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Multimedia systems and equipment – Colour measurement and management – Part 2-5: Colour management – Optional RGB colour space – opRGB

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

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MULTIMEDIA SYSTEMS AND EQUIPMENT – COLOUR MEASUREMENT AND MANAGEMENT –

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International Standard IEC 61966-2-5 has been prepared by technical area 2: Colour measurement and management, of IEC technical committee 100: Audio, video and multimedia systems and equipment.

The text of this standard is based on the following documents:

CDV	Report on voting
100/1212/CDV	100/1282/RVC

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The list of all parts of the IEC 61966 series, under the general title *Multimedia systems and equipment – Colour measurement and management,* can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

The colour gamut for various image I/O devices has been gradually extended in recent years. IEC 61966-2-1 “Multimedia Systems and Equipment – Colour Measurement and Management – Part 2-1: Colour Management – Default RGB Colour Space – sRGB” is the International Standard issued in 1999, based on the colour characteristics of contemporary CRT displays.

Subsequently, displays with a wider colour gamut have been commercialized in order to better cover the colour gamut that is available for digital still cameras, printers and other devices. This International Standard specifies a colour image encoding similar to the sRGB encoding, but based on a wider gamut colour space than sRGB. The rendering of the image for specific applications is beyond the scope of this standard. A display that has a colour gamut wider than conventional displays has been selected as the “Reference image display system characteristics” in this standard. These wider colour gamut displays provide advantages in commercial printing industry workflows and are intended to be used by professional photographers, prepress industry including DTP and designers.

MULTIMEDIA SYSTEMS AND EQUIPMENT – COLOUR MEASUREMENT AND MANAGEMENT –

Part 2-5: Colour management – Optional RGB colour space – opRGB

1 Scope

This part of IEC 61966 is applicable to the encoding and communication of RGB colours optionally used in computer systems and similar applications by defining encoding transformations for use in defined reference conditions.

If actual conditions differ from the reference conditions, additional rendering transformations may be required. Such additional rendering transformations are beyond the scope of this standard.

2 Normative references

The following referenced documents are indispensable for the application 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.

IEC 60050(845):1987, *International Electrotechnical Vocabulary (IEV) – Chapter 845: Lighting /* CIE 17.4:1987, *International Lighting Vocabulary (Joint IEC/CIE publication)*

ISO 3664:2000, *Viewing conditions – Graphic technology and photography*

ISO/CIE 10527:1991, *CIE standard colorimetric observers*

CIE 15:2004, *Colorimetry, 3rd ed.*

CIE 122:1996, *The relationship between digital and colorimetric data for computer-controlled CRT displays*

CIE 1931, *CIE XYZ color space*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply. Definitions of colour space, illuminance, luminance, tristimulus and other related lighting terms are provided in IEC 60050(845).

3.1
ambient illuminance level
illuminance level due to lighting in the viewing environment, excluding that from the display, measured in the plane of the display faceplate

3.2
ambient white point
coordinate point in the CIE 1931 XYZ chromaticity coordinate defined by ISO/CIE 10527 and CIE 15.2 due to lighting in the viewing environment, excluding that from the display, measured in the plane of the display faceplate

3.3
display illuminant white point
point in the CIE 1931 XYZ chromaticity diagram defined by ISO/CIE 10527 and CIE 15.2, at which the red, green and blue intensities are at 100 %, measured in a direction perpendicular to the display faceplate

3.4
display background
environment of the colour element, extending typically for about ten degrees from the edge of the proximal field in all, or most, directions. When the proximal field is the same colour as the background, the latter is regarded as extending from the edge of the colour element considered

3.5
display black level
the luminance level characteristic measured in a direction perpendicular to the display faceplate, including unwanted leak light through the faceplate and veiling glare from ambient illumination, at which the red, green and blue intensities are at 0 %

3.6
veiling glare
light, reflected from an imaging medium, that has not been modulated by the means used to produce the image

NOTE In CIE 122, the veiling glare of a CRT display is referred to as ambient flare.

3.7
display model offset
parameter measured consistently with CIE 122, representing the black offset level of the display grid voltage

3.8
display input/output characteristic
transfer characteristic relating the normalised digital code value and the normalised output luminance as represented by a power function

3.9
display luminance level
luminance of the display measured consistently with CIE 122

3.10
display surround
field outside the background, filling the field of vision

3.11
display proximal field
immediate environment of the colour element considered, extending typically for about two degrees from the edge of the colour element considered in all, or most, directions

4 Reference conditions

4.1 Reference image display system characteristics

The reference image display system is a computer controlled display and shall be as follows.

- Display luminance level — 160 cd/m^2
- Display white point — $x =$ 0,312 7, $y =$ 0,329 0 (D65)

  $X_W = 152{,}07$

  $Y_W = 160{,}00$

  $Z_W = 174{,}25$
- Display model offset (R, G and B) — 0,0
- Display input/output characteristic (R, G and B) — 2,2
- Display black level — 0,4 cd/m^2

The CIE chromaticities for the red, green and blue reference display primaries, and for CIE standard illuminant D65, are given in table 1.

