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SERIES H: AUDIOVISUAL AND MULTIMEDIA SYSTEMS

Infrastructure of audiovisual services – Coding of moving
video

**Procedures and values for video gamma
compensation in multimedia systems**

ITU-T Recommendation H.272



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ITU-T Recommendation H.272

Procedures and values for video gamma compensation in multimedia systems

Summary

This Recommendation provides guidance on default gamma correction values and gamma compensation procedures for use in multimedia systems (such as video conferencing and video telephony systems) where the treatment of video gamma is not otherwise specified. The recommended values and procedures are consistent with those of [ITU-R BT.709-5].

Source

ITU-T Recommendation H.272 was approved on 13 January 2007 by ITU-T Study Group 16 (2005-2008) under the ITU-T Recommendation A.8 procedure.

FOREWORD

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ITU-T Recommendation H.272

Procedures and values for video gamma compensation in multimedia systems

1 Scope

This Recommendation addresses procedures and values for video gamma compensation in multimedia systems (such as video conferencing and video telephony systems) in cases where a gamma correction function is not otherwise specified.

2 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.

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

3 Definitions

This Recommendation defines the following term:

3.1 gamma: The exponent used in an opto-electronic input-output relationship transfer characteristics equation between a video signal level used to stimulate a visual display element and the intensity of the resulting light, ordinarily based on red, green and blue display element components. Alternatively, gamma can be used to describe the input-output relationship between the intensity of a source colour component and the corresponding video signal level generated from a camera sensor. The relationship is generally approximately exponential, with the brightness of a display element within a scaled nominal range from 0 to 1 being approximately proportional to the signal level input to the display within a scaled nominal range from 0 to 1, raised to an exponent gamma. The actual ideal opto-electronic transfer characteristics that are informally referred to by the exponent gamma may differ somewhat from an exponential input-output relationship, especially in the range near zero. However, such a functional relationship is often still referred to as "gamma".

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

CRT Cathode Ray Tube

MCU Multipoint Control Unit

NTSC National Television Standards Committee

PAL Phase Alternating Line

5 Conventions

The word "shall" is used in this Recommendation to specify a mandatory requirement.

The word "should" is used in this Recommendation to specify a suggested, but not required, course of action.

The word "may" is used in this Recommendation to specify an optional course of action, without expressing a preference.

6 Introduction

The proper interpretation and display of coded video material requires knowledge of the colour space characteristics of the decoded video.

A complete colour space definition for digital video representation may include specification of the following aspects:

- The chromaticity coordinates of the source colour primaries (ordinarily referred to as red, green and blue, or R , G and B) and reference white point.
- The opto-electronic transfer characteristics (i.e., *gamma*) of the source components (e.g., definition of E'_R , E'_G and E'_B as a function of R , G and B).
- Matrix coefficients for transformation of the RGB components into luma and chroma components (e.g., definition of components E'_Y , E'_{PB} and E'_{PR} as a function of E'_R , E'_G and E'_B).
- Definition of scaling, offsets, and quantization for digital representation.
- A gamut boundary definition specifying the range of values over which effective representations of colours can be achieved.

7 Gamma for multimedia systems

A key aspect of the colour representation system is the opto-electronic transfer characteristics, which are informally referred to as *gamma*. Gamma can be used to describe the input-output relationship between the video signal level used to stimulate a display element and the intensity of the resulting light. Alternatively, gamma can be used to describe the input-output relationship between the intensity of a source colour component and the corresponding video signal level generated from a camera sensor.

The relationship is generally non-linear, with the brightness of a display element within a scaled nominal range from 0 to 1 being approximately proportional to the signal level input to the display within a scaled nominal range from 0 to 1, raised to an exponent gamma.

Typical displays, for example those intended to reproduce the [ITU-R BT.709-5] signal format recommended by the ITU-R, use a gamma exponent of approximately 1/0.45 (approximately 2.2). To compensate for this non-linearity, typical video cameras apply a gamma pre-correction on their output signal, using a gamma of approximately 0.45. The ideal opto-electronic transfer characteristics that are informally referred to by the exponent gamma differ somewhat from this exponential input-output relationship, especially in the range near zero. The exact opto-electronic transfer characteristics equation specified for such use is typically that specified in clause 1.2 of [ITU-R BT.709-5].

In order to ensure that the colour intensities are consistently signalled to the decoder, encoded video transmitted by a terminal should thus use a gamma of 0.45. A different value may be used if explicitly specified, given as a default value, negotiated, or, in the case that the decoding system has signalled the ability to display an indicated gamma value, indicated.

If the video input source (camera, playback device, etc.) provides a video signal with a different gamma, a gamma correction functional module should be inserted between the video source and video encoder to correct the gamma of the output from the video source to a value of 0.45 before encoding, as illustrated in Figure 1 below. A different value may be used if explicitly specified, given as a default value, negotiated, or, in the case that the decoding system has signalled the ability to display an indicated gamma value, indicated.

Decoded video should be assumed to have a gamma of 0.45 unless a different value is explicitly specified, given as a default value, negotiated, or indicated. Herein, the phrase "gamma of 0.45" is intended to refer to the opto-electronic transfer characteristics equation specified in clause 1.2 of [ITU-R BT.709-5].

If the terminal's video display has a gamma other than 1/0.45 (approximately 2.2), a gamma correction functional module may be inserted between the video decoder and the display to correct the video signal gamma to a value of 1/(display gamma) before display, as illustrated in Figure 1.

NOTE 1 – In some cases, for example to compensate for the ambient illumination level at the display location, a different display gamma may be desirable.

In the case of display of locally captured video, the gamma of the camera output and display input should also be corrected as described above.

NOTE 2 – The method used for gamma pre-correction by the gamma correction function is left to implementers, but in many cases a look-up table with 256 or 1024 values for each of the *R*, *G* and *B* channels of video will be sufficient.

NOTE 3 – If both terminals in Figure 1 correct gamma as described in this Recommendation, the brightness of the display elements will be proportional to the brightness of the video source. In practice, some terminals will not fully correct gamma. If only one terminal corrects gamma, only partial gamma correction will be achieved.

NOTE 4 – Video signals generated according to NTSC specifications (see Part A of [b-ITU-R BT.1700]) are specified as using a gamma value of 0.45 already, and therefore do not require the application of an additional gamma correction function.

NOTE 5 – Video signals generated according to PAL specifications (see Part B of [b-ITU-R BT.1700]) are currently specified as using a gamma value of 1/2.8. However, professional television broadcast cameras used for SDTV and HDTV typically use a gamma value of 0.45 with slight variations; the older 1/2.8 specified value no longer being in current use.

NOTE 6 – [b-ITU-T H.261] and [b-ITU-T H.263] refer only to [b-ITU-R BT.601] for definition of the colour space used for video representation. [b-ITU-R BT.601] did not actually specify a gamma correction function until its 2007 version. The gamma value of 0.45 is specified in the 2007 version of [b-ITU-R BT.601], and it represents typical current industry practice for source acquisition using that Recommendation. Thus, if source acquisition is conducted using some other gamma value, a gamma correction function should be applied prior to the encoding process for [b-ITU-T H.261] or [b-ITU-T H.263] use in the absence of some means for encoder-decoder negotiation of the use of a different gamma function.

NOTE 7 – [b-ITU-T H.262] and [b-ITU-T H.264] provide a `transfer_characteristics` syntax element by which means an encoder may indicate the gamma pre-correction applied to the source video. However, these Recommendations do not require the `transfer_characteristics` syntax element to be present in all video bitstreams and specify that the default interpretation to be inferred in the absence of the use of the `transfer_characteristics` syntax element for this purpose is to be determined by the application. Thus, in the absence of the use of the `transfer_characteristics` syntax element and in the absence of other system-specified default values, negotiations or indicators, the inferred value for use in multimedia systems (such as video conferencing and video telephony systems) should be 0.45 for [b-ITU-T H.262] and [b-ITU-T H.264] use.

The gamma exponential non-linearity arises from voltage conversion for CRT displays. This occurs in the red, green and blue signal domain, such that applying gamma creates units proportional to light output. Applying 1/gamma creates units proportional to CRT drive voltage. Therefore, in a system such as that shown in Figure 1, the gamma correction function should be applied in the red, green, and blue signal domain. Signals in transformed alternative signal domains, such as signals using luminance and colour difference representations, should be converted to the red, green and blue signal domain prior to the application of a gamma correction function.

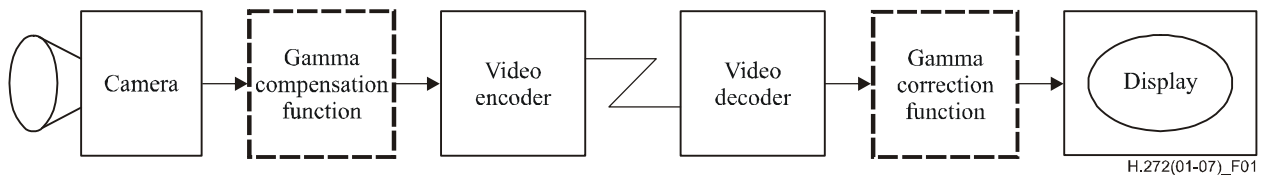


Figure 1 – Gamma compensation and gamma correction

7.1 Video signal composition from multiple video sources

In the case of a multipoint control unit (MCU) or other intermediate video processing device which composes an output video signal from more than one received video source, the device should check if the video signal gamma of the received video signals differs from each other. If so, the device should perform gamma correction to ensure that the gamma of the received video sources is adjusted to a common value before composing the output video signal.

Bibliography

- [b-ITU-T H.261] ITU-T Recommendation H.261 (1993), *Video codec for audiovisual services at $p \times 64$ kbit/s*.
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