

Multimedia systems and equipment — Colour measurement and management —

Part 2-1: Colour management — Default RGB colour space — sRGB

The European Standard EN 61966-2-1:2000, with the incorporation of amendment A1:2003, has the status of a British Standard

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National foreword

This British Standard is the official English language version of EN 61966-2-1:2000, including amendment A1:2003. It is identical with IEC 61966-2-1:1999, including amendment 1:2003.

The UK participation in its preparation was entrusted to Technical Committee EPL/100, Audio, video and multimedia systems and equipment, which has the responsibility to:

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Default RGB colour space — sRGB**
(includes amendment A1:2003)
(IEC 61966-2-1:1999 + A1:2003)

Mesure et gestion de la couleur dans les
systèmes et appareils multimédia
Partie 2-1: Gestion de la couleur
Espace chromatique RVB par défaut-sRVB
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Multimediasysteme und Geräte
Farbmessung und Farbmanagement
Teil 2-1: Vorgabe-RGB-Farbenraum-sRGB
(enthält Änderung A1:2003)
(IEC 61966-2-1:1999 + A1:2003)

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

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Annexes designated “normative” are part of the body of the standard.
Annexes designated “informative” are given for information only.
In this standard, annex ZA is normative and annexes A, B, C, D and E are informative.
Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61966-2-1:1999 was approved by CENELEC as a European Standard without any modification.

Foreword to amendment A1

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Annexes designated “informative” are given for information only.
In this standard, Annex F is normative and Annex G and H are informative.

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INTRODUCTION

The method of digitisation in this part of IEC 61966 is designed to complement current colour management strategies by enabling a method of handling colour in the operating systems, device drivers and the Internet that utilises a simple and robust device-independent colour definition. This will provide good quality and backward compatibility with minimum transmission and system overhead. Based on a calibrated colorimetric RGB colour space well suited to cathode ray tube (CRT) displays, flat panel displays, television, scanners, digital cameras, and printing systems, such a space can be supported with minimum cost to software and hardware vendors. While there does exist a difference in the underlying physical responses between CRT and flat panel technology, most flat panel displays have internal compensations to simulate CRT displays in order to be commercially viable. The intent is to promote its adoption, by showing the benefits of supporting a standard colour space and the suitability of this standard colour space, sRGB.

Recently, the International Color Consortium has proposed breakthrough solutions to problems in communicating colour in open systems. Yet the ICC profile format does not provide a complete solution for all situations.

Currently, the ICC has one means of tracking and ensuring that a colour is correctly mapped from the input to the output colour space. This is done by attaching a profile for the input colour space to the image in question. This is appropriate for the high-quality publishing industry. However, there is a broad range of users who do not require this level of flexibility and control in an embedded profile mechanism. Instead, it is possible to create a single, standard default colour-space definition that can be processed as an implicit ICC sRGB profile. Additionally, most existing file formats do not, and may never, support colour profile embedding, and finally, there is a broad range of uses that actually discourage people from appending any extra data to their files. A common standard RGB colour space addresses these issues and is useful and necessary. This approach maintains the advantage of a clear relationship with ICC colour management systems while minimising software processes and support requirements.

Application developers and users who do not want the overhead of embedding profiles with documents or images should convert them to a common colour space for storage. Currently, there is a plethora of RGB CRT-based colour spaces attempting to fill this void with little guidance or attempts at standardisation. There is a need to merge the many standard and non-standard RGB display spaces into a single standard RGB colour space. This standard dramatically improves the colour fidelity in the desktop environment by meeting this need. For example, if operating system vendors provide support for this standard RGB colour space, the input and output device vendors that support this standard colour space could easily and confidently communicate colour without further colour management overhead in the most common situations. The three major factors of this RGB space are the colorimetric RGB definition, the simple exponent value of 2,2, and the well-defined viewing conditions, along with a number of secondary details necessary to enable the clear and unambiguous communication of colour.

The dichotomy between the device-dependent (for example, amounts of ink expressed in CMYK or digitised video voltages expressed in RGB) and device-independent colour spaces (such as CIELAB or CIEXYZ) has created a performance burden on applications that have attempted to avoid device colour spaces. This is primarily due to the complexity of the colour transforms they need to perform to return the colours to device-dependent colour spaces. This situation is worsened by a reliability gap between the complexity and variety of the transforms, making it hard to ensure that the system is properly configured.

This standard addresses these concerns, serves the needs of personal computer and World Wide Web-based colour imaging systems, and is based on the average performance of personal computer displays. This solution is supported by the following observations.

- Most computer displays are similar in their key colour characteristics – the phosphor chromaticities (primaries) and transfer function.
- RGB spaces are native to displays, scanners and digital cameras, which are the devices with the highest performance constraints.
- RGB spaces can be made device-independent in a straightforward way. They can also describe colour gamuts that are large enough for all but a small number of applications.

