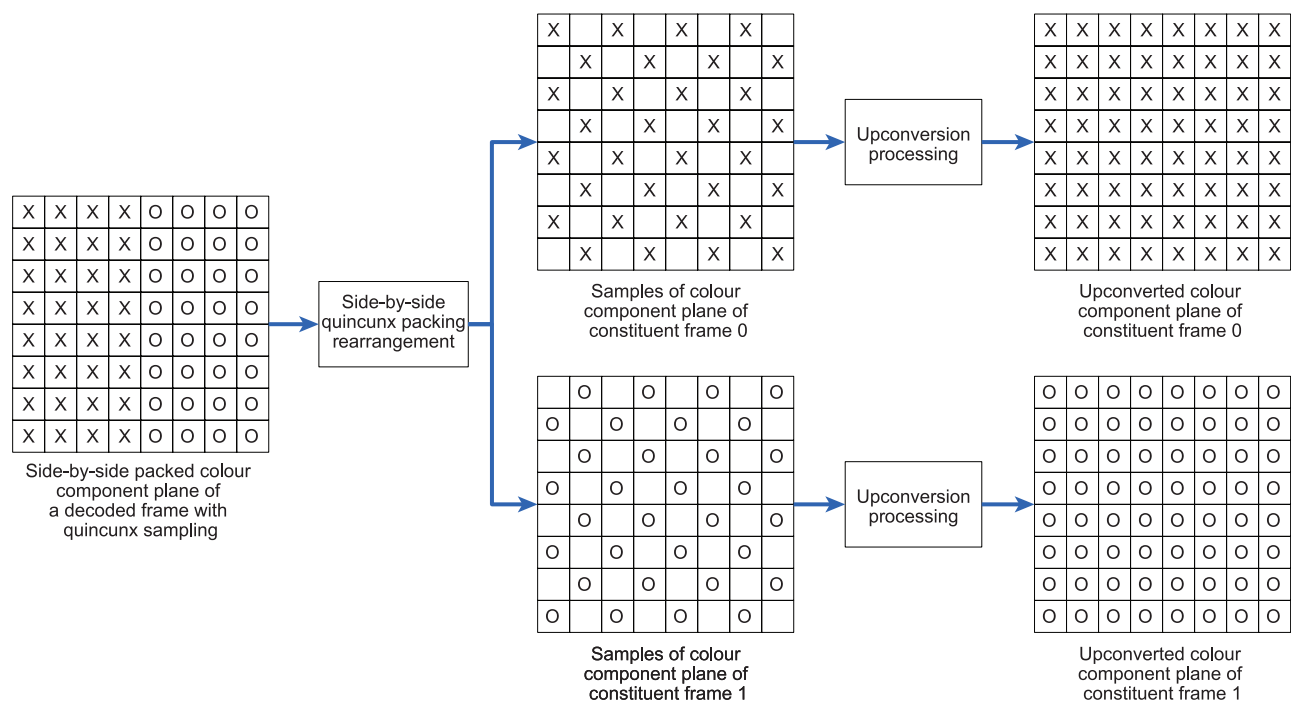
**Figure 4 — Rearrangement and upconversion flowchart for row interleaving (VideoFramePackingType equal to 2 with QuincunxSamplingFlag equal to 0)**



