
**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 ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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

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

For an explanation 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.

This document was prepared by Technical Committee ISO/IEC JTC1, *Information technology*, Subcommittee SC 29, *Coding of audio, picture, multimedia and hypermedia information*, in collaboration with ITU-T. The technically identical text is published as ITU-T H.273 (12/2016).

Together with ISO/IEC 23091-1 and ISO/IEC 23091-3, this first edition of ISO/IEC 23091-2 cancels and replaces ISO/IEC 23001-8:2016, which has been technically revised.

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

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.

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 may 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 may 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 may 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.

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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 could describe the appropriate interpretation of decoded data or could, 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 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 terminological databases for use in standardization at the following addresses:

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

3.1

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 the term chrominance in order to avoid the implication of the use of linear light transfer characteristics that is often associated with the term chrominance.

3.2

component

array or single sample from one of the three arrays [*luma* (3.3) and two *chroma* (3.1)] that compose a *picture* 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

3.3

luma

sample array or single sample is 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 the term luminance in order to avoid the implication of the use of linear light transfer characteristics that is often associated with the term luminance. The symbol L is sometimes used instead of the symbol Y to avoid confusion with the symbol y as used for vertical location.

3.4

picture

array of *luma* (3.3) samples in monochrome format or array of *luma* samples and two corresponding arrays of *chroma* (3.1) samples in 4:2:0, 4:2:2, and 4:4:4 colour format

3.5

reserved

values of a particular code point that are for future use by ITU-T | ISO/IEC and shall not be used in identifiers conforming to this version of this document, but which may be used in a manner yet to be specified in some future extensions of this document by ITU-T | ISO/IEC

3.6

unspecified

values of a particular code point that have no specified meaning in this version of this document and will not have a specified meaning in the future as an integral part of future versions 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)
÷	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

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

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

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

where 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 BitDepth_C is the representation bit depth of the corresponding chroma colour component signal C. In general, BitDepth_C may be distinct for different chroma colour components signals C – e.g. for C corresponding to Cb or Cr.

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

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

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

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

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

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

$$\text{Sqrt}(x) = \sqrt{x}. \quad (11)$$

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 ^y "
"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	8.1
TransferCharacteristics	Video colour transfer characteristics	8.2
MatrixCoefficients and VideoFullRangeFlag	Video matrix colour coefficients	8.3
VideoFramePackingType and QuincunxSamplingFlag	Video frame packing	8.4
PackedContentInterpretationType	Interpretation of packed video frames	8.5
SampleAspectRatio , SarWidth , and SarHeight	Sample aspect ratio of video	8.6

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.

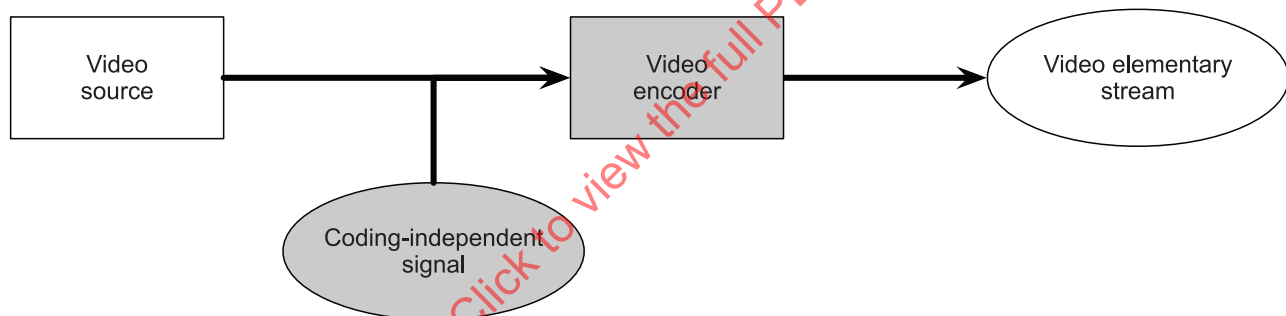


Figure 1 — Example usage

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 may 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 must 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 could 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 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
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	United States Federal Communications Commission Title 47 Code of Federal Regulations (2003) 73.682 (a) (20)
	red	0.67	0.33	
	white C	0.310	0.316	
5	primary	x	y	Rec. ITU-R BT.470-6 System B, G (historical)
	green	0.29	0.60	Rec. ITU-R BT.601-7 625
	blue	0.15	0.06	Rec. ITU-R BT.1358-0 625 (historical)
	red	0.64	0.33	Rec. ITU-R BT.1700-0 625 PAL and 625 SECAM
	white D65	0.3127	0.3290	

Table 3 (continued)

Value	Colour primaries			Informative remarks
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) (historical)
	green	0.310	0.595	(functionally the same as the value 6)
	blue	0.155	0.070	
	red	0.630	0.340	
	white D65	0.3127	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.2100-1
	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
	green (Y)	0.0	1.0	(CIE 1931 XYZ as in ISO 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	
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	EBU Tech. 3213-E (1975)
	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 α over a region bounded by the variable β or by the variables β and γ , the values of α and β are defined to be the positive constants necessary for the curve segments that meet at the value β to have continuity of both value and slope at the value β . The value of γ , when applicable, is defined to be the positive constant necessary for the associated curve segments to meet at the value γ . For example, for TransferCharacteristics equal to 1, 6, 14, or 15, α has the value $1 + 5.5 * \beta = 1.099\ 296\ 826\ 809\ 442\dots$ and β has the value $0.018\ 053\ 968\ 510\ 807\dots$

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 could 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, certain combinations of TransferCharacteristics, VideoFullRangeFlag, BitDepth_v, and BitDepth_c may 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

Table 4 (continued)

Value	Transfer characteristics	Informative remarks
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) (historical)
8	$V = L_c$ for $1 > L_c \geq 0$	Linear transfer characteristics
9	$V = 1.0 + \text{Log}_{10}(L_c) \div 2$ for $1 \geq L_c \geq 0.01$ $V = 0.0$ for $0.01 > L_c \geq 0$	Logarithmic transfer characteristic (100:1 range)
10	$V = 1.0 + \text{Log}_{10}(L_c) \div 2.5$ for $1 \geq L_c \geq \text{Sqrt}(10) \div 1000$ $V = 0.0$ for $\text{Sqrt}(10) \div 1000 > L_c \geq 0$	Logarithmic transfer characteristic (100 * Sqrt(10) : 1 range)
11	$V = \alpha * L_c^{0.45} - (\alpha - 1)$ for $L_c \geq \beta$ $V = 4.500 * L_c$ for $\beta > L_c > -\beta$ $V = -\alpha * (-L_c)^{0.45} + (\alpha - 1)$ for $-\beta \geq L_c$	IEC 61966-2-4
12	$V = \alpha * L_c^{0.45} - (\alpha - 1)$ for $1.33 > L_c \geq \beta$ $V = 4.500 * L_c$ for $\beta > L_c \geq -\gamma$ $V = -(\alpha * (-4 * L_c)^{0.45} - (\alpha - 1)) \div 4$ for $-\gamma \geq L_c \geq -0.25$	Rec. ITU-R BT.1361-0 extended colour gamut system (historical)
13	$V = \alpha * L_c^{(1 \div 2.4)} - (\alpha - 1)$ for $1 > L_c \geq \beta$ $V = 12.92 * L_c$ for $\beta > L_c \geq 0$	IEC 61966-2-1 sRGB or sYCC
14	$V = \alpha * L_c^{0.45} - (\alpha - 1)$ for $1 \geq L_c \geq \beta$ $V = 4.500 * L_c$ for $\beta > L_c \geq 0$	Rec. ITU-R BT.2020-2 (10-bit system) (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 (12-bit system) (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	Society of Motion Picture and Television Engineers ST 2084 for 10, 12, 14, and 16-bit systems Rec. ITU-R BT.2100-1 perceptual quantization (PQ) system

Table 4 (continued)

Value	Transfer characteristics	Informative remarks
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
18	$V = a * \text{Ln}(12 * L_c - b) + c$ for $1 \geq L_c > 1 \div 12$ $V = \text{Sqrt}(3) * L_c^{0.5}$ for $1 \div 12 \geq L_c \geq 0$ $a = 0.178\ 832\ 77$ $b = 0.284\ 668\ 92$ $c = 0.559\ 910\ 73$	Association of Radio Industries and Businesses (ARIB) STD-B67 Rec. ITU-R BT.2100-1 hybrid log-gamma (HLG) system
19–255	Reserved	For future use by ITU-T ISO/IEC

NOTE 2 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 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_Y and BitDepth_C.

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 subclause 8.1) before applying the transfer characteristics (see subclause 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_C is equal to BitDepth_Y, [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_C is not equal to BitDepth_Y), [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), [Formulae \(73\)](#) to [\(75\)](#) apply:

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

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

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

In this case, 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 [\(75\)](#) may be referred to as I , C_T , and C_P , respectively.

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 See Formulae 42 to 44
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 61966-2-1 sYCC IEC 61966-2-4 xvYCC ₇₀₉ Society of Motion Picture and Television Engineers RP 177 (1993) Annex B See Formulae (39) to (41)
2	Unspecified	Image characteristics are unknown or are determined by the application
3	Reserved	For future use by ITU-T ISO/IEC
4	$K_R = 0.30$; $K_B = 0.11$	United States Federal Communications Commission Title 47 Code of Federal Regulations (2003) 73.682 (a) (20) See Formulae (39) to (41)

Table 5 (continued)

Value	Matrix coefficients	Informative remarks
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 61966-2-4 xvYCC ₆₀₁ (functionally the same as the value 6) See Formulae (39) to (41)
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 Formulae (39) to (41)
7	$K_R = 0.212$; $K_B = 0.087$	Society of Motion Picture and Television Engineers ST 240 (1999) (historical) See Formulae (39) to (41)
8	YCgCo	See Formulae (45) to (59)
9	$K_R = 0.2627$; $K_B = 0.0593$	Rec. ITU-R BT.2020-2 (non-constant luminance) Rec. ITU-R BT.2100-1 Y'CbCr See Formulae (39) to (41)
10	$K_R = 0.2627$; $K_B = 0.0593$	Rec. ITU-R BT.2020-2 (constant luminance) See Formulae (60) to (69)
11	$Y'D'_ZD'_X$	Society of Motion Picture and Television Engineers ST 2085 (2015) See Formulae (70) to (72)
12	See Formulae (39) to (44)	Chromaticity-derived non-constant luminance system See Formulae (39) to (41)
13	See Formulae (39) to (44)	Chromaticity-derived constant luminance system See Formulae (60) to (69)
14	$IC_T C_P$	Rec. ITU-R BT.2100-1 $IC_T C_P$ See Formulae (73) to (75)
15-255	Reserved	For future use by ITU-T ISO/IEC

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 Figure 2
1	Each component plane of the decoded frames contains a column-based interleaving of corresponding planes of two constituent frames as illustrated in Figure 3
2	Each component plane of the decoded frames contains a row-based interleaving of corresponding planes of two constituent frames as illustrated in Figure 4
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 Figure 5 and Figure 7
4	Each component plane of the decoded frames contains top-bottom packing arrangement of corresponding planes of two constituent frames as illustrated in Figure 6
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 Figure 8
6	The decoded frame constitutes a complete 2D frame without any frame packing (See NOTE 4).

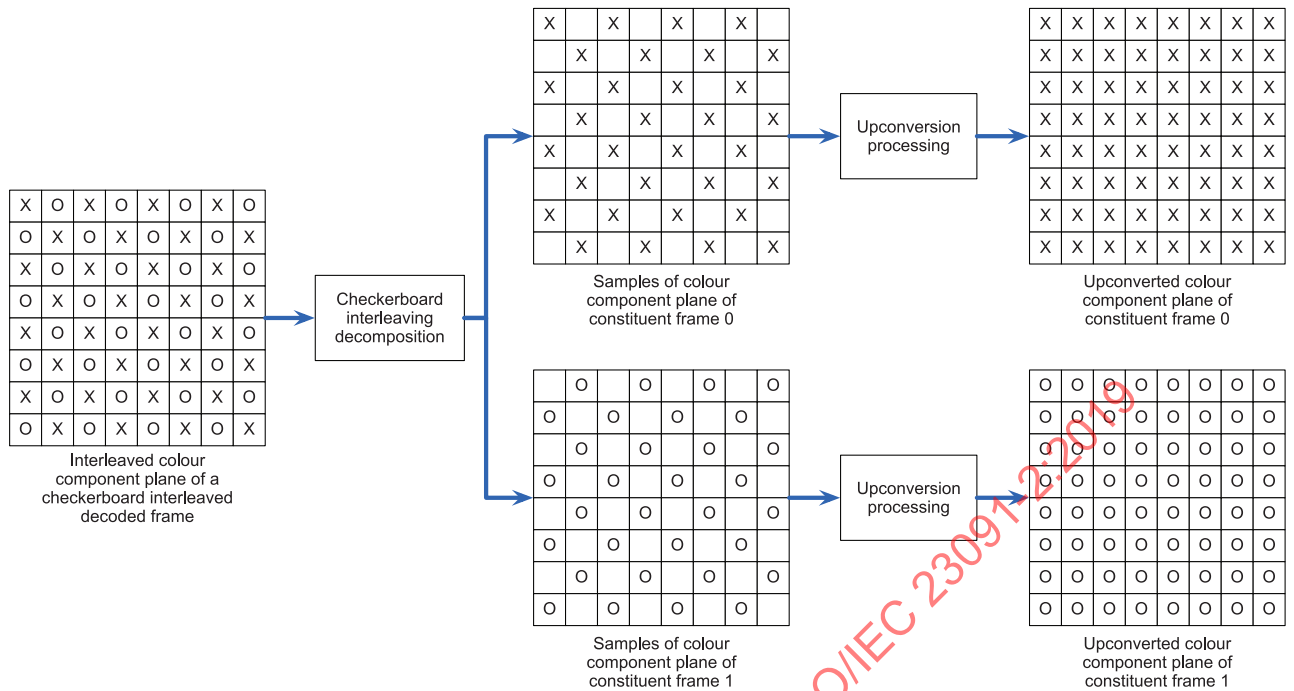
NOTE 1 [Figure 2](#) to [Figure 7](#) provide typical examples of rearrangement and upconversion processing for various packing arrangement schemes. In [Figure 2](#) to [Figure 7](#), an upconversion processing is performed on each constituent frame to produce frames having the same resolution as that 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.

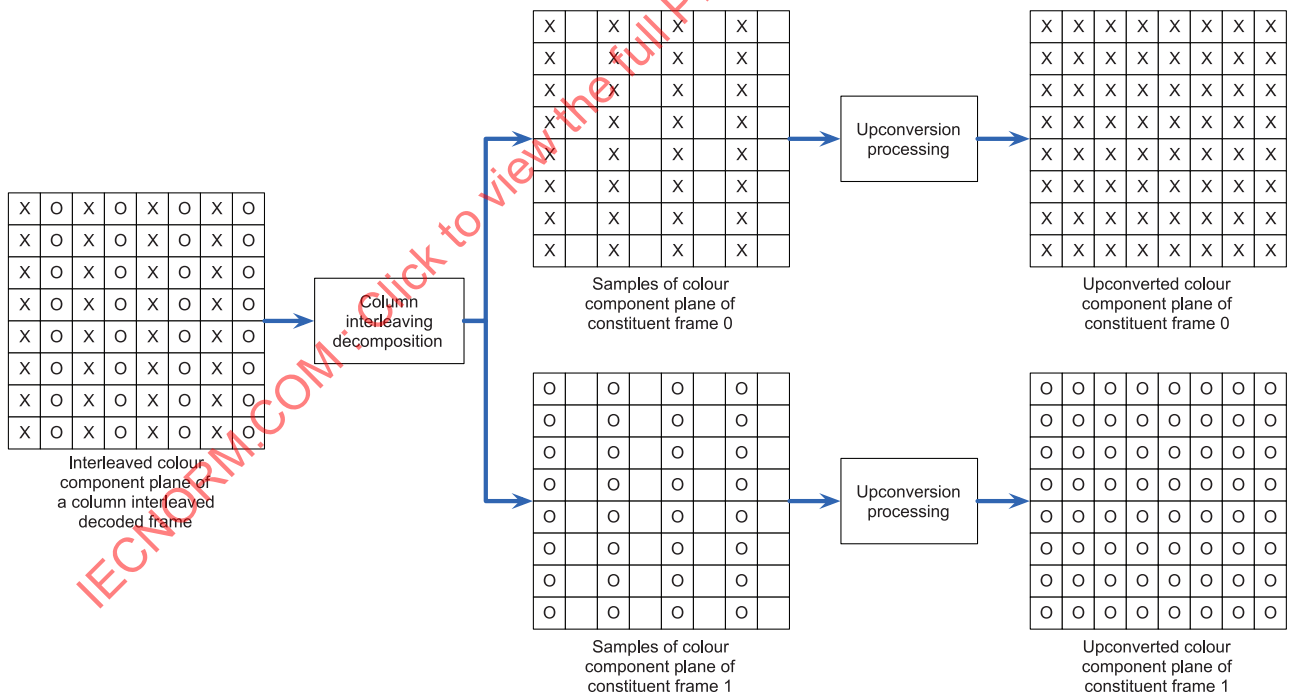
NOTE 3 VideoFramePackingType equal to 5 describes a temporal interleaving process of different frames.

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 of checkerboard interleaving
(VideoFramePackingType equal to 0)**



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

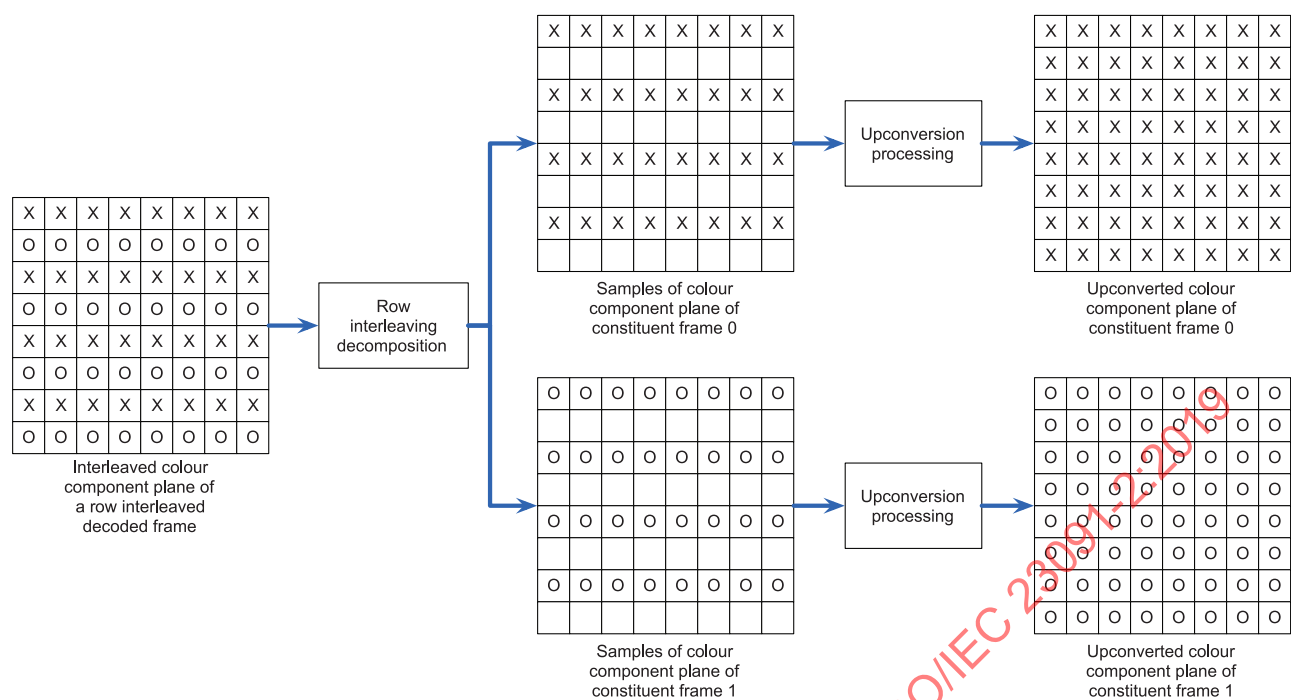


Figure 4 — Rearrangement and upconversion of row interleaving
 (VideoFramePackingType equal to 2 with QuincunxSamplingFlag equal to 0)

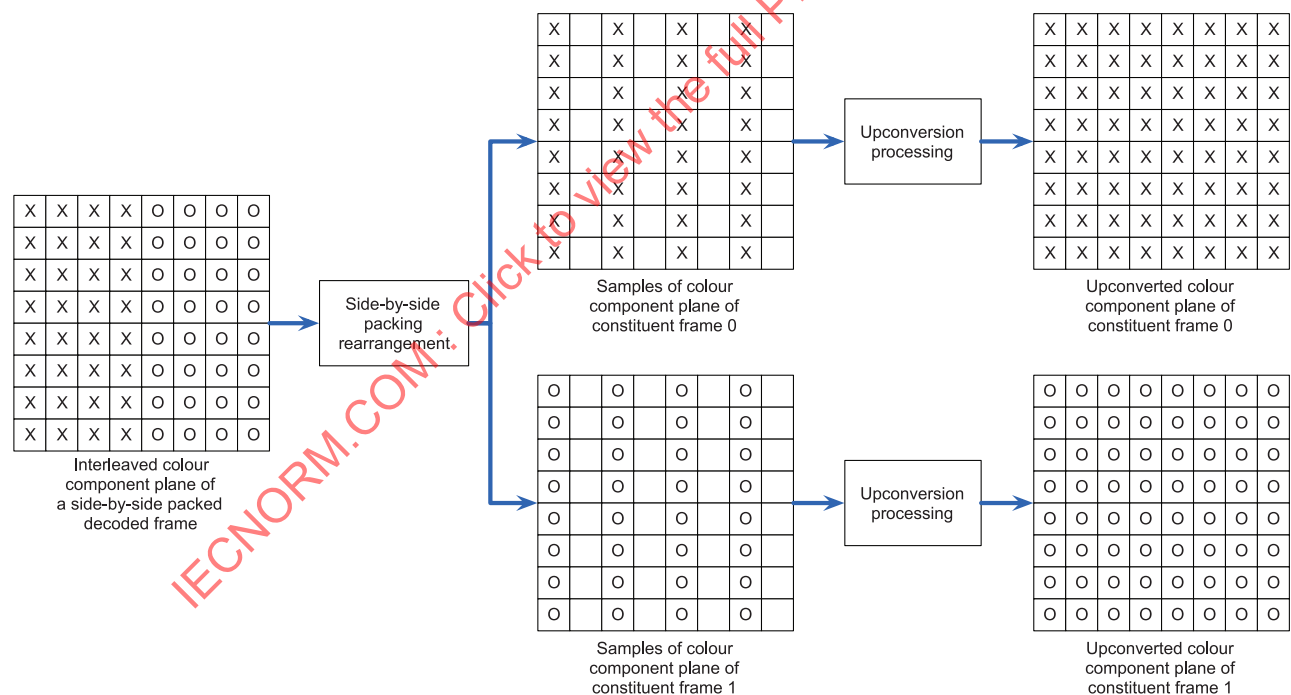


Figure 5 — Rearrangement and upconversion of side-by-side packing arrangement
 (VideoFramePackingType equal to 3 with QuincunxSamplingFlag equal to 0)

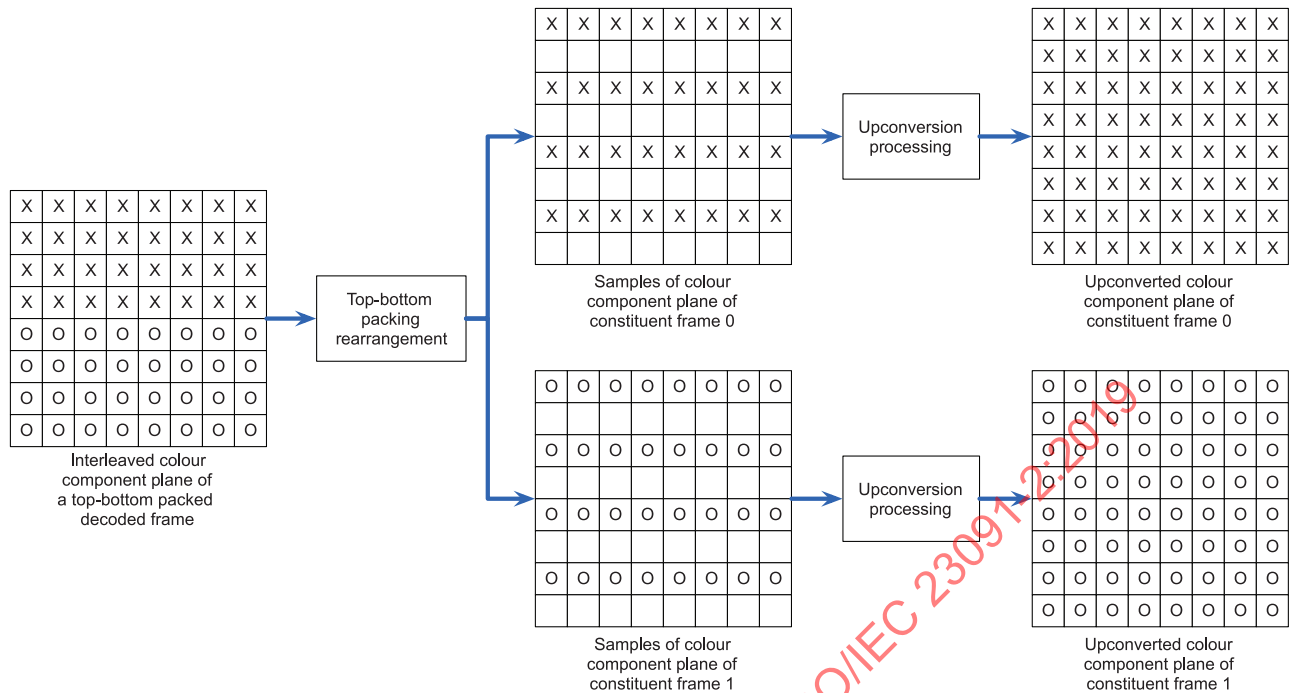


Figure 6 — Rearrangement and upconversion of top-bottom packing arrangement (VideoFramePackingType equal to 4 with QuincunxSamplingFlag equal to 0)

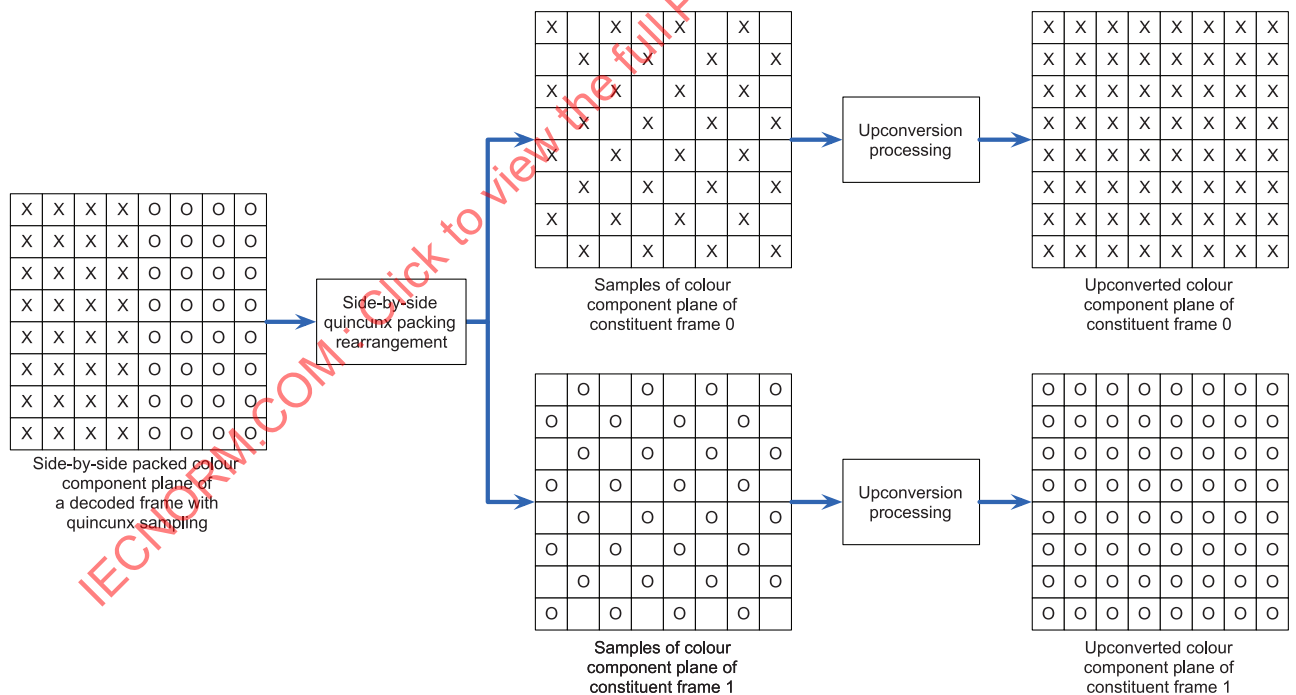


Figure 7 — Rearrangement and upconversion of side-by-side packing arrangement with quincunx sampling (VideoFramePackingType equal to 3 with QuincunxSamplingFlag equal to 1)