Table 1 – CIE chromaticities and CIE standard illuminant

	Red	Green	Blue	D65
x	0,640 0	0,210 0	0,150 0	0,312 7
y	0,330 0	0,710 0	0,060 0	0,329 0
z	0,030 0	0,080 0	0,790 0	0,358 3

The reference display characterization is based on the characterization in CIE 122. Relative to this methodology, the reference display is characterised by the equation below, where V'_{opRGB} is the normalised digital count and V_{opRGB} is the output normalised luminance.

$$V_{opRGB} = \left(V'_{opRGB} + 0{,}0\right)^{2{,}2} \quad (1)$$

4.2 Reference viewing conditions

Specifications for the reference viewing environments are derived from ISO 3664 and shall be as follows:

a) Reference background — for the background as part of the display screen, the background is 20 % of the reference display luminance level (32 cd/m^2); the chromaticity should average to $x =$0,312 7, $y =$0,329 0 (D65).

b) Reference surround — 20 % diffuse reflectance of the maximum reference ambient illuminance level (4,07 cd/m^2); the chromaticity should average to $x =$ 0,345 7, $y =$0,358 5 (D50).

NOTE This is the luminance of the adapting field.

c) Reference proximal field — 20 % of the reference display luminance level (32 cd/m²); the chromaticity should average to $x = 0{,}312\ 7$, $y = 0{,}329\ 0$ (D65).

d) Reference ambient illuminance level — 64 lx.

e) Reference ambient white point — $x = 0{,}345\ 7$, $y = 0{,}358\ 5$ (D50).

4.3 Reference observer

The reference observer shall be the CIE 1931 two-degree standard observer from ISO/CIE 10527.

5 Encoding transformations

5.1 Introduction

The encoding transformations between CIE 1931 XYZ values and N-bit RGB values provide unambiguous methods for representing optimum image colorimetry when viewed on the reference display in the reference viewing conditions by the reference observer. The CIE 1931 XYZ values are normalized by display luminance level and are scaled 0.0 to 1.0. The opRGB tristimulus values are linear combinations of the normalized CIE 1931 XYZ values as measured on the faceplate of the display. The non-linear opR′G′B′ values represent the colorimetry of the image as displayed on the reference display.

5.2 Transformation from opRGB values to CIE 1931 XYZ values

The digital code values are converted to non-linear opR′G′B′ values.

This standard specifies a black digital count of 0 and a white digital count of $2^N - 1$ for N-bits/channel encoding. The resulting non-linear opR′G′B′ values are formed according to the following equations.

$$\left.\begin{aligned} R'_{\text{opRGB}} &= R_{\text{opRGB(N)}} \div (2^N - 1) \\ G'_{\text{opRGB}} &= G_{\text{opRGB(N)}} \div (2^N - 1) \\ B'_{\text{opRGB}} &= B_{\text{opRGB(N)}} \div (2^N - 1) \end{aligned}\right\} \qquad (2)$$

The non-linear opR′G′B′ values are transformed to CIE 1931 XYZ values as follows:

$$\left.\begin{aligned} R_{\text{opRGB}} &= \left(R'_{\text{opRGB}}\right)^{2,2} \\ G_{\text{opRGB}} &= \left(G'_{\text{opRGB}}\right)^{2,2} \\ B_{\text{opRGB}} &= \left(B'_{\text{opRGB}}\right)^{2,2} \end{aligned}\right\} \qquad (3)$$

and

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 0{,}576\ 7 & 0{,}185\ 6 & 0{,}188\ 2 \\ 0{,}297\ 3 & 0{,}627\ 4 & 0{,}075\ 3 \\ 0{,}027\ 0 & 0{,}070\ 7 & 0{,}991\ 3 \end{bmatrix} \begin{bmatrix} R_{\text{opRGB}} \\ G_{\text{opRGB}} \\ B_{\text{opRGB}} \end{bmatrix} \qquad (4)$$

5.3 Transformation from CIE 1931 XYZ values to opRGB values

For 24 bit encoding (8-bit/channel), the opRGB tristimulus values can be computed using the following relationship:

$$\begin{bmatrix} R_{\text{opRGB}} \\ G_{\text{opRGB}} \\ B_{\text{opRGB}} \end{bmatrix} = \begin{bmatrix} 2{,}041\,6 & -0{,}565\,0 & -0{,}344\,7 \\ -0{,}969\,2 & 1{,}876\,0 & 0{,}041\,6 \\ 0{,}013\,4 & -0{,}118\,4 & 1{,}015\,2 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix} \tag{5}$$

other N-bit/channel encoding is supported ($N > 8$), the relationship is defined as;

$$\begin{bmatrix} R_{\text{opRGB}} \\ G_{\text{opRGB}} \\ B_{\text{opRGB}} \end{bmatrix} = \begin{bmatrix} 2{,}041\,588 & -0{,}565\,007 & -0{,}344\,731 \\ -0{,}969\,244 & 1{,}875\,968 & 0{,}041\,555 \\ 0{,}013\,444 & -0{,}118\,362 & 1{,}015\,175 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix} \tag{5'}$$

In the RGB encoding process, negative opRGB tristimulus values and opRGB tristimulus values greater than 1,00 are not retained. The luminance dynamic range and colour gamut of RGB is limited to the tristimulus values between 0,0 and 1,0 by simple clipping.

The opRGB tristimulus values are transformed to non-linear opR′G′B′ values as follows:

$$\left.\begin{aligned} R'_{\text{opRGB}} &= R_{\text{opRGB}}^{(1{,}0/2{,}2)} \\ G'_{\text{opRGB}} &= G_{\text{opRGB}}^{(1{,}0/2{,}2)} \\ B'_{\text{opRGB}} &= B_{\text{opRGB}}^{(1{,}0/2{,}2)} \end{aligned}\right\} \tag{6}$$

The non-linear opR′G′B′ values are converted to digital code values.

This standard specifies a black digital count of 0 and a white digital count of $2^N - 1$ for N-bits/channel encoding. The resulting RGB values are formed according to the following equations where the round function rounds the resulting value to the nearest integer.

$$\left.\begin{aligned} R_{\text{opRGB(N)}} &= \text{round}\left\{(2^N - 1) \times R'_{\text{opRGB}}\right\} \\ G_{\text{opRGB(N)}} &= \text{round}\left\{(2^N - 1) \times G'_{\text{opRGB}}\right\} \\ B_{\text{opRGB(N)}} &= \text{round}\left\{(2^N - 1) \times B'_{\text{opRGB}}\right\} \end{aligned}\right\} \tag{7}$$

Annex A
(normative)

Transformation between opRGB values and YCC values for image compression

A.1 Transformation from opRGB values to YCC values for image compression

The digital code values are converted to non-linear opR′G′B′ values. This conversion scales the digital code values by using the equation below, where WDC represents the white digital count and KDC represents the black digital count.

$$\left.\begin{aligned} R'_{\text{opRGB}} &= \left(R_{\text{opRGB(N)}} - KDC\right) \big/ \left(WDC - KDC\right) \\ G'_{\text{opRGB}} &= \left(G_{\text{opRGB(N)}} - KDC\right) \big/ \left(WDC - KDC\right) \\ B'_{\text{opRGB}} &= \left(B_{\text{opRGB(N)}} - KDC\right) \big/ \left(WDC - KDC\right) \end{aligned}\right\} \quad (A.1)$$

This standard specifies a black digital count of 0 and a white digital count of $2^N - 1$ for N-bits/channel encoding. The resulting non-linear opR′G′B′ values are formed according to the following equations.

$$\left.\begin{aligned} R'_{\text{opRGB}} &= R_{\text{opRGB(N)}} \div (2^N - 1) \\ G'_{\text{opRGB}} &= G_{\text{opRGB(N)}} \div (2^N - 1) \\ B'_{\text{opRGB}} &= B_{\text{opRGB(N)}} \div (2^N - 1) \end{aligned}\right\} \quad (A.2)$$

The non-linear opR′G′B′ values are transformed to YCC values for image compression as follows:

$$\begin{bmatrix} Y'_{\text{opRGB}} \\ Cb'_{\text{opRGB}} \\ Cr'_{\text{opRGB}} \end{bmatrix} = \begin{bmatrix} 0{,}299\,0 & 0{,}587\,0 & 0{,}114\,0 \\ -0{,}168\,7 & -0{,}331\,3 & 0{,}500\,0 \\ 0{,}500\,0 & -0{,}418\,7 & -0{,}081\,3 \end{bmatrix} \begin{bmatrix} R'_{\text{opRGB}} \\ G'_{\text{opRGB}} \\ B'_{\text{opRGB}} \end{bmatrix} \quad (A.3)$$

$$\left.\begin{aligned} Y_{\text{opRGB(8)}} &= \text{round}\left(255 \times Y'_{\text{opRGB}}\right) \\ Cb_{\text{opRGB}_{(8)}} &= \text{round}\left[\left(255 \times Cb'_{\text{opRGB}}\right) + 128\right] \\ Cr_{\text{opRGB}_{(8)}} &= \text{round}\left[\left(255 \times Cr'_{\text{opRGB}}\right) + 128\right] \end{aligned}\right\} \quad (A.4)$$

$$\left.\begin{aligned} Y_{\text{opRGB}_{(N)}} &= \text{round}\left[\left(2^N - 1\right) \times Y'_{\text{opRGB}}\right] \\ Cb_{\text{opRGB}_{(N)}} &= \text{round}\left[\left(\left(2^N - 1\right) \times Cb'_{\text{opRGB}}\right) + 2^{N-1}\right] \\ Cr_{\text{opRGB}_{(N)}} &= \text{round}\left[\left(\left(2^N - 1\right) \times Cr'_{\text{opRGB}}\right) + 2^{N-1}\right] \end{aligned}\right\} \quad (A.5)$$

A.2 Transformation from YCC for image compression values to opRGB values

The non-linear Y'Cb'Cr' values for image compression can be computed using the following relationship:

$$\left.\begin{aligned} Y'_{\text{opRGB}} &= (Y_{\text{opRGB}} - KDC)/(WDC - KDC) \\ Cb'_{\text{opRGB}} &= (Cb_{\text{opRGB}} - Offset)/Range \\ Cr'_{\text{opRGB}} &= (Cr_{\text{opRGB}} - Offset)/Range \end{aligned}\right\} \quad \text{(A.6)}$$

For 24-bit encoding (8-bit/channel), WDC = 255, KDC = 0, Range = 255 and Offset = 128, the relationship is defined as:

$$\left.\begin{aligned} Y'_{\text{opRGB}} &= (Y_{\text{opRGB(8)}} - 0)/(255 - 0) = Y_{\text{opRGB(8)}}/255 \\ Cb'_{\text{opRGB}} &= (Cb_{\text{opRGB(8)}} - 128)/255 \\ Cr'_{\text{opRGB}} &= (Cr_{\text{opRGB(8)}} - 128)/255 \end{aligned}\right\} \quad \text{(A.7)}$$

24-bit encoding (8-bit/channel) should be the default YCC for image compression encoding bit depth. Other bit depths may be unsupported for general use.

Where other N-bit/channel encoding is supported ($N > 8$), the relationship is defined as:

$$\left.\begin{aligned} Y'_{\text{opRGB}} &= Y_{\text{opRGB(N)}}/(2^N - 1) \\ Cb'_{\text{opRGB}} &= (Cb_{\text{opRGB(N)}} - 2^{N-1})/(2^N - 1) \\ Cr'_{\text{opRGB}} &= (Cr_{\text{opRGB(N)}} - 2^{N-1})/(2^N - 1) \end{aligned}\right\} \quad \text{(A.7')}$$

The non-linear Y′Cb′Cr′ for image compression values are transformed to the nonlinear opR′G′B′ values as follows:

$$\begin{bmatrix} R'_{\text{opRGB}} \\ G'_{\text{opRGB}} \\ B'_{\text{opRGB}} \end{bmatrix} = \begin{bmatrix} 1{,}000\,0 & 0{,}000\,0 & 1{,}402\,0 \\ 1{,}000\,0 & -0{,}344\,1 & -0{,}714\,1 \\ 1{,}000\,0 & 1{,}772\,0 & 0{,}000\,0 \end{bmatrix} \begin{bmatrix} Y'_{\text{opRGB}} \\ Cb'_{\text{opRGB}} \\ Cr'_{\text{opRGB}} \end{bmatrix} \quad \text{(A.8)}$$

In opRGB encoding process, negative opRGB tristimulus values and opRGB tristimulus values greater than 1,00 are not retained by simple clipping.

$$\left.\begin{aligned} R_{\text{opRGB(8)}} &= \text{round}(255 \times R'_{\text{opRGB}}) \\ G_{\text{opRGB(8)}} &= \text{round}(255 \times G'_{\text{opRGB}}) \\ B_{\text{opRGB(8)}} &= \text{round}(255 \times B'_{\text{opRGB}}) \end{aligned}\right\} \quad \text{(A.9)}$$

For 24-bit encoding (8-bit/channel), the $\text{opRGB}_{(8)}$ values should be limited to a range from 0 to 255 after equation (A.9).

$$\left.\begin{aligned} R_{\text{opRGB(N)}} &= \text{round}\left\{(2^{N}-1)\times R'_{\text{opRGB}}\right\} \\ G_{\text{opRGB(N)}} &= \text{round}\left\{(2^{N}-1)\times G'_{\text{opRGB}}\right\} \\ B_{\text{opRGB(N)}} &= \text{round}\left\{(2^{N}-1)\times B'_{\text{opRGB}}\right\} \end{aligned}\right\} \qquad \text{(A.10)}$$

For N-bit/channel encoding ($N > 8$), the $\text{opRGB}_{\text{(N)}}$ values should be limited to a range from 0 to 2^{N}–1 after equation (A.10).

Annex B
(informative)

Example transformation between opRGB values and sYCC values

B.1 General

Since the opRGB and sYCC colour encodings have different colour gamut capabilities and different reference display characteristics, it is not possible to define a single transform from one to the other that will always produce optimal results. There will be preferential aspects to the transform that may depend on the intended use case, and potentially even the images to be converted. Different colour re-rendering and gamut mapping algorithms may be preferred in different situations. However, in the absence of more sophisticated optimization, the following example transformation may be used.