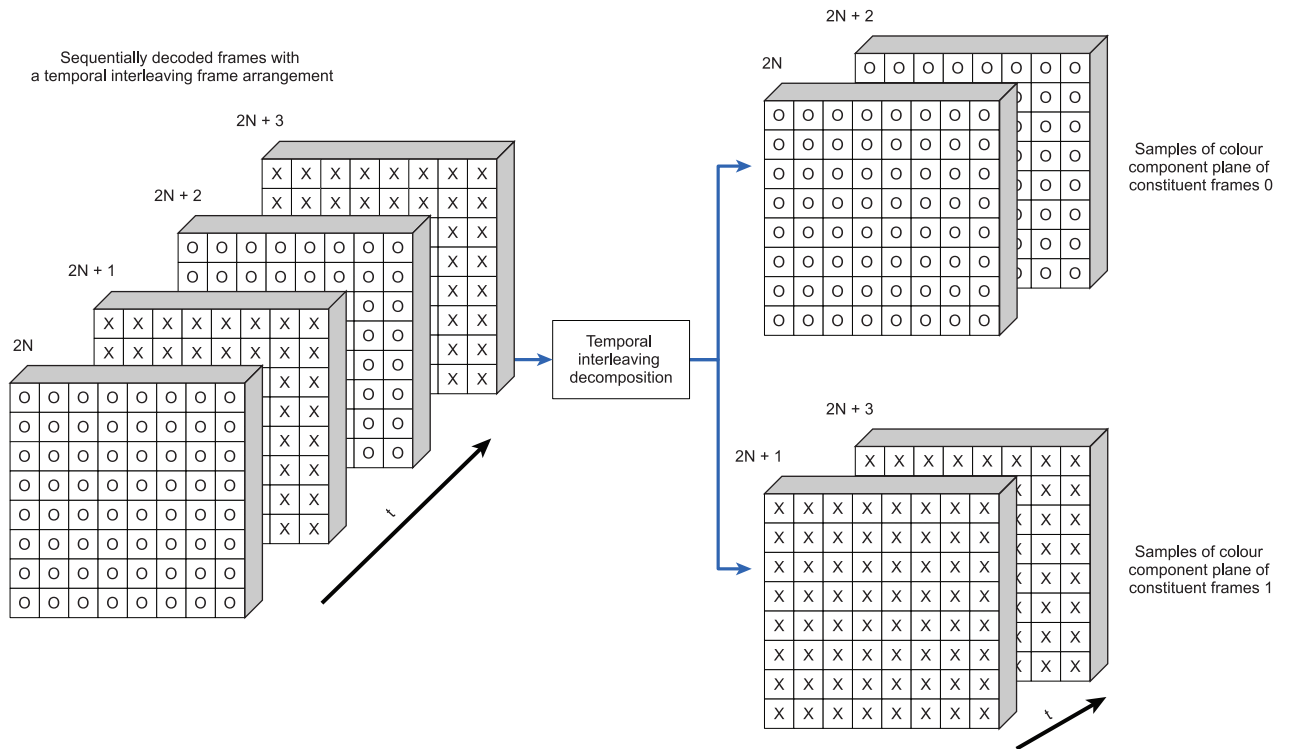
**Figure 5 — Rearrangement and upconversion flowchart for side-by-side packing arrangement (VideoFramePackingType equal to 3 with QuincunxSamplingFlag equal to 0)**



**Figure 6 — Rearrangement and upconversion flowchart for top-bottom packing arrangement (VideoFramePackingType equal to 4 with QuincunxSamplingFlag equal to 0)**



**Figure 7 — Rearrangement and upconversion flowchart for side-by-side packing arrangement with quincunx sampling (VideoFramePackingType equal to 3 with QuincunxSamplingFlag equal to 1)**



**Figure 8 — Rearrangement flowchart for temporal interleaving frame arrangement (VideoFramePackingType equal to 5)**

## 8.5 Packed video content interpretation

Type: *Unsigned integer, enumeration*

Range: 0 – 15

**PackedContentInterpretationType** indicates the intended interpretation of the constituent frames as specified in [Table 7](#). Values of PackedContentInterpretationType that do not appear in [Table 7](#) are reserved for future specification by ITU-T | ISO/IEC.

NOTE 1 All currently specified packed content interpretation types are for purposes relating to stereoscopic video imagery.

For each specified frame packing arrangement scheme, there are two constituent frames that are referred to as frame 0 and frame 1.

**Table 7 — Definition of PackedContentInterpretationType**

Value	Interpretation
0	Unspecified relationship between the frame packed constituent frames
1	Indicates that the two constituent frames form the left and right views of a stereo view scene, with frame 0 being associated with the left view and frame 1 being associated with the right view
2	Indicates that the two constituent frames form the right and left views of a stereo view scene, with frame 0 being associated with the right view and frame 1 being associated with the left view

NOTE 2 The value 2 for PackedContentInterpretationType is not expected to be prevalent in industry use. However, the value was specified herein for purposes of completeness.

