
Colorimetry —

Part 5:

**CIE 1976 $L^*u^*v^*$ colour space and u', v'
uniform chromaticity scale diagram**

Colorimétrie —

*Partie 5: Espace chromatique $L^*u^*v^*$ et diagramme de chromaticité
uniforme u', v' CIE 1976*
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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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).

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For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

The committee responsible for this document is ISO/TC 274, *Light and lighting*.

This first edition of ISO/CIE 11664-5 cancels and replaces ISO 11664-5:2009, of which it constitutes a minor revision. (ISO 11664-5:2009 was prepared by CIE Technical Committee TC-1-57 of Division 1.)

ISO 11664 consists of the following parts, under the general title *Colorimetry*:

- Part 1: CIE standard colorimetric observers
- Part 2: CIE standard illuminants
- Part 3: CIE tristimulus values
- Part 4: CIE 1976 $L^*a^*b^*$ Colour space

ISO/CIE 11664 consists of the following parts, under the general title *Colorimetry*:

- Part 5: CIE 1976 $L^*u^*v^*$ colour space and u', v' uniform chromaticity scale diagram
- Part 6: CIEDE2000 Colour-difference formula

Introduction

The three-dimensional colour space produced by plotting CIE tristimulus values (X, Y, Z) in rectangular coordinates is not visually uniform nor is the (x, y, Y) space nor the two-dimensional CIE x, y chromaticity diagram. Equal distances in these spaces and diagrams do not represent equally perceptible differences between colour stimuli. For this reason, in 1976, the CIE introduced and recommended two new spaces (known as CIELAB and CIELUV) whose coordinates are non-linear functions of X, Y and Z . The recommendation was put forward in an attempt to unify the then very diverse practice in uniform colour spaces and associated colour difference formulae.^[2]^[8] Both these more-nearly uniform colour spaces have become well accepted and widely used. Numerical values representing approximately the relative magnitude of colour differences can be described by simple Euclidean distances in the spaces or by more sophisticated formulae that improve the correlation with the relative perceived size of differences. The purpose of this part of ISO/CIE 11664 is to define procedures for calculating the coordinates of the CIE 1976 $L^*u^*v^*$ (CIELUV) colour space and the Euclidean colour difference values based on these coordinates. This part of ISO/CIE 11664 also defines a related chromaticity diagram that is a projection of the CIE x, y chromaticity diagram maintaining straight lines of dominant and complementary wavelengths. This part of ISO/CIE 11664 does not cover the alternative uniform colour space, CIELAB,^[5] nor does it cover more sophisticated colour difference formulae based on CIELAB, such as the CMC formula,^[3] the CIE 94 formula,^[1] the DIN 99 formula,^[4] and the CIEDE2000 formula.^[6]

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Colorimetry —

Part 5:

CIE 1976 $L^*u^*v^*$ colour space and u', v' uniform chromaticity scale diagram

1 Scope

This part of ISO/CIE 11664 specifies the method of calculating the coordinates of the CIE 1976 $L^*u^*v^*$ colour space including correlates of lightness, chroma, saturation and hue. It includes two methods for calculating Euclidean distances in this space to represent the relative perceived magnitude of colour differences. It also specifies the method of calculating the coordinates of the u', v' uniform chromaticity scale diagram.

This part of ISO/CIE 11664 is applicable to tristimulus values calculated using the colour-matching functions of the CIE 1931 standard colorimetric system or the CIE 1964 standard colorimetric system. This part of ISO/CIE 11664 may be used for the specification of colour stimuli perceived as belonging to a reflecting or transmitting object, where a three-dimensional space more uniform than tristimulus space is required. This includes self-luminous displays, like cathode ray tubes, if they are being used to simulate reflecting or transmitting objects and if the stimuli are appropriately normalized. This part of ISO/CIE 11664, as a whole, does not apply to colour stimuli perceived as belonging to an area that appears to be emitting light as a primary light source or that appears to be specularly reflecting such light. Only the u', v' uniform chromaticity scale diagram defined in 4.1 and the correlates of hue and saturation defined in 4.3 apply to such colour stimuli.

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2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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/CIE S 014-1, *Colorimetry — Part 1: CIE standard colorimetric observers*

ISO 11664-2/CIE S 014-1, *Colorimetry — Part 2: CIE standard illuminants*

CIE S 017, *ILV: International Lighting Vocabulary*

3 Terms, definitions, symbols and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in CIE S 017 apply.

3.2 Symbols and abbreviated terms

X, Y, Z	tristimulus values of a test stimulus calculated using the colour-matching functions of the CIE 1931 standard colorimetric system (also known as the CIE 2° standard colorimetric system)
Y_n	tristimulus value, Y , of a specified white colour stimulus calculated using the colour-matching functions of the CIE 1931 standard colorimetric system
x, y	chromaticity coordinates of a test stimulus calculated using the colour-matching functions of the CIE 1931 standard colorimetric system
L^*	CIELUV lightness
u^*, v^*	CIELUV u^*, v^* coordinates
u', v'	CIE 1976 chromaticity coordinates
u'_n, v'_n	CIE 1976 chromaticity coordinates of a specified white stimulus
S_{uv}	CIELUV saturation
C_{uv}^*	CIELUV chroma
h_{uv}	CIELUV hue angle
$\Delta(u', v')$	CIELUV chromaticity difference
ΔL^*	CIELUV lightness difference
$\Delta u^*, \Delta v^*$	CIELUV u^*, v^* differences
ΔC_{uv}^*	CIELUV chroma difference
Δh_{uv}	CIELUV hue angle difference
ΔH_{uv}^*	CIELUV hue difference
ΔE_{uv}^*	CIELUV colour difference

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If the character “ Δ ” is not available, it may be replaced by the character “D”.

The terms “CIE 1976 $L^*u^*v^*$ ” and “CIELUV” may be used interchangeably.

Where tristimulus values are calculated using the colour-matching functions of the CIE 1964 standard colorimetric system (also known as the CIE 10° standard colorimetric system), a subscript 10 shall be added to all the above symbols.

4 Calculation method

4.1 Uniform chromaticity scale diagram (UCS diagram)

The CIE 1976 uniform chromaticity scale diagram is a projective transformation of the CIE x, y chromaticity diagram yielding perceptually more uniform colour spacing. It is produced by plotting, as abscissa and ordinate, respectively, quantities defined by the following formulae:

$$u' = 4X / (X + 15Y + 3Z) \tag{1}$$

$$v' = 9Y / (X + 15Y + 3Z) \quad (2)$$

where X , Y , Z are the tristimulus values of the test colour stimulus based on the CIE 1931 standard colorimetric system defined in ISO 11664-1/CIE S 014-1.

The same quantities may be obtained by the following formulae:

$$u' = 4x / (-2x + 12y + 3) \quad (3)$$

$$v' = 9y / (-2x + 12y + 3) \quad (4)$$

where x and y are obtained by the following formulae:

$$x = X / (X + Y + Z) \quad (5)$$

$$y = Y / (X + Y + Z) \quad (6)$$

Euclidean distances in this diagram can be used to represent approximately the relative perceived magnitude of colour differences between colour stimuli of negligibly different luminances, of approximately the same size, and viewed in identical surroundings, by an observer photopically adapted to a field with the chromaticity of CIE standard illuminant D65 defined in ISO 11664-2/CIE S 014-2. The values given by this part of ISO/CIE 11664 may not correlate well with relative perceived colour differences in other viewing conditions. The Euclidean distances are defined by the following formula:

$$\Delta(u', v') = \left[(\Delta u')^2 + (\Delta v')^2 \right]^{1/2} \quad (7)$$

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where

$$\Delta u' = u'_1 - u'_0 \quad (8)$$

$$\Delta v' = v'_1 - v'_0 \quad (9)$$

and the subscripts 0 (usually the reference) and 1 (usually the test) indicate the two stimuli being compared.

4.2 Uniform colour space

The CIE 1976 $L^*u^*v^*$ colour space is a three-dimensional, approximately uniform colour space produced by plotting in rectangular coordinates, L^* , u^* , v^* , quantities defined by the following formulae:

$$L^* = 116 f(Y/Y_n) - 16 \quad (10)$$

$$u^* = 13L^* (u' - u'_n) \quad (11)$$

$$v^* = 13L^* (v' - v'_n) \quad (12)$$