This combination of factors makes a colorimetric RGB space well suited for wide adoption since it can both describe the colours in an unambiguous way and be the native space for actual hardware devices. This, many readers will recognise, describes in a roundabout way what has been the practice in colour television for some 45 years. This proven methodology provides excellent performance where it is needed the most, the rapid display of images in CRT displays.

There are two parts to the methodology described in this standard: the encoding transformations and the reference conditions. The encoding transformations provide all of the necessary information to encode an image for optimum display in the reference conditions. If actual conditions differ from reference conditions, additional rendering transformations may be required. The encoding transformations are the default RGB colour definition when no other colour-space information is available or appropriate.

MULTIMEDIA SYSTEMS AND EQUIPMENT – COLOUR MEASUREMENT AND MANAGEMENT –

Part 2-1: Colour management – Default RGB colour space – sRGB

1 Scope

This part of IEC 61966 is applicable to the encoding and communication of RGB colours 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 normative documents contain provisions, which, through reference in this text, constitute provisions of this part of IEC 61966. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of IEC 61966 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60050(845):1987, *International Electrotechnical Vocabulary (IEV) – Chapter 845: Lighting*

ISO 3664:—, *Viewing conditions for graphic technology and photography*

ISO 9358:1994, *Optics and optical instruments – Veiling glare of image forming systems – Definitions and methods of measurement*

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

CIE 15.2:1986, *Colorimetry*

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

ITU-R Recommendation BT.709-3:1998, *Parameter values for the HDTV standards for production and international programme exchange*

3 Definitions

For the purposes of this International Standard, the following definitions apply. Definitions of illuminance, luminance, tristimulus, and other related lighting terms are defined in IEC 60050(845). Veiling glare is defined in ISO 3664.

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 model offset

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

3.6

display input/output characteristic

transfer characteristic relating the normalised digital code value and the normalised output luminance as represented by a power function ¹⁾

3.7

display luminance level

luminance of the display measured consistently with CIE 122

3.8

display surround

field outside the background, filling the field of vision

3.9

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

¹⁾ The term "gamma" is not used in this standard for the reasons discussed in annex A.

4 Reference conditions

4.1 Reference image display system characteristics

The reference image display system is a computer controlled cathode-ray tube display and shall be as follows.

- Display luminance level 80 cd/m²
- Display white point $x = 0,312\ 7$, $y = 0,329\ 0$ (D65)
- Display model offset (R, G and B) 0,0
- Display input/output characteristic (R, G, and B) 2,2

The CIE chromaticities for the red, green, and blue reference display primaries, and for CIE standard illuminant D65, are given in table 1. These primaries and white point values are identical to those of ITU-R BT.709-3.

Table 1 – CIE chromaticities for ITU-R BT.709-3 reference primaries and CIE standard illuminant

	Red	Green	Blue	D65
x	0,640 0	0,300 0	0,150 0	0,312 7
y	0,330 0	0,600 0	0,060 0	0,329 0
z	0,030 0	0,100 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'_{sRGB} is the normalised digital count and V_{sRGB} is the output normalised luminance.

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

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 (16 cd/m²); the chromaticity should average to $x = 0,312\ 7$, $y = 0,329\ 0$ (D65).
- b) Reference surround 20 % of the reference ambient luminance level (4,1 cd m⁻²); the chromaticity should average to $x = 0,345\ 7$, $y = 0,358\ 5$ (D50).
- c) Reference proximal field 20 % of the reference display luminance level (16 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).

f) Reference veiling glare $0,2\ \text{cd m}^{-2}$

NOTE When positioning a display within the viewing environment, it is important to achieve an angle of at least 45° relative to the ambient lighting and to the observer's direction of gaze (0° relative to the normal of the display). This geometry will result in a display surface reflectance that is dominated by Lambertian (diffuse) reflection and will avoid any specular reflection component. See IEC 61966-3 for more on the measurement of display surface reflection with this geometry.

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 8-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 scaled from 0,0 to 1,0, not 0,0 to 100,0. These non-linear sR'G'B' values represent the appearance of the image as displayed on the reference display in the reference viewing condition. The sRGB tristimulus values are linear combinations of the CIE 1931 XYZ values as measured on the faceplate of the display, which assumes the absence of any significant veiling glare. One impact of this encoding specification is the creation of a mismatch between theoretical reference display tristimulus values and those generated from the encoding implementation. The advantages of optimising encoding outweigh the disadvantages of this mismatch. A linear portion of the transfer function of the dark-end signal is integrated into the encoding specification to optimise encoding implementations. Recommended treatments for both veiling glare and viewing conditions are provided in annexes D and E.

5.2 Transformation from RGB values to CIE 1931 XYZ values

The digital code values are converted to non-linear sR'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.

$$\begin{aligned} R'_{sRGB} &= (R_{8\text{bit}} - KDC) / (WDC - KDC) \\ G'_{sRGB} &= (G_{8\text{bit}} - KDC) / (WDC - KDC) \\ B'_{sRGB} &= (B_{8\text{bit}} - KDC) / (WDC - KDC) \end{aligned} \quad (2)$$

This standard specifies a black digital count of 0 and a white digital count of 255 for 24-bit (8-bits/channel) encoding. The resulting non-linear sR'G'B' values are formed according to the following equations.

$$\begin{aligned} R'_{sRGB} &= (R_{8\text{bit}} - 0) / (255 - 0) \\ G'_{sRGB} &= (G_{8\text{bit}} - 0) / (255 - 0) \\ B'_{sRGB} &= (B_{8\text{bit}} - 0) / (255 - 0) \end{aligned} \quad (3)$$

The relationship is defined as follows:

$$\begin{aligned} R'_{sRGB} &= R_{8bit} \div 255 \\ G'_{sRGB} &= G_{8bit} \div 255 \\ B'_{sRGB} &= B_{8bit} \div 255 \end{aligned} \quad (4)$$

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

$$\begin{aligned} R_{sRGB} &= R'_{sRGB} \div 12,92 \\ G_{sRGB} &= G'_{sRGB} \div 12,92 \\ B_{sRGB} &= B'_{sRGB} \div 12,92 \end{aligned} \quad (5)$$

or if $R'_{sRGB}, G'_{sRGB}, B'_{sRGB} > 0,040 45$

$$\begin{aligned} R_{sRGB} &= \left[\frac{(R'_{sRGB} + 0,055)}{1,055} \right]^{2,4} \\ G_{sRGB} &= \left[\frac{(G'_{sRGB} + 0,055)}{1,055} \right]^{2,4} \\ B_{sRGB} &= \left[\frac{(B'_{sRGB} + 0,055)}{1,055} \right]^{2,4} \end{aligned} \quad (6)$$

and

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 0,4124 & 0,3576 & 0,1805 \\ 0,2126 & 0,7152 & 0,0722 \\ 0,0193 & 0,1192 & 0,9505 \end{bmatrix} \begin{bmatrix} R_{sRGB} \\ G_{sRGB} \\ B_{sRGB} \end{bmatrix} \quad (7)$$

The above equations closely fit a simple power function with an exponent of 2,2. This maintains consistency with the legacy of desktop and video images.

These CIE 1931 XYZ values represent optimum image colorimetry when viewed on the reference display, in the reference viewing conditions, by the reference observer, and as measured on the faceplate of the display, which assumes the absence of any significant veiling glare.

5.3 Transformation from CIE 1931 XYZ values to RGB values

The sRGB tristimulus values can be computed using the following relationship:

$$\begin{bmatrix} R_{sRGB} \\ G_{sRGB} \\ B_{sRGB} \end{bmatrix} = \begin{bmatrix} 3,2406 & -1,5372 & -0,4986 \\ -0,9689 & 1,8758 & 0,0415 \\ 0,0557 & -0,2040 & 1,0570 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix} \quad (8)$$

In the RGB encoding process, negative sRGB tristimulus values, and sRGB 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 sRGB tristimulus values are transformed to non-linear sR'G'B' values as follows:

If $R_{sRGB}, G_{sRGB}, B_{sRGB} \leq 0,003\,130\,8$

$$\begin{aligned} R'_{sRGB} &= 12,92 \times R_{sRGB} \\ G'_{sRGB} &= 12,92 \times G_{sRGB} \\ B'_{sRGB} &= 12,92 \times B_{sRGB} \end{aligned} \quad (9)$$

or if $R_{sRGB}, G_{sRGB}, B_{sRGB} > 0,003\,130\,8$

$$\begin{aligned} R'_{sRGB} &= 1,055 \times R_{sRGB}^{(1,0/2,4)} - 0,055 \\ G'_{sRGB} &= 1,055 \times G_{sRGB}^{(1,0/2,4)} - 0,055 \\ B'_{sRGB} &= 1,055 \times B_{sRGB}^{(1,0/2,4)} - 0,055 \end{aligned} \quad (10)$$

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

$$\begin{aligned} R_{8bit} &= \text{round}(((WDC - KDC) \times R'_{sRGB}) + KDC) \\ G_{8bit} &= \text{round}(((WDC - KDC) \times G'_{sRGB}) + KDC) \\ B_{8bit} &= \text{round}(((WDC - KDC) \times B'_{sRGB}) + KDC) \end{aligned} \quad (11)$$

This standard specifies a black digital count of 0 and a white digital count of 255 for 24-bit (8-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:

$$\begin{aligned} R_{8bit} &= \text{round}(((255,0 - 0,0) \times R'_{sRGB}) + 0,0) \\ G_{8bit} &= \text{round}(((255,0 - 0,0) \times G'_{sRGB}) + 0,0) \\ B_{8bit} &= \text{round}(((255,0 - 0,0) \times B'_{sRGB}) + 0,0) \end{aligned} \quad (12)$$

This is simplified as shown below:

$$\begin{aligned} R_{8bit} &= \text{round}(255,0 \times R'_{sRGB}) \\ G_{8bit} &= \text{round}(255,0 \times G'_{sRGB}) \\ B_{8bit} &= \text{round}(255,0 \times B'_{sRGB}) \end{aligned} \quad (13)$$