## 8.6 Sample aspect ratio

Type: *Unsigned integer, enumeration*

Range: 0 – 255 for SampleAspectRatio

Range: 0 – 65535 for SarWidth and SarHeight

**SampleAspectRatio**, when present and not equal to 255, indicates the value of the sample aspect ratio of the luma samples. [Table 8](#) shows the meaning of the code. When SampleAspectRatio is not present or is equal to 255, the sample aspect ratio is indicated by SarWidth : SarHeight.

**Table 8 — Meaning of sample aspect ratio indicator (SampleAspectRatio)**

Value	Sample aspect ratio	Examples of use
0	Unspecified	
1	1:1 ("square")	7680 × 4320 16:9 frame without horizontal overscan 3840 × 2160 16:9 frame without horizontal overscan 1280 × 720 16:9 frame without horizontal overscan 1920 × 1080 16:9 frame without horizontal overscan (cropped from 1920 × 1088) 640 × 480 4:3 frame without horizontal overscan
2	12:11	720 × 576 4:3 frame with horizontal overscan 352 × 288 4:3 frame without horizontal overscan
3	10:11	720 × 480 4:3 frame with horizontal overscan 352 × 240 4:3 frame without horizontal overscan

Table 8 (continued)

Value	Sample aspect ratio	Examples of use
4	16:11	720 × 576 16:9 frame with horizontal overscan 528 × 576 4:3 frame without horizontal overscan
5	40:33	720 × 480 16:9 frame with horizontal overscan 528 × 480 4:3 frame without horizontal overscan
6	24:11	352 × 576 4:3 frame without horizontal overscan 480 × 576 16:9 frame with horizontal overscan
7	20:11	352 × 480 4:3 frame without horizontal overscan 480 × 480 16:9 frame with horizontal overscan
8	32:11	352 × 576 16:9 frame without horizontal overscan
9	80:33	352 × 480 16:9 frame without horizontal overscan
10	18:11	480 × 576 4:3 frame with horizontal overscan
11	15:11	480 × 480 4:3 frame with horizontal overscan
12	64:33	528 × 576 16:9 frame without horizontal overscan
13	160:99	528 × 480 16:9 frame without horizontal overscan
14	4:3	1440 × 1080 16:9 frame without horizontal overscan
15	3:2	1280 × 1080 16:9 frame without horizontal overscan
16	2:1	960 × 1080 16:9 frame without horizontal overscan
17–254	Reserved	
255	SarWidth : SarHeight	

NOTE For the examples in [Table 8](#), 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 "720 × 576 4:3 frame with horizontal overscan" for SampleAspectRatio equal to 2 refers to having an area of 704 × 576 luma samples (which has an aspect ratio of 4:3) of the cropped decoded frame (720 × 576 luma samples) that is visible in the display area.

When SampleAspectRatio is not present or is equal to 255, the following applies:

- If SarWidth and SarHeight are present and are not equal to 0, the values of SarWidth and SarHeight shall be relatively prime, and the following applies:
- **SarWidth** indicates the horizontal size of the sample aspect ratio (in arbitrary units).
- **SarHeight** indicates the vertical size of the sample aspect ratio (in the same arbitrary units as SarWidth).
- Otherwise, the sample aspect ratio shall be considered unspecified by this document.

When SampleAspectRatio is present and is not equal to 255, if SarWidth and SarHeight are present, their values shall be equal to the values specified in [Table 8](#).

## 8.7 Chroma 4:2:0 sample location type

Type: Unsigned integer, enumeration

Range: 0 – 5

**Chroma420SampleLocType** indicates the chroma sampling grid alignment for video fields or frames using the 4:2:0 colour format (in which the two chroma arrays have half the width and half the height of the associated luma array), as shown in [Figure 9](#).