B.2 Example transformation from opRGB values to sYCC values

The digital code values are converted to non-linear opR′G′B′ values. This conversion scales the digital code values by using the equation below, where WDC represents the white digital count and KDC represents the black digital count.

$$\left.\begin{aligned} R'_{\text{opRGB}} &= \left(R_{\text{opRGB(N)}} - KDC\right) / \left(WDC - KDC\right) \\ G'_{\text{opRGB}} &= \left(G_{\text{opRGB(N)}} - KDC\right) / \left(WDC - KDC\right) \\ B'_{\text{opRGB}} &= \left(B_{\text{opRGB(N)}} - KDC\right) / \left(WDC - KDC\right) \end{aligned}\right\} \tag{B.1}$$

This standard specifies a black digital count of 0 and a white digital count of $2^N - 1$ for N-bits/channel encoding. The resulting non-linear opR′G′B′ values are formed according to the following equations.

$$\left.\begin{aligned} R'_{\text{opRGB}} &= R_{\text{opRGB(N)}} \div (2^N - 1) \\ G'_{\text{opRGB}} &= G_{\text{opRGB(N)}} \div (2^N - 1) \\ B'_{\text{opRGB}} &= B_{\text{opRGB(N)}} \div (2^N - 1) \end{aligned}\right\} \tag{B.2}$$

The non-linear opR′G′B′ values are transformed to sRGB values as follows:

$$\left.\begin{aligned} R_{\text{opRGB}} &= \left(R'_{\text{opRGB}}\right)^{2,2} \\ G_{\text{opRGB}} &= \left(G'_{\text{opRGB}}\right)^{2,2} \\ B_{\text{opRGB}} &= \left(B'_{\text{opRGB}}\right)^{2,2} \end{aligned}\right\} \tag{B.3}$$

and

$$\begin{bmatrix} R_{\text{sRGB}} \\ G_{\text{sRGB}} \\ B_{\text{sRGB}} \end{bmatrix} = \begin{bmatrix} 1{,}398\,4 & -0{,}398\,4 & 0{,}000\,0 \\ 0{,}000\,0 & 1{,}000\,0 & 0{,}000\,0 \\ 0{,}000\,0 & -0{,}042\,9 & 1{,}042\,9 \end{bmatrix} \begin{bmatrix} R_{\text{opRGB}} \\ G_{\text{opRGB}} \\ B_{\text{opRGB}} \end{bmatrix} \tag{B.4}$$

In the sYCC encoding process, negative sRGB tristimulus values and sRGB tristimulus value greater than 1,0 are retained.

If R_{sRGB}, G_{sRGB}, B_{sRGB} <-0,003 130 8

$$\left.\begin{aligned} R'_{\text{sRGB}} &= -1{,}055 \times (-R_{\text{sRGB}})^{(1{,}0/2{,}4)} + 0{,}055 \\ G'_{\text{sRGB}} &= -1{,}055 \times (-G_{\text{sRGB}})^{(1{,}0/2{,}4)} + 0{,}055 \\ B'_{\text{sRGB}} &= -1{,}055 \times (-B_{\text{sRGB}})^{(1{,}0/2{,}4)} + 0{,}055 \end{aligned}\right\} \quad (B.5)$$

If −0,003 130 8 $\le R_{\text{sRGB}}$, G_{sRGB}, $B_{\text{sRGB}} \le$ 0,003 130 8

$$\left.\begin{aligned} R'_{\text{sRGB}} &= 12{,}92 \times R_{\text{sRGB}} \\ G'_{\text{sRGB}} &= 12{,}92 \times G_{\text{sRGB}} \\ B'_{\text{sRGB}} &= 12{,}92 \times B_{\text{sRGB}} \end{aligned}\right\} \quad (B.6)$$

If R_{sRGB}, G_{sRGB}, B_{sRGB} >0,003 130 8

$$\left.\begin{aligned} R'_{\text{sRGB}} &= 1{,}055 \times (R_{\text{sRGB}})^{(1{,}0/2{,}4)} - 0{,}055 \\ G'_{\text{sRGB}} &= 1{,}055 \times (G_{\text{sRGB}})^{(1{,}0/2{,}4)} - 0{,}055 \\ B'_{\text{sRGB}} &= 1{,}055 \times (B_{\text{sRGB}})^{(1{,}0/2{,}4)} - 0{,}055 \end{aligned}\right\} \quad (B.7)$$

The relationship between non-linear sRGB and sYCC is defined as follows:

$$\begin{bmatrix} Y'_{\text{sYCC}} \\ Cb'_{\text{sYCC}} \\ Cr'_{\text{sYCC}} \end{bmatrix} = \begin{bmatrix} 0{,}299\,0 & 0{,}587\,0 & 0{,}114\,0 \\ -0{,}168\,7 & -0{,}331\,3 & 0{,}500\,0 \\ 0{,}500\,0 & -0{,}418\,7 & -0{,}081\,3 \end{bmatrix} \begin{bmatrix} R'_{\text{sRGB}} \\ G'_{\text{sRGB}} \\ B'_{\text{sRGB}} \end{bmatrix} \quad (B.8)$$

Quantization for sYCC is defined as:

$$\left.\begin{aligned} Y_{\text{sYCC}} &= \text{round}\left[(WDC - KDC) \times Y'_{\text{sYCC}} + KDC\right] \\ Cb_{\text{sYCC}} &= \text{round}\left[(Range \times Cb'_{\text{sYCC}}) + Offset\right] \\ Cr_{\text{sYCC}} &= \text{round}\left[(Range \times Cr'_{\text{sYCC}}) + Offset\right] \end{aligned}\right\} \quad (B.9)$$

For 24-bit encoding (8-bit/channel), the relationship is defined as:

$$\left.\begin{aligned} Y_{\text{sYCC(8)}} &= \text{round}\left[(255 - 0) \times Y'_{\text{sYCC}} + 0\right] = \text{round}\left[255 \times Y'_{\text{sYCC}}\right] \\ Cb_{\text{sYCC(8)}} &= \text{round}\left[(255 \times Cb'_{\text{sYCC}}) + 128\right] \\ Cr_{\text{sYCC(8)}} &= \text{round}\left[(255 \times Cr'_{\text{sYCC}}) + 128\right] \end{aligned}\right\} \quad (B.10)$$

Where other N-bit/channel encoding is supported ($N > 8$), the relationship is defined as:

$$\left.\begin{aligned} Y_{\text{sYCC(N)}} &= \text{round}\left[\left(2^N - 1\right)\times Y'_{\text{sYCC}}\right] \\ Cb_{\text{sYCC(N)}} &= \text{round}\left[\left(\left(2^N - 1\right)\times Cb'_{\text{sYCC}}\right) + 2^{N-1}\right] \\ Cr_{\text{sYCC(N)}} &= \text{round}\left[\left(\left(2^N - 1\right)\times Cr'_{\text{sYCC}}\right) + 2^{N-1}\right] \end{aligned}\right\} \quad \text{(B.11)}$$

For N-bit/channel encoding ($N > 8$), the s$YCC_{\text{(N)}}$ values should be limited to a range from 0 to 2^N-1 after equation (B.11).

B.3 Example transformation from sYCC values to opRGB values

The non-linear sY'Cb'Cr' values can be computed using the following relationship:

$$\left.\begin{aligned} Y'_{\text{sYCC}} &= \left(Y_{\text{sYCC}} - KDC\right)/\left(WDC - KDC\right) \\ Cb'_{\text{sYCC}} &= \left(Cb_{\text{sYCC}} - Offset\right)/Range \\ Cr'_{\text{sYCC}} &= \left(Cr_{\text{sYCC}} - Offset\right)/Range \end{aligned}\right\} \quad \text{(B.12)}$$

For 24-bit encoding (8-bit/channel), WDC = 255, KDC = 0, Range = 255 and Offset = 128, the relationship is defined as;

$$\left.\begin{aligned} Y'_{\text{sYCC}} &= \left(Y_{\text{sYCC(8)}} - 0\right)/\left(255 - 0\right) = Y_{\text{sYCC(8)}}/255 \\ Cb'_{\text{sYCC}} &= \left(Cb_{\text{sYCC(8)}} - 128\right)/255 \\ Cr'_{\text{sYCC}} &= \left(Cr_{\text{sYCC(8)}} - 128\right)/255 \end{aligned}\right\} \quad \text{(B.13)}$$

24-bit encoding (8-bit/channel) should be the default sYCC encoding bit depth. Other bit depths may be unsupported for general use.

Where other N-bit/channel encoding is supported ($N > 8$), the relationship is defined as;

$$\left.\begin{aligned} Y'_{\text{sYCC}} &= Y_{\text{sYCC(N)}}/\left(2^N - 1\right) \\ Cb'_{\text{sYCC}} &= \left(Cb_{\text{sYCC(N)}} - 2^{N-1}\right)/\left(2^N - 1\right) \\ Cr'_{\text{sYCC}} &= \left(Cr_{\text{sYCC(N)}} - 2^{N-1}\right)/\left(2^N - 1\right) \end{aligned}\right\} \quad \text{(B.14)}$$

For 24-bit encoding (8-bit/channel), the non-linear sY′Cb′Cr′ values are transformed to the nonlinear sR′G′B′ values as follows:

$$\begin{bmatrix} R'_{\text{sRGB}} \\ G'_{\text{sRGB}} \\ B'_{\text{sRGB}} \end{bmatrix} = \begin{bmatrix} 1{,}000\,0 & 0{,}000\,0 & 1{,}402\,0 \\ 1{,}000\,0 & -0{,}344\,1 & -0{,}714\,1 \\ 1{,}000\,0 & 1{,}772\,0 & 0{,}000\,0 \end{bmatrix} \begin{bmatrix} Y'_{\text{sYCC}} \\ Cb'_{\text{sYCC}} \\ Cr'_{\text{sYCC}} \end{bmatrix} \quad \text{(B.15)}$$

For N-bit/channel encoding ($N > 8$), it is recommended to replace the matrix coefficients in the equation B.15 with the coefficients of the inverse matrix of the equation B.8 with enough accuracy decimal points. For example, following matrix with 6 decimal points has enough accuracy for the case of 16-bit/channel.

$$\begin{bmatrix} R'_{sRGB} \\ G'_{sRGB} \\ B'_{sRGB} \end{bmatrix} = \begin{bmatrix} 1{,}000\,000 & 0{,}000\,037 & 1{,}401\,988 \\ 1{,}000\,000 & -0{,}344\,113 & -0{,}714\,104 \\ 1{,}000\,000 & 1{,}771\,978 & 0{,}000\,135 \end{bmatrix} \begin{bmatrix} Y'_{sYCC} \\ Cb'_{sYCC} \\ Cr'_{sYCC} \end{bmatrix} \qquad \text{(B.15')}$$

The non-linear sR'G'B' values are then transformed to opRGB values as follows:

If R'_{sRGB}, G'_{sRGB}, B'_{sRGB} <-0,040 45:

$$\left.\begin{aligned} R_{sRGB} &= -\left[{(-R'_{sRGB} + 0{,}055)}/{1{,}055}\right]^{2{,}4} \\ G_{sRGB} &= -\left[{(-G'_{sRGB} + 0{,}055)}/{1{,}055}\right]^{2{,}4} \\ B_{sRGB} &= -\left[{(-B'_{sRGB} + 0{,}055)}/{1{,}055}\right]^{2{,}4} \end{aligned}\right\} \qquad \text{(B.16)}$$

If −0,040 45 $\leq R'_{sRGB}$, G'_{sRGB}, $B'_{sRGB} \leq$ 0,040 45:

$$\left.\begin{aligned} R_{sRGB} &= R'_{sRGB} \div 12{,}92 \\ G_{sRGB} &= G'_{sRGB} \div 12{,}92 \\ B_{sRGB} &= B'_{sRGB} \div 12{,}92 \end{aligned}\right\} \qquad \text{(B.17)}$$

If R'_{sRGB}, G'_{sRGB}, B'_{sRGB} >0,040 45:

$$\left.\begin{aligned} R_{sRGB} &= \left[{(R'_{sRGB} + 0{,}055)}/{1{,}055}\right]^{2{,}4} \\ G_{sRGB} &= \left[{(G'_{sRGB} + 0{,}055)}/{1{,}055}\right]^{2{,}4} \\ B_{sRGB} &= \left[{(B'_{sRGB} + 0{,}055)}/{1{,}055}\right]^{2{,}4} \end{aligned}\right\} \qquad \text{(B.18)}$$

The linear sRGB values are transformed to opRGB values as follows:

$$\begin{bmatrix} R_{opRGB} \\ G_{opRGB} \\ B_{opRGB} \end{bmatrix} = \begin{bmatrix} 0{,}715\,1 & 0{,}284\,9 & 0{,}000\,0 \\ 0{,}000\,0 & 1{,}000\,0 & 0{,}000\,0 \\ 0{,}000\,0 & 0{,}041\,2 & 0{,}958\,9 \end{bmatrix} \begin{bmatrix} R_{sRGB} \\ G_{sRGB} \\ B_{sRGB} \end{bmatrix} \qquad \text{(B.19)}$$

In the RGB encoding process, negative opRGB tristimulus values and opRGB tristimulus values greater than 1,00 are not retained. The luminance dynamic range and colour gamut of RGB is limited to the tristimulus values between 0,0 and 1,0 by simple clipping.

The opRGB tristimulus values are transformed to non-linear opR′G′B′ values as follows:

$$\left.\begin{aligned} R'_{opRGB} &= R_{opRGB}^{(1{,}0/2{,}2)} \\ G'_{opRGB} &= G_{opRGB}^{(1{,}0/2{,}2)} \\ B'_{opRGB} &= B_{opRGB}^{(1{,}0/2{,}2)} \end{aligned}\right\} \qquad \text{(B.20)}$$

The non-linear opR′G′B′ values are converted to digital code values. This conversion scales the above opR′G′B′ values by using the equation below, where WDC represents the white digital count and KDC represents the black digital count.

$$\left.\begin{aligned} R_{\text{opRGB(N)}} &= \text{round}\left[\left\{(WDC - KDC)\times R'_{\text{opRGB}}\right\} + KDC\right] \\ G_{\text{opRGB(N)}} &= \text{round}\left[\left\{(WDC - KDC)\times G'_{\text{opRGB}}\right\} + KDC\right] \\ B_{\text{opRGB(N)}} &= \text{round}\left[\left\{(WDC - KDC)\times B'_{\text{opRGB}}\right\} + KDC\right] \end{aligned}\right\} \qquad \text{(B.21)}$$

This standard specifies a black digital count of 0 and a white digital count of $2^N - 1$ for N-bits/channel encoding. The resulting RGB values are formed according to the following equations where the round function rounds the resulting value to the nearest integer:

$$\left.\begin{aligned} R_{\text{opRGB(N)}} &= \text{round}\left\{(2^N - 1)\times R'_{\text{opRGB}}\right\} \\ G_{\text{opRGB(N)}} &= \text{round}\left\{(2^N - 1)\times G'_{\text{opRGB}}\right\} \\ B_{\text{opRGB(N)}} &= \text{round}\left\{(2^N - 1)\times B'_{\text{opRGB}}\right\} \end{aligned}\right\} \qquad \text{(B.22)}$$

For N-bit/channel encoding ($N > 8$), the $\text{opRGB}_{(N)}$ values should be limited to a range from 0 to 2^N-1 after equation (B.22).

Annex C
(informative)

Example interpretation for colour image encoding specifications

C.1 General

The following additional specifications are provided for an example interpretation of encoded values by receiving software and printers, and for making ICC profiles, and are consistent with the specifications provided in the Adobe® RGB (1998) Color Image Encoding specification version 2005-05, published by Adobe Systems Incorporated.

C.2 Image state

The image state of image data encoded should be output-referred; however, the appropriateness of the rendering of the image for specific applications is beyond the scope of this standard.

C.3 Reference viewer observed display black point

The reference viewer observed display black point should be 0,555 7 cd/m^2 and the same chromaticity as the reference display white point.

The corresponding absolute XYZ_K tristimulus values for the Reference viewer observed display black point should be X_K = 0,528 2, Y_K = 0,555 7, Z_K=0,605 2.

The reference viewer observed display black point should be as measured from the viewer position in the reference viewing conditions, according to the method recommended in CIE 122. The reference viewer observed display black point therefore includes the viewer observed veiling glare in the reference viewing conditions.

NOTE When positioning a display in a viewing environment, it is important to arrange the ambient lighting so that specular reflections off the display faceplate, as seen from the viewer position, are avoided. This can usually be achieved by placing ambient light sources at an angle of at least 45 ° relative to the normal to the display faceplate, which is assumed to be the viewer's direction of gaze. See CIE 122 for more information about the measurement of display colorimetry, but note that in CIE 122 veiling glare is referred to as ambient flare.

C.4 Assumed adapted white point

Unless more sophisticated methods for estimating the adapted white point from the displayed image contents and viewing conditions are used, the adapted white point should be assumed to be equal to the reference display luminance level and white point.

C.5 Normalizing absolute XYZ tristimulus values for encoding

An image’s normalized XYZ tristimulus values should be encoded as specified in 5.3. The normalized XYZ tristimulus values 0,000 0, 0,000 0, 0,000 0 should correspond to the viewer observed reference display black point. The normalized XYZ tristimulus values 0,950 5, 1,000 0, 1,089 1 should correspond to the reference display luminance level and white point.

C.5.1 Obtaining tristimulus values

The absolute CIE $X_A Y_A Z_A$ tristimulus values should be those of the image as viewed on the reference display by the reference observer in the reference viewing environment, measured from the viewer position as recommended in CIE 122.

C.5.2 Normalizing absolute XYZ tristimulus values

Normalized XYZ image tristimulus values should be obtained from absolute $X_A Y_A Z_A$ tristimulus values, using the reference display luminance level and white point and viewer observed reference display black point values, as follows.

$$X = \frac{(X_A - X_K)}{(X_W - X_K)} \frac{X_W}{Y_W}$$
$$Y = \frac{(Y_A - Y_K)}{(Y_W - Y_K)} \qquad \text{(C.1)}$$
$$Z = \frac{(Z_A - Z_K)}{(Z_W - Z_K)} \frac{Z_W}{Y_W}$$

C.6 Converting from normalized XYZ to absolute XYZ tristimulus values

An image's encoded opRGB values should be converted to normalized XYZ tristimulus values as specified in 5.2, and converted to viewer observed absolute CIE $X_A Y_A Z_A$ tristimulus values as follows, using the reference display luminance level and white point and reference viewer observed display black point values.

$$X_A = X(X_W - X_K)\frac{Y_W}{X_W} + X_K$$
$$Y_A = Y(Y_W - Y_K) + Y_K \qquad \text{(C.2)}$$
$$Z_A = Z(Z_W - Z_K)\frac{Y_W}{Z_W} + Z_K$$

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

3, rue de Varembé
P.O. Box 131
CH-1211 Geneva 20
Switzerland

Tel: + 41 22 919 02 11
Fax: + 41 22 919 03 00
info@iec.ch
www.iec.ch