IEC 61966-2-4

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Multimedia systems and equipment – Colour measurement and management – Part 2-4: Colour management – Extended-gamut YCC colour space for video applications – xvYCC

Systèmes et appareils multimédia – Mesure et gestion de la couleur – Partie 2-4: Gestion de la couleur – Extension de gamme de l'espace chromatique YCC pour applications vidéo – xvYCC

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

Useful links:

IEC publications search - www.iec.ch/searchpub

The advanced search enables you to find IEC publications by a variety of criteria (reference number, text, technical committee,…).

It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available on-line and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary (IEV) on-line.

Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

A propos de la CEI

La Commission Electrotechnique Internationale (CEI) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Liens utiles:

Recherche de publications CEI - www.iec.ch/searchpub

La recherche avancée vous permet de trouver des publications CEI en utilisant différents critères (numéro de référence, texte, comité d'études,…).

Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

Just Published CEI - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications de la CEI. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

Electropedia - www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 30 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (VEI) en ligne.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: csc@iec.ch.

IEC 61966-2-4

Edition 1.0   2006-01

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Multimedia systems and equipment – Colour measurement and management –
Part 2-4: Colour management – Extended-gamut YCC colour space for video applications – xvYCC

Systèmes et appareils multimédia – Mesure et gestion de la couleur –
Partie 2-4: Gestion de la couleur – Extension de gamme de l'espace chromatique YCC pour applications vidéo – xvYCC

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX

R

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION
_____

MULTIMEDIA SYSTEMS AND EQUIPMENT – COLOUR MEASUREMENT AND MANAGEMENT –

Part 2-4: Colour management – Extended-gamut YCC colour space for video applications – xvYCC

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.

3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.

4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.

5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.

6) All users should ensure that they have the latest edition of this publication.

7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.

8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.

9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61966-2-4 has been prepared by IEC technical committee 100: Audio, video and multimedia systems and equipment.

This bilingual version (2013-03) corresponds to the monolingual English version, published in 2006-01.

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

CDV	Report on voting
100/967/CDV	100/1026/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.

The French version of this standard has not been voted upon.

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

IEC 61966 consists of the following parts, under the general title *Multimedia systems and equipment – Colour measurement and management:*

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

Part 2-2:   Colour management – Extended RGB colour space – scRGB

Part 2-4:   Colour management – Extended-gamut YCC colour space for video applications – xvYCC

Part 2-5:   Colour management – Optional RGB colour space – opRGB (under consideration)

Part 3:   Equipment using cathode ray tubes

Part 4:   Equipment using liquid crystal display panels

Part 5:   Equipment using plasma display panels

Part 6:   Front projection displays

Part 7-1:   Colour printers – Reflective prints – RGB inputs

Part 7-2:   Colour printers – Reflective prints – CMYK inputs (proposed work item)

Part 8:   Multimedia colour scanners

Part 9:   Digital cameras

Part 10:   Quality assessment (proposed work item)

Part 11:   Quality assessment – Impaired video in network systems (proposed work item)

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.

The contents of the corrigendum of November 2006 have been included in this copy.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

After the publication of IEC 61966-2-1, Amendment 1, the sYCC colour encoding was used to capture, store and print extended colour gamut for still image applications. Users received pleasant benefit by exchanging and reproducing wide-gamut colour images.

Recently, various kinds of displays that are capable of producing a wider gamut of colour than the conventional CRT-based displays are emerging. However, most of the current video contents that are displayed on conventional displays, are rendered for the sRGB-gamut. Users of wide-gamut displays could benefit from wide-gamut colour images by video colour encoding that supports a larger colour gamut.

This standard defines the "extended-gamut YCC colour space for video applications". It is based on the current implementation of YCC colour encoding that is used in the video industry (namely ITU-R BT.709-5) and extends its definition to the wider gamut of colour range.

MULTIMEDIA SYSTEMS AND EQUIPMENT – COLOUR MEASUREMENT AND MANAGEMENT –

Part 2-4: Colour management – Extended-gamut YCC colour space for video applications – xvYCC

1 Scope

This part of IEC 61966 is applicable to the encoding and communication of YCC colours used in video systems and similar applications by defining encoding transformations for use in defined reference capturing 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) – Part 845: Lighting*

ITU-R Recommendation BT.601-5:1995, *Studio encoding parameters of digital television for standard 4:3 and wide-screen 16:9 aspect ratios*

ITU-R Recommendation BT.709-5:2002, *Parameter values for the HDTV standards for production and international programme exchange*

3 Terms and definitions

For the purposes of this document, the following terms and definitions, as well as those concerning illuminance, luminance, tristimulus, and other related lighting terms given in IEC 60050-845, apply.

3.1
scene-referred colour encoding
representation of estimated colour-space coordinates of the elements of an original scene, where a scene is defined to be the relative spectral radiance

3.2
output-referred colour encoding
representation of estimated colour-space coordinates of image data that are appropriate for specified output device and viewing conditions

3.3
extended gamut
colour gamut extending outside that of the standard sRGB CRT display defined in IEC 61966-2-1

3.4
luma
luminance signal as defined by SMPTE/EG28:1993

NOTE 1   To avoid interdisciplinary confusion resulting from the two distinct definitions of luminance, it has been proposed that the video documents use "luma" for "luminance, television" (i.e., the luminance signal).

NOTE 2   Video systems approximate the lightness response of vision by computing a luma component Y' as a weighted sum of non-linear (or gamma-corrected) R'G'B' primary components. Luma is often carelessly referred to as luminance.

4   Colorimetric parameters and related characteristics

This clause defines colorimetric parameters and the related characteristics of reference capturing devices.

4.1   Primary colours and reference white

The CIE chromaticities for the reference red, green, and blue primary colours, and for reference white CIE standard illuminant D65, are given in Table 1. These primaries and white point values are identical to those of ITU-R BT.709-5.

Table 1 – CIE chromaticities for reference primary colours and reference white

	Red	Green	Blue	White/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

4.2   Opto-electronic transfer characteristics

Opto-electronic transfer characteristics are defined as follows.

If $R, G, B \leq -0{,}018$,

$$R' = -1{,}099 \times (-R)^{0{,}45} + 0{,}099$$
$$G' = -1{,}099 \times (-G)^{0{,}45} + 0{,}099 \qquad (1)$$
$$B' = -1{,}099 \times (-B)^{0{,}45} + 0{,}099$$

If $-0{,}018 < R, G, B < 0{,}018$,

$$R' = 4{,}50 \times R$$
$$G' = 4{,}50 \times G \qquad (2)$$
$$B' = 4{,}50 \times B$$

If $R, G, B \geq 0{,}018$,

$$R' = 1{,}099 \times (R)^{0{,}45} - 0{,}099$$
$$G' = 1{,}099 \times (G)^{0{,}45} - 0{,}099 \qquad (3)$$
$$B' = 1{,}099 \times (B)^{0{,}45} - 0{,}099$$

where R, G, B is a voltage normalized by reference white level and proportional to the implicit light intensity that would be detected with a reference camera colour channel; R', G', B' is the resulting non-linear primary signal.

4.3 YCC (luma-chroma-chroma) encoding methods

The encoding equations from the primary RGB (red-green-blue) signal: R', G', B' to the YCC (luma-chroma-chroma) signal: Y', Cb', Cr' is defined by the following two methods. It is important to follow one of the encodings in the specified application.

xvYCC$_{601}$, which is implemented mainly in the SDTV (standard-definition television) applications as defined in ITU-R BT. 601-5, is defined as follows:

$$\begin{bmatrix} Y'_{601} \\ Cb'_{601} \\ Cr'_{601} \end{bmatrix} = \begin{bmatrix} 0,299\,0 & 0,587\,0 & 0,114\,0 \\ -0,168\,7 & -0,331\,3 & 0,500\,0 \\ 0,500\,0 & -0,418\,7 & -0,081\,3 \end{bmatrix} \begin{bmatrix} R' \\ G' \\ B' \end{bmatrix} \tag{4}$$

NOTE The coefficients in equation (4) are from ITU-R BT.601-5 which defines Y' of YCC to the three decimal place accuracy. An additional decimal place is defined above to be consistent with the other matrix coefficients defined in this standard.

xvYCC$_{709}$, which is implemented mainly in the HDTV (high-definition television) applications as defined in ITU-R BT. 709-5, is defined as follows:

$$\begin{bmatrix} Y'_{709} \\ Cb'_{709} \\ Cr'_{709} \end{bmatrix} = \begin{bmatrix} 0,212\,6 & 0,715\,2 & 0,072\,2 \\ -0,114\,6 & -0,385\,4 & 0,500\,0 \\ 0,500\,0 & -0,454\,2 & -0,045\,8 \end{bmatrix} \begin{bmatrix} R' \\ G' \\ B' \end{bmatrix} \tag{5}$$

4.4 Digital quantization methods

Quantization of YCC (luma-chroma-chroma) signal: Y', Cb', Cr' is defined as follows.

For 8-bit representation:

$$\begin{aligned} Y_{\text{xvYCC(8)}} &= \text{round}[219 \times Y' + 16] \\ Cb_{\text{xvYCC(8)}} &= \text{round}[224 \times Cb' + 128] \\ Cr_{\text{xvYCC(8)}} &= \text{round}[224 \times Cr' + 128] \end{aligned} \tag{6}$$

For n-bit ($n > 8$) representation:

$$\begin{aligned} Y_{\text{xvYCC}(N)} &= \text{round}\left[(219 \times Y' + 16) \times 2^{n-8}\right] \\ Cb_{\text{xvYCC}(N)} &= \text{round}\left[(224 \times Cb' + 128) \times 2^{n-8}\right] \\ Cr_{\text{xvYCC}(N)} &= \text{round}\left[(224 \times Cr' + 128) \times 2^{n-8}\right] \end{aligned} \tag{7}$$

NOTE Bit levels "from 0 to $2^{N-8}-1$" and "from $255 \times 2^{N-8}$ to 2^N-1" (0 and 255, for the case of 8-bit encoding) are used exclusively for synchronization and are not allowed for storing colour values. Levels from "2^{N-8}" to "$255 \times 2^{N-8}-1$" (from 1 to 254, for the case of 8-bit encoding) are available.

5 Encoding transformations

5.1 Introduction

The encoding transformations between xvYCC values and CIE 1931 XYZ values provide unambiguous methods to represent optimum image colorimetry of the captured scene. Scene colorimetry is defined as relative to the white objects, assuming that the exposure is properly controlled. It should be noted that dynamic range compression is needed when storing the wide dynamic range images (see Annex A for descriptions). Additionally, if the condition of the capturing device deviates from the ideal condition defined in Clause 4, operations such as colour compensation, colour correction and a certain degree of colour rendering can be performed. However, the methods for these operations are beyond the scope of this standard.

5.2 Transformation from xvYCC values to CIE 1931 XYZ values

For 24-bit encoding (8-bit/channel), the relationship between 8-bit values and Y', Cb', Cr' is defined as:

$$
\begin{aligned}
Y' &= \left(Y_{\text{xvYCC(8)}} - 16 \right) / 219 \\
Cb' &= \left(Cb_{\text{xvYCC(8)}} - 128 \right) / 224 \\
Cr' &= \left(Cr_{\text{xvYCC(8)}} - 128 \right) / 224
\end{aligned}
\tag{8}
$$

For N-bit/channel ($N > 8$) encoding, the relationship between N-bit values and Y', Cb', Cr' is defined as:

$$
\begin{aligned}
Y' &= \left(\frac{Y_{\text{xvYCC}(N)}}{2^{N-8}} - 16 \right) / 219 \\[2mm]
Cb' &= \left(\frac{Cb_{\text{xvYCC}(N)}}{2^{N-8}} - 128 \right) / 224 \\[2mm]
Cr' &= \left(\frac{Cr_{\text{xvYCC}(N)}}{2^{N-8}} - 128 \right) / 224
\end{aligned}
\tag{9}
$$

For xvYCC$_{601}$ encoding, the non-linear Y', Cb', Cr' values are transformed to the non-linear R', G', B' values as follows:

$$
\begin{bmatrix} R' \\ G' \\ B' \end{bmatrix} =
\begin{bmatrix}
1,000\ 0 & 0,000\ 0 & 1,402\ 0 \\
1,000\ 0 & -0,344\ 1 & -0,714\ 1 \\
1,000\ 0 & 1,772\ 0 & 0,000\ 0
\end{bmatrix}
\begin{bmatrix} Y'_{601} \\ Cb'_{601} \\ Cr'_{601} \end{bmatrix}
\tag{10}
$$

NOTE   The possible range for non-linear R'G'B'$_{(601)}$ calculated from, for example, equation (10) will be between -1,0732 and 2,0835.

For xvYCC$_{709}$ encoding, the non-linear Y', Cb', Cr' values are transformed to the non-linear R', G', B' values as follows:

$$
\begin{bmatrix} R' \\ G' \\ B' \end{bmatrix} =
\begin{bmatrix}
1,000\ 0 & 0,000\ 0 & 1,574\ 8 \\
1,000\ 0 & -0,187\ 3 & -0,468\ 1 \\
1,000\ 0 & 1,855\ 6 & 0,000\ 0
\end{bmatrix}
\begin{bmatrix} Y'_{709} \\ Cb'_{709} \\ Cr'_{709} \end{bmatrix}
\tag{11}
$$

NOTE   The possible range for non-linear R'G'B'$_{(709)}$ calculated from, for example, equation (11) will be between -1,1206 and 2,1305.

The non-linear R', G', B' values are then transformed to linear R, G, B values as follows.

If $R', G', B' \leq -0{,}081$

$$R = -\left(\frac{R' - 0{,}099}{-1{,}099}\right)^{\frac{1}{0{,}45}}$$

$$G = -\left(\frac{G' - 0{,}099}{-1{,}099}\right)^{\frac{1}{0{,}45}} \qquad (12)$$

$$B = -\left(\frac{B' - 0{,}099}{-1{,}099}\right)^{\frac{1}{0{,}45}}$$

If $-0{,}081 < R', G', B' < 0{,}081$

$$R = R'/4{,}50$$
$$G = G'/4{,}50 \qquad (13)$$
$$B = B'/4{,}50$$

If $R', G', B' \geq 0{,}081$

$$R = \left(\frac{R' + 0{,}099}{1{,}099}\right)^{\frac{1}{0{,}45}}$$

$$G = \left(\frac{G' + 0{,}099}{1{,}099}\right)^{\frac{1}{0{,}45}} \qquad (14)$$

$$B = \left(\frac{B' + 0{,}099}{1{,}099}\right)^{\frac{1}{0{,}45}}$$

The linear R, G, B values are transformed to CIE 1931 XYZ values as follows:

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 0{,}412\ 4 & 0{,}357\ 6 & 0{,}180\ 5 \\ 0{,}212\ 6 & 0{,}715\ 2 & 0{,}072\ 2 \\ 0{,}019\ 3 & 0{,}119\ 2 & 0{,}950\ 5 \end{bmatrix} \begin{bmatrix} R \\ G \\ B \end{bmatrix} \qquad (15)$$

NOTE   When the capturing device performs dynamic range compression of the brighter-than-white (for example, specular) components, the compressed colours will be displayed at the top-end range of the "reference" display as described in Annex C. In this case, the XYZ tristimulus values of the compressed components represent the colorimetry of the rendered scene, not the colorimetry of the original scene.

5.3 Transformation from CIE 1931 XYZ values to xvYCC values

The CIE 1931 XYZ values can be transformed to linear R, G, B values as follows:

$$\begin{bmatrix} R \\ G \\ B \end{bmatrix} = \begin{bmatrix} 3,241\,0 & -1,537\,4 & -0,498\,6 \\ -0,969\,2 & 1,876\,0 & 0,041\,6 \\ 0,055\,6 & -0,204\,0 & 1,057\,0 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix} \tag{16}$$

In the xvYCC encoding process, negative RGB tristimulus values and RGB tristimulus values greater than 1,0 are retained.

The linear R, G, B values are then transformed to non-linear R', G', B' values as follows.

If $R, G, B \leq -0,018$,

$$\begin{aligned} R' &= -1,099 \times (-R)^{0,45} + 0,099 \\ G' &= -1,099 \times (-G)^{0,45} + 0,099 \\ B' &= -1,099 \times (-B)^{0,45} + 0,099 \end{aligned} \tag{17}$$

If $-0,018 < R, G, B < 0,018$,

$$\begin{aligned} R' &= 4,50 \times R \\ G' &= 4,50 \times G \\ B' &= 4,50 \times B \end{aligned} \tag{18}$$

If $R, G, B \geq 0,018$,

$$\begin{aligned} R' &= 1,099 \times (R)^{0,45} - 0,099 \\ G' &= 1,099 \times (G)^{0,45} - 0,099 \\ B' &= 1,099 \times (B)^{0,45} - 0,099 \end{aligned} \tag{19}$$

The relationship between non-linear R', G', B' and xvYCC$_{601}$ is defined as follows:

$$\begin{bmatrix} Y'_{601} \\ Cb'_{601} \\ Cr'_{601} \end{bmatrix} = \begin{bmatrix} 0,299\,0 & 0,587\,0 & 0,114\,0 \\ -0,168\,7 & -0,331\,3 & 0,500\,0 \\ 0,500\,0 & -0,418\,7 & -0,081\,3 \end{bmatrix} \begin{bmatrix} R' \\ G' \\ B' \end{bmatrix} \tag{20}$$

The relationship between non-linear R', G', B' and xvYCC$_{709}$ is defined as follows:

$$\begin{bmatrix} Y'_{709} \\ Cb'_{709} \\ Cr'_{709} \end{bmatrix} = \begin{bmatrix} 0,212\,6 & 0,715\,2 & 0,072\,2 \\ -0,114\,6 & -0,385\,4 & 0,500\,0 \\ 0,500\,0 & -0,454\,2 & -0,045\,8 \end{bmatrix} \begin{bmatrix} R' \\ G' \\ B' \end{bmatrix} \tag{21}$$

NOTE   If the capturing device is capable of storing Y' greater than 238/219 (or 1,086 758), dynamic range compression can be performed at this stage. Please refer to Annex A for the descriptions.

and quantization for xvYCC for 24-bit encoding (8-bit/channel) is defined as: