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# Continuous-tone colour representation method for facsimile

ITU-T Recommendation T.42

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## Continuous-tone colour representation method for facsimile


### Summary

This Recommendation defines a colour data representation method in order to make it possible to interchange continuous-tone colour image data over facsimile communication services such as Group 4 and Group 3 facsimile. CIELAB space is selected as the basic colour space mainly for hard copy (printed) application. CIE Illuminant D50 and its perfectly diffuse reflecting white point ($X_0 = 96.422$; $Y_0 = 100.000$; $Z_0 = 82.521$) is selected as the basic illuminant and white point respectively. The default gamut range chosen is L* = [0, 100], a* = [–85, 85], b* = [–75, 125]. The exact expression is in terms of offset and range. The YCC space based on sYCC is selected also as the basic color space mainly for soft copy (displayed) application. CIE illuminant D65 and its perfectly diffuse reflecting white point ($X_0 = 95.045$; $Y_0 = 100.000$; $Z_0 = 108.892$) is the illuminant and white point respectively. The default gamut is chosen is Y = [0, 1], Cb = [–0.5, 0.5], Cr = [–0.5, 0.5]. The exact expression is in terms of offset and range.

The main difference from the previous version is the following:

– ITU-YCC addition.



### Source

ITU-T Recommendation T.42 was approved by ITU-T Study Group 16 (2001-2004) under the ITU-T Recommendation A.8 procedure on 14 July 2003.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementors are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database.

**CONTENTS**


| | | Page |
|---|---|---|
| 1 | Scope | 1 |
| 2 | Field of application | 1 |
| 3 | References | 1 |
| 4 | Definitions | 1 |
| 5 | Conventions | 2 |
| 6 | Colour representation model | 2 |
| | 6.1 Overview | 2 |
| | 6.2 Colour representation recommendation | 2 |
| 7 | Colour reproduction information | 5 |
| Appendix I – Method for colorimetric calculation from spectral measurement | | 6 |
| Appendix II – Calculation of CIELAB real values from CIE XYZ values | | 10 |
| Appendix III – Calculation of ITU-YCC real values from CIE XYZ values | | 10 |

# ITU-T Recommendation T.42

## Continuous-tone colour representation method for facsimile

### 1 Scope

**1.1** This Recommendation defines a continuous-tone colour data representation method in order to make it possible to interchange continuous-tone colour image data over a facsimile communication service such as Group 4 or Group 3 facsimile.

Its purpose is to specify a colour space, reference white point, illuminant type, gamut range, and colour reproduction information for the interchange of colour data.

**1.2** This Recommendation, together with documents such as clauses of ITU-T Recs T.4 and T.30, or T.563, T.503 and T.521, will define a colour image data format that may be used by colour facsimile service and by other telematic services.

### 2 Field of application

**2.1** This Recommendation defines a colour data representation method which enables a receiver to reproduce colour image data as specified by the sender. The basic values are for hard copy (printed) colour image data and for soft copy (displayed) colour image data.

**2.2** It is assumed that when a service is performed using this Recommendation, all non-basic features are subject to negotiation.

### 3 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.


– CIE Publication No. 15.2 (1986), *Colorimetry*, Second edition.

– ISO 5-1 to 5-4 (1984-2001), *Photography – Density measurements*.

– ISO 13655:1996, *Graphic technology – Spectral measurement and colorimetric computation for graphic arts images*.

– IEC 61966-2-1 (1999) Amd.1 Ed. 1.0 (2003), *Multimedia systems and equipment – Colour measurement and management – Part 2-1: Colour management – Default RGB colour space – sRGB*.


### 4 Definitions

The definitions in ITU-T Rec. T.411 apply to this Recommendation.

The definitions in CIE Publication No. 15.2 apply to this Recommendation.

The definitions in IEC 61966-2-1 Amd.1 Ed. 1.0 Annex F apply to this Recommendation.

This Recommendation defines the following terms:

**4.1** **CIELAB**: This refers to 1976 CIE L*a*b* colour space.

**4.2** **ITU-YCC**: This refers to sYCC in IEC 61966-2-1 Amd.1 Ed. 1.0, Annex F.

## 5 Conventions

The conventions in CIE Publication No. 15.2 apply to this Recommendation.

The conventions in the part of IEC 61966-2-1 Amd.1 Ed. 1.0, Annex F, apply to this Recommendation

The conventions in ISO 13655 apply to this Recommendation.

## 6 Colour representation model

### 6.1 Overview

In order to represent continuous-tone colour data accurately and uniquely, a device-independent interchange colour space is needed. This colour image space should encode the range of hard copy image data the range of soft copy image data.

The following represents an example for the use of this model: a Sender scans an original colour image using a specific device-dependent colour space which may depend on the illuminant and/or filters of a particular scanner system. The Sender converts the device-dependent colour data to the interchange colour representation. The Sender then encodes the data using a coding algorithm such as ITU-T Rec. T.81 (JPEG). The Receiver receives the encoded data. The data is decoded and converted to the colour space which is device dependent.

In order to define the colour representation, it is necessary to specify the white point, illuminant and gamut range used in the interchange data representation.

Certain additional information for better and/or more desirable colour reproduction may optionally be specified.

### 6.2 Colour representation recommendation

#### 6.2.1 CIELAB space

##### 6.2.1.1 Colour space specification

In this Recommendation, CIELAB space is the basic value mainly for hard copy (printed) colour image.

Conversion from spectral measurement data to CIE XYZ is defined in ISO 13655. (See Appendix I.)

Conversion from CIE XYZ colour space to CIELAB real values is the same as that defined in CIE Publication No. 15.2. (See Appendix II.)

White point and illuminant data, and gamut range are specified in 6.2.1.2 and 6.2.1.3.

##### 6.2.1.2 White point and illuminant data

CIE Illuminant D50 and its perfectly diffuse reflecting white point ($X_0 = 96.422$; $Y_0 = 100.000$; $Z_0 = 82.521$) are the basic values. Other illuminants and/or white points are optional and must be negotiated before use. Optional values are for further study.

#### 6.2.1.3 Gamut range

The basic gamut range is chosen to span the union of available hard copy device gamuts as observed under D50 illumination. This range is as follows, with the exact definition expressed below:

$L^* = [0, 100]$

$a^* = [-85, 85]$

$b^* = [-75, 125]$

The gamut range is expressed as an OFFSET in the communication space and a RANGE, with the exception of the minimum and maximum values, which are explicitly defined in the definitions above.

The calculations from real values $L^*a^*b^*$ to $n_L n_a n_b$ bit integers, which are expressed by $N_L N_a N_b$, are made as follows:

$N_L = [(2^{**}n_L - 1)/RANGE_L] \times L^* + OFFSET_L$

$N_a = [(2^{**}n_a - 1)/RANGE_a] \times a^* + OFFSET_a$

$N_b = [(2^{**}n_b - 1)/RANGE_b] \times b^* + OFFSET_b$

The RANGE, OFFSET pairs for basic range L*, a* and b* for the case where $N_L N_a N_b$ are $n_L n_a n_b$ bit integers are:

| Variable | Range | Offset |
|---|---|---|
| $L^*$ | 100.00 | 0 |
| $a^*$ | 170.00 | $2^{**}(n_a - 1)$ |
| $b^*$ | 200.00 | $2^{**}(n_b - 2) + 2^{**}(n_b - 3)$ |

In the case of eight-bit values, the calculations are as follows for the basic range:

$N_L = \text{round}\ [(255./100.) \times L^*]$

$N_a = \text{round}\ [(255./170.) \times a^* + 128.]$

$N_b = \text{round}\ [(255./200.) \times b^* + 96.]$

In the case of twelve-bit values, the calculations are as follows for the basic range:

$N_L = \text{round}\ [(4095./100.) \times L^*]$

$N_a = \text{round}\ [(4095./170.) \times a^* + 2048.]$

$N_b = \text{round}\ [(4095./200.) \times b^* + 1536.]$

Other gamut range values are optional and must be negotiated before use.

For example, the following optional range:

$L^* = [0, 100]$

$a^* = [-128, 127]$

$b^* = [-128, 127]$

would be expressed using range and offset in the case of eight-bit values by:

$N_L = \text{round}\ [(255./100.) \times L^*]$

$N_a = \text{round}\ [(255./255.) \times a^* + 128.]$

$N_b = \text{round}\ [(255./255.) \times b^* + 128.]$

Note that values of L* greater than 100 are not disallowed, but are not in general reproducible, as they correspond to colours which may be produced by fluorescence or specular reflection in the hard copy case. In the soft copy case, tristimulus values X, Y, Z of image data shall be scaled under the condition that the maximum Y should not be over 100. Usually, the maximum of a monitor or an image may be used for the scaling. Values of L* less than 0 have no physical meaning.

In addition, values of a* outside the range [–500, 500] and values of b* outside the range [–200, 200] are not representable from X, Y, Z tristimulus values, and have no meaning.

### 6.2.2 ITU-YCC space

#### 6.2.2.1 Colour space specification

In this Recommendation, ITU-YCC space is the basic value mainly for soft copy (displayed) color image data.

Conversion from spectral measurement data to CIE XYZ is defined in ISO 13655. (See Appendix I.)

Conversion from CIE XYZ colour space to ITU-YCC real values is the same as that defined in IEC 61966-2-1 Amd.1 Ed. 1.0, Annex F. (See Appendix III.)

White point and illuminant data, and gamut range are specified in 6.2.2.2 and 6.2.2.3.

#### 6.2.2.2 White point and illuminant data

CIE Illuminant D65 and its perfectly diffuse reflecting white point ($X_0 = 95.045$; $Y_0 = 100.000$; $Z_0 = 108.892$) are the basic values. Other illuminants and/or white points are not permitted for ITU-YCC.

#### 6.2.2.3 Gamut range

The basic gamut range is as follows, with the exact definition expressed below:

$$Y = [0, 1]$$

$$Cb = [-0.5, 0.5]$$

$$Cr = [-0.5, 0.5]$$

The gamut range is expressed as an OFFSET in the communication space and a RANGE, with the exception of the minimum and maximum values, which are explicitly defined in the definitions above.

The calculations from real values YCbCr to $n_Y n_{Cb} n_{Cr}$ bit integers, which are expressed by $N_Y N_{Cb} N_{Cr}$, are made as follows:

$$N_Y = [(2^{**}n_L - 1)/RANGE_Y] \times Y + OFFSET_Y$$

$$N_{Cb} = [(2^{**}n_a - 1)/RANGE_{Cb}] \times Cb + OFFSET_{Cb}$$

$$N_{Cr} = [(2^{**}n_b - 1)/RANGE_{Cr}] \times Cr + OFFSET_{Cr}$$

The RANGE, OFFSET pairs for basic range Y, Cb and Cr for the case where $N_Y N_{Cb} N_{Cr}$ are $n_Y n_{Cb} n_{Cr}$ bit integers are:

| Variable | Range | Offset |
|---|---|---|
| Y | 1.00 | 0 |
| Cb | 1.00 | $2^{**}(n_{Cb} - 1)$ |
| Cr | 1.00 | $2^{**}(n_{Cr} - 1)$ |

In the case of eight-bit values, the calculations are as follows for the basic range:

$N_Y$ = round[(255./1.) × Y]

$N_{Cb}$ = round[(255./1.) × Cb + 128.]

$N_{Cr}$ = round[(255./1.) × Cr + 128.]

Other gamut range values are optional and must be negotiated before use.

For example, the following optional range:

Y = [0, 1.0]

Cb = [–1.0, 1.0]

Cr = [–1.0, 1.0]

would be expressed using range and offset in the case of ten-bit values by:

$N_Y$ = round[(1023./1.) × Y]

$N_{Cb}$ = round[(1023./2.) × Cb + 512.]

$N_{Cr}$ = round[(1023./2.) × Cr + 512.]

## 7 Colour reproduction information

Colour reproduction information may be optionally provided, in addition to absolute values (CIELAB values or ITU-YCC values) for colour image data. This information may be used for better and/or more desirable colour reproduction. This information is described in Table 1. Colour reproduction information is a non-basic feature.

**Table 1/T.42 – Colour reproduction information list**

| No. | From Receiver to Sender | From Sender to Receiver | Type of data |
|---|---|---|---|
| 1 | Device White<br>(Paper white for hard copy, display white for soft copy) | Original (Note)<br>White | CIELAB or<br>ITU-YCC |
| 2 | Device Black<br>(Cyan + magenta + yellow or + black colorant for hard copy, display black for soft copy) | Original (Note)<br>Black | CIELAB or<br>ITU-YCC |
| 3 | Device Cyan<br>(Cyan colorant for hard copy, green + blue phosphor for soft copy) | Original (Note)<br>Cyan | CIELAB or<br>ITU-YCC |
| 4 | Device Magenta<br>(Magenta colorant for hard copy, blue + red phosphor for soft copy) | Original (Note)<br>Magenta | CIELAB or<br>ITU-YCC |
| 5 | Device Yellow<br>(Yellow colorant for hard copy, red + green phosphor for soft copy) | Original (Note)<br>Yellow | CIELAB or<br>ITU-YCC |
| 6 | Device Red<br>(Magenta + yellow colorant for hard copy, red phosphor for soft copy) | Original (Note)<br>Red | CIELAB or<br>ITU-YCC |

**Table 1/T.42 – Colour reproduction information list**

| No. | From Receiver to Sender | From Sender to Receiver | Type of data |
|---|---|---|---|
| 7 | Device Green<br>(Yellow + cyan colorant for hard copy, green phosphor for soft copy) | Original (Note)<br>Green | CIELAB or ITU-YCC |
| 8 | Device Blue<br>(Cyan + magenta colorant for hard copy, blue phosphor for soft copy) | Original (Note)<br>Blue | CIELAB or ITU-YCC |
| NOTE – Original means not restricted only to input device gamut, but sometimes corresponds to original image data gamut. | | | |

# Appendix I

## Method for colorimetric calculation from spectral measurement

The following is a brief synopsis of the material presented in ISO 13655, *Graphic technology – Spectral measurement and colorimetric computation for graphic arts images*.

The data shall be measured from at least 400 nm to at least 700 nm inclusive, at not greater than 20-nm intervals. The reference for spectral data shall be based on computed data at 10-nm intervals where the spectral function is triangular with a 10-nm bandwidth at the half-power point. The measurements will be made with a sample mounted on a back backing, as defined by ISO 5, Part 4, subclause 4.7 The reflectance measurement geometry will be 45/0 or 0/45 as defined in ISO 5, Part 4. The measurement resolution shall be to the nearest 0.01% relative to a perfectly diffuse reflector.

The tristimulus values of the reference white under D50 illumination will be defined as $X_0 = 96.422$; $Y_0 = 100.000$ and $Z_0 = 82.521$. The spectral weights for illuminant D50 and 2° observer are given in Table I.1.

The tristimulus values of the reference white under D65 illumination will be defined as $X_0 = 95.045$; $Y_0 = 100.000$; and $Z_0 = 108.892$. The spectral weights for illuminant D65 and 2° observer are given in Table I.2.

These weights, Wx, Wy and Wz, will be used in the following manner to derive the tristimulus values:

$$X = \sum_{\lambda} \left( R(\lambda) Wx(\lambda) \right)$$

summed over λ ranging from 360 to 780 nm. R is the reflectance value as a function of wave length (λ).

**Table I.1/T.42 – Spectral weights (W) for illuminant D50 and 2° observer for calculating tristimulus values at 10-nm intervals**

| Wavelength (nm) | W(X) | W(Y) | W(Z) |
|---|---|---|---|
| 360 | 0.000 | 0.000 | 0.001 |
| 370 | 0.001 | 0.000 | 0.005 |
| 380 | 0.003 | 0.000 | 0.013 |
| 390 | 0.012 | 0.000 | 0.057 |
| 400 | 0.060 | 0.002 | 0.285 |
| 410 | 0.234 | 0.006 | 1.113 |
| 420 | 0.775 | 0.023 | 3.723 |
| 430 | 1.610 | 0.066 | 7.862 |
| 440 | 2.453 | 0.162 | 12.309 |
| 450 | 2.777 | 0.313 | 14.647 |
| 460 | 2.500 | 0.514 | 14.346 |
| 470 | 1.717 | 0.798 | 11.299 |
| 480 | 0.861 | 1.239 | 7.309 |
| 490 | 0.283 | 1.839 | 4.128 |
| 500 | 0.040 | 2.948 | 2.466 |
| 510 | 0.088 | 4.632 | 1.447 |
| 520 | 0.593 | 6.587 | 0.736 |
| 530 | 1.590 | 8.308 | 0.401 |
| 540 | 2.799 | 9.197 | 0.196 |
| 550 | 4.207 | 9.650 | 0.085 |
| 560 | 5.657 | 9.471 | 0.037 |
| 570 | 7.132 | 8.902 | 0.020 |
| 580 | 8.540 | 8.112 | 0.015 |
| 590 | 9.255 | 6.829 | 0.010 |
| 600 | 9.835 | 5.838 | 0.007 |
| 610 | 9.469 | 4.753 | 0.004 |
| 620 | 8.009 | 3.573 | 0.002 |
| 630 | 5.926 | 2.443 | 0.001 |
| 640 | 4.171 | 1.629 | 0.000 |
| 650 | 2.609 | 0.984 | 0.000 |
| 660 | 1.541 | 0.570 | 0.000 |
| 670 | 0.855 | 0.313 | 0.000 |
| 680 | 0.434 | 0.158 | 0.000 |
| 690 | 0.194 | 0.070 | 0.000 |
| 700 | 0.097 | 0.035 | 0.000 |
| 710 | 0.050 | 0.018 | 0.000 |
| 720 | 0.022 | 0.008 | 0.000 |

**Table I.1/T.42 – Spectral weights (W) for illuminant D50 and 2° observer for calculating tristimulus values at 10-nm intervals**

| Wavelength (nm) | W(X) | W(Y) | W(Z) |
|---|---|---|---|
| 730 | 0.012 | 0.004 | 0.000 |
| 740 | 0.006 | 0.002 | 0.000 |
| 750 | 0.002 | 0.001 | 0.000 |
| 760 | 0.001 | 0.000 | 0.000 |
| 770 | 0.001 | 0.000 | 0.000 |
| 780 | 0.000 | 0.000 | 0.000 |
| Total | X = 96.421 | Y = 99.997 | Z = 82.524 |
| NOTE – This table is extracted from ASTM E308 – 1985. The sums are intended as check-sums for the spectral weights, and are not normative for the white point tristimulus values. | | | |

**Table I.2/T.42 – Spectral weights (W) for illuminant D65 and 2° observer for calculating tristimulus values at 10-nm intervals**

| Wavelength (nm) | W(X) | W(Y) | W(Z) |
|---|---|---|---|
| 360 | 0.000 | 0.000 | 0.000 |
| 370 | 0.000 | 0.000 | 0.001 |
| 380 | 0.001 | 0.000 | 0.003 |
| 390 | 0.002 | 0.000 | 0.010 |
| 400 | 0.011 | 0.000 | 0.053 |
| 410 | 0.038 | 0.001 | 0.180 |
| 420 | 0.119 | 0.004 | 0.571 |
| 430 | 0.233 | 0.010 | 1.136 |
| 440 | 0.346 | 0.023 | 1.733 |
| 450 | 0.372 | 0.042 | 1.962 |
| 460 | 0.324 | 0.067 | 1.861 |
| 470 | 0.212 | 0.099 | 1.399 |
| 480 | 0.105 | 0.152 | 0.892 |
| 490 | 0.033 | 0.214 | 0.479 |
| 500 | 0.005 | 0.334 | 0.281 |
| 510 | 0.009 | 0.513 | 0.161 |
| 520 | 0.063 | 0.704 | 0.078 |
| 530 | 0.169 | 0.878 | 0.043 |
| 540 | 0.287 | 0.943 | 0.020 |
| 550 | 0.427 | 0.980 | 0.009 |
| 560 | 0.563 | 0.942 | 0.004 |
| 570 | 0.695 | 0.868 | 0.002 |
| 580 | 0.831 | 0.789 | 0.001 |

**Table I.2/T.42 – Spectral weights (W) for illuminant D65 and 2° observer for calculating tristimulus values at 10-nm intervals**

| Wavelength (nm) | W(X) | W(Y) | W(Z) |
|---|---|---|---|
| 590 | 0.861 | 0.635 | 0.001 |
| 600 | 0.905 | 0.537 | 0.001 |
| 610 | 0.850 | 0.426 | 0.000 |
| 620 | 0.709 | 0.316 | 0.000 |
| 630 | 0.506 | 0.209 | 0.000 |
| 640 | 0.355 | 0.139 | 0.000 |
| 650 | 0.215 | 0.081 | 0.000 |
| 660 | 0.125 | 0.046 | 0.000 |
| 670 | 0.068 | 0.025 | 0.000 |
| 680 | 0.035 | 0.013 | 0.000 |
| 690 | 0.015 | 0.005 | 0.000 |
| 700 | 0.008 | 0.003 | 0.000 |
| 710 | 0.004 | 0.001 | 0.000 |
| 720 | 0.002 | 0.001 | 0.000 |
| 730 | 0.001 | 0.000 | 0.000 |
| 740 | 0.000 | 0.000 | 0.000 |
| 750 | 0.000 | 0.000 | 0.000 |
| 760 | 0.000 | 0.000 | 0.000 |
| 770 | 0.000 | 0.000 | 0.000 |
| 780 | 0.000 | 0.000 | 0.000 |
| Total | 95.020 | 100.000 | 108.822 |
| NOTE – This table is extracted from ASTM E308 – 1985. The sums are intended as check-sums for the spectral weights, and are not normative for the white point tristimulus values. | | | |

## Appendix II

## Calculation of CIELAB real values from CIE XYZ values

The CIELAB real values are calculated from the tristimulus values X, Y, Z, where X, Y and Z represent the tristimulus values as measured using the procedure of Appendix I. $X_n$, $Y_n$ and $Z_n$ are tristimulus values from the reference white.

Using these values:

$$L^* = 116\,(Y/Y_n)^{1/3} - 16 \qquad \text{for } Y/Y_n > 0.008856$$

$$L^* = 903.3\; Y/Y_n \qquad \text{for } Y/Y_n \leq 0.008856$$

$$a^* = 500\,[(X/X_n)^{1/3} - (Y/Y_n)^{1/3}]$$

$$b^* = 200\,[(Y/Y_n)^{1/3} - (Z/Z_n)^{1/3}]$$

In addition, if any of the ratios $X/X_n$, $Y/Y_n$ or $Z/Z_n$ is equal to or less than 0.008856, it is replaced in the above formula by 7.7867F + 16/116, where F is $X/X_n$, $Y/Y_n$ or $Z/Z_n$, as the case may be.

## Appendix III

## Calculation of ITU-YCC real values from CIE XYZ values

The ITU-YCC real values are calculated from the tristimulus values X, Y, Z, where X, Y and Z represent the tristimulus values as measured using the procedure of Appendix I.

The CIE 1931 XYZ values can be transformed to non-linear sR'G'B' values as follows:

$$\begin{bmatrix} R_{\text{sRGB}} \\ G_{\text{sRGB}} \\ B_{\text{sRGB}} \end{bmatrix} = \begin{bmatrix} 3{,}240\,6 & -1{,}537\,2 & -0{,}498\,6 \\ -0{,}968\,9 & 1{,}875\,8 & 0{,}041\,5 \\ 0{,}055\,7 & -0{,}204\,0 & 1{,}057\,0 \end{bmatrix} \begin{bmatrix} X \\ Y \\ Z \end{bmatrix} \qquad \text{(III-1)}$$

For N-bits/channel encoding case, it is recommended to replace the matrix coefficient in Equation III-1 with the inverse matrix coefficients of the matrix in Equation III-2 with enough decimal digits accuracy.

$$\begin{bmatrix} X \\ Y \\ Z \end{bmatrix} = \begin{bmatrix} 0{,}412\,4 & 0{,}357\,6 & 0{,}180\,5 \\ 0{,}212\,6 & 0{,}715\,2 & 0{,}072\,2 \\ 0{,}019\,3 & 0{,}119\,2 & 0{,}950\,5 \end{bmatrix} \begin{bmatrix} R_{\text{sRGB}} \\ G_{\text{sRGB}} \\ B_{\text{sRGB}} \end{bmatrix} \qquad \text{(III-2)}$$

For example, following matrix with 6 decimal digits has enough accuracy in the case of 16-bit/channel.

$$\begin{bmatrix} R_{\text{sRGB}} \\ G_{\text{sRGB}} \\ B_{\text{sRGB}} \end{bmatrix} = \begin{bmatrix} 3{,}240\,6255 & -1{,}537\,2080 & -0{,}498\,6286 \\ -0{,}968\,9307 & 1{,}875\,7561 & 0{,}041\,5175 \\ 0{,}055\,7101 & -0{,}204\,0211 & 1{,}056\,9559 \end{bmatrix} \begin{bmatrix} \text{X} \\ \text{Y} \\ \text{Z} \end{bmatrix} \qquad \text{(III-3)}$$

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

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

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

If $-0{,}003\ 130\ 8 \leq R_{sRGB}, G_{sRGB}, B_{sRGB} \leq 0{,}003\ 1308$,

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

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

$$\begin{aligned} R'_{sRGB} &= 1{,}055 \times (-R_{sRGB})^{(1{,}0/2{,}4)} - 0{,}055 \\ G'_{sRGB} &= 1{,}055 \times (-G_{sRGB})^{(1{,}0/2{,}4)} - 0{,}055 \\ B'_{sRGB} &= 1{,}055 \times (-B_{sRGB})^{(1{,}0/2{,}4)} - 0{,}055 \end{aligned} \quad \text{(III-6)}$$

The relationship between non-linear sR'G'B' and YCC is defined as follows:

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

NOTE – The coefficients in Equation III-7 are from ITU-R Rec. BT.601-5. ITU-R Rec. BT.601-5 defines Y of YCC to a three decimal place accuracy.

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| | |
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| Series D | General tariff principles |
| Series E | Overall network operation, telephone service, service operation and human factors |
| Series F | Non-telephone telecommunication services |
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| Series H | Audiovisual and multimedia systems |
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| Series J | Cable networks and transmission of television, sound programme and other multimedia signals |
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| Series L | Construction, installation and protection of cables and other elements of outside plant |
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| Series N | Maintenance: international sound programme and television transmission circuits |
| Series O | Specifications of measuring equipment |
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| Series Q | Switching and signalling |
| Series R | Telegraph transmission |
| Series S | Telegraph services terminal equipment |
| **Series T** | **Terminals for telematic services** |
| Series U | Telegraph switching |
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