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| *Title:* | **NHK’s proposal for an extended image dynamic range television (EIDRTV) system** | | |
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| *Purpose:* | Proposal | | |
| *Author(s) or Contact(s):* | M. Sugawara, Y. Kusakabe, Y. Nishida,  A. Ichigaya 1-10-11 Kinuta, Setagaya-ku Tokyo 157-8510 Japan | Tel: Email: | +81-3-5494-3101 sugawara.m-fq@nhk.or.jp kusakabe.y-ee@nhk.or.jp nishida.y-fe@nhk.or.jp ichigaya.a-go@nhk.or.jp |
| *Source:* | NHK (Japan Broadcasting Corporation) | | |

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# Abstract

This document presents NHK’s proposed parameter values for an extended image dynamic range (EIDRTV) system in order to meet the requirements for EIDRTV systems identified by ITU-R Working Party 6C. The proposed parameter values can be regarded as a simple extension to those for ultra high definition television (UHDTV) systems specified in Recommendation ITU-R BT.2020. Only the nonlinear transfer function for relative scene luminance to video (OETF) has been modified associated with a new parameter “reference white level” to accommodate higher dynamic range images without changing the display’s nonlinear transfer function (EOTF). A new entry to transfer characteristics of VUI parameter values is also proposed to signal the proposed EIDRTV.

# Introduction

Image systems with higher dynamic range and wider color gamut have been studying around the world and international standardization is also under way. MPEG has been studying implications of such systems on video coding systems and ITU-R has been studying baseband video systems.

This document presents NHK’s proposed parameter values for an extended image dynamic range (EIDRTV) system. Since our system has been proposed to ITU-R, the same terminology as used by ITU-R Working Party 6C is used in this document.

# Proposal for EIDRTV system parameters

## Requirements for EIDRTV systems

We used the following four major requirements for EIDRTV systems identified by ITU-R WP 6C to determine the proposed parameter values.

*Req. 1 The system should be capable of producing a “step-change” improvement in viewer experience which can substantially increase brightness and detail in highlights, increase brightness and detail for diffuse reflecting objects while providing good detail in dark areas.*

*Req. 2 The system should have, where appropriate, a degree of compatibility with existing workflows and broadcaster (legacy) infrastructure.*

*Req. 3 The system should be applicable to a range of domestic viewing environments, preference and displays (including mobile and tablets) and be cost effective for both consumers and broadcasters.*

*Req. 4 The system should have a defined reference display and viewing environment in order that there is consistency of images that are produced.Image systems with higher dynamic range and wider color gamut have been studying around the world.*

## Proposed EIDRTV system parameter values

A set of proposed parameter values is shown in Tables 1 through 4. We anticipate that EIDRTV will be introduced as an extension of UHDTV including 4K and 8K systems. In this respect, Tables 1, 2, 3 and 5 show the systems parameter values more or less identical to those specified in Recommendation ITU-R BT.2020. In Table 4, only the nonlinear transfer function has been modified associated with a new parameter “reference white level” to accommodate higher dynamic range images.

TABLE 1

Picture spatial characteristics

|  |  |
| --- | --- |
| Parameter | Values |
| Picture aspect ratio | 16:9 |
| Pixel count  (horizontal × vertical) | 7 680 × 4 320  3 840 × 2 160 |
| Sampling lattice | Orthogonal |
| Pixel aspect ratio | 1:1 (square pixels) |
| Pixel addressing | Pixel ordering in each row is from left to right, and rows are ordered from top to bottom. |

TABLE 2

Picture temporal characteristics

|  |  |
| --- | --- |
| Parameter | Values |
| Frame frequency (Hz) | 120, 120/1.001, 100, 60, 60/1.001, 50, 48, 48/1.001, 30, 30/1.001, 25, 24, 24/1.001 |
| Scan mode | Progressive |

TABLE 3

System colorimetry

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Values | | |
| Opto-electronic transfer characteristics before non-linear pre-correction | Assumed linear 1 | | |
| Primary colours and reference white 2 | Chromaticity coordinates (CIE, 1931) | x | y |
| Red primary (R) | 0.708 | 0.292 |
| Green primary (G) | 0.170 | 0.797 |
| Blue primary (B) | 0.131 | 0.046 |
| Reference white (D65) | 0.3127 | 0.3290 |
| 1 Picture information can be linearly indicated by the tristimulus values of RGB in the range of 0-1.  2 The colorimetric values of the picture information can be determined based on the reference RGB primaries and the reference white. | | | |

TABLE 4

Signal format

|  |  |
| --- | --- |
| Parameter | Values |
| Transfer characteristics before non-linearity | Assumed linear light |
| Signal format | *R'G'B'* or Non-constant luminance *Y'C'BC'R* |
| Video level for reference white level, *r* 1 | [0.5] |
| Non-linear transfer function 2, 3 | where  is relative scene luminance level normalized by reference white luminance level, and *E'* is resulting non-linear signal.  *α* and *β* are solutions to following