A value of Chroma420SampleLocType may be indicated for a top field, a bottom field, or a frame. When Chroma420SampleLocType is indicated for a frame, the same value applies to both the top field and bottom field of the frame.

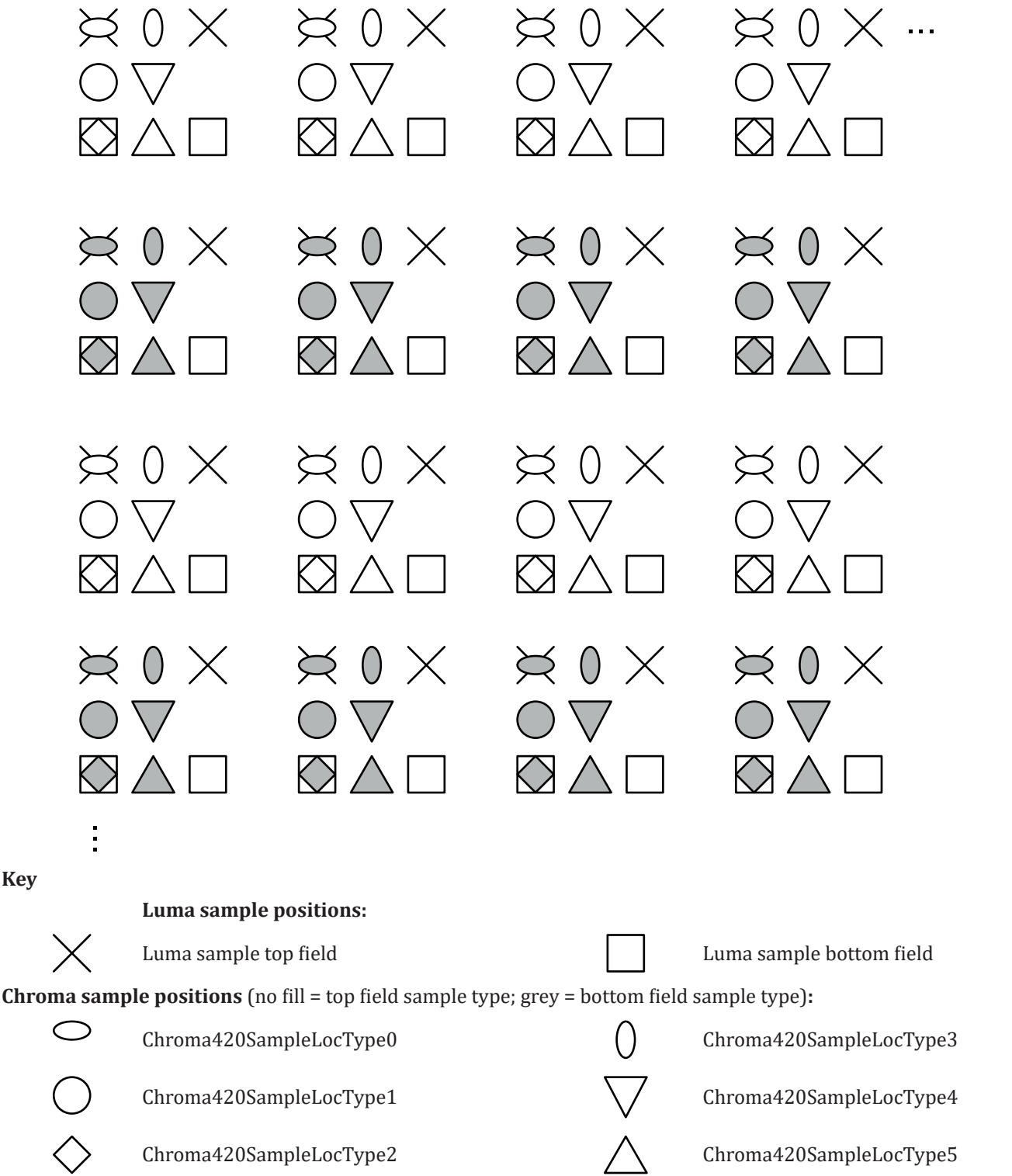
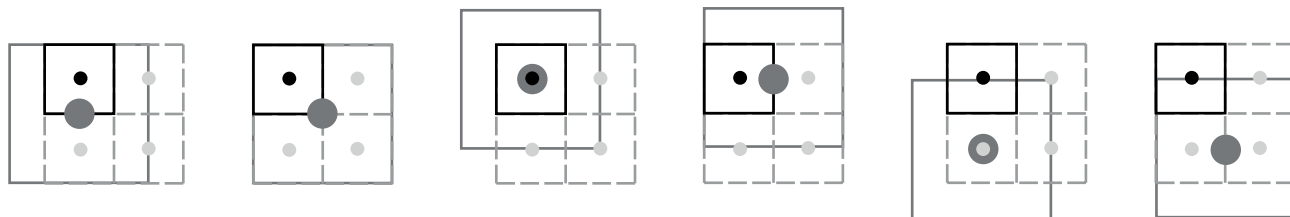


Figure 9 — Location of 4:2:0 chroma samples for top and bottom fields as a function of Chroma420SampleLocType

Figure 10 illustrates the indicated relative position of the top-left chroma sample when Chroma420SampleLocType is indicated for a frame and thus applies to both the top field and bottom field of the frame. The region represented by the top-left 4:2:0 chroma sample (depicted as a large grey,



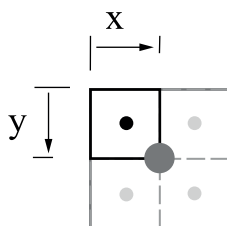
solid-line square with a large grey dot at its centre) is shown relative to the region represented by the top-left luma sample (depicted as a small black square with a small black dot at its centre). The regions represented by neighbouring luma samples are depicted as small grey squares with small grey dots at their centres.



**Figure 10 — Location of the top-left chroma sample for a frame as a function of Chroma420SampleLocType equal to 0 to 5, inclusive, from left to right**

The relative spatial positioning of the chroma samples, as illustrated in [Figure 11](#), can be expressed by defining two variables HorizontalOffsetC and VerticalOffsetC as a function of Chroma420SampleLocType as given by [Table 9](#), where HorizontalOffsetC is the horizontal (x) position of the centre of the top-left chroma sample relative to the centre of the top-left luma sample in units of luma samples and VerticalOffsetC is the vertical (y) position of the centre of the top-left chroma sample relative to the centre of the top-left luma sample in units of luma samples.

In a typical finite-impulse-response filter design, HorizontalOffsetC and VerticalOffsetC would serve as the phase offsets for the horizontal and vertical filter operations, respectively, for separable downsampling from the 4:4:4 colour format (in which the two chroma arrays have the same width and height as the associated luma array) to the 4:2:0 colour format.



#### Key

- x HorizontalOffsetC
- y VerticalOffsetC

**Figure 11 — Location of the top-left chroma sample when Chroma420SampleLocType is equal to 1 and thus HorizontalOffsetC and VerticalOffsetC are both equal to 0.5**

**Table 9 — Meaning of chroma 4:2:0 sample location type indicator (Chroma420SampleLocType)**

<b>Chroma420SampleLocType</b>	<b>HorizontalOffsetC</b>	<b>VerticalOffsetC</b>
0	0	0.5
1	0.5	0.5
2	0	0
3	0.5	0
4	0	1
5	0.5	1

NOTE Typical industry practice for standard-definition and high-definition television content with standard dynamic range (e.g. with colour interpretation according to Rec. ITU-R BT.601-7 or Rec. ITU-R BT.709-6) has been to use vertically interstitial and horizontally collocated chroma sampling for the 4:2:0 colour format, corresponding to Chroma420SampleLocType equal to 0. However, the 4:2:0 chroma format sampling specified in Rec. ITU-R BT.2020-2 for ultra-high definition television and in Rec. ITU-R BT.2100-2 for high dynamic range television correspond to Chroma420SampleLocType equal to 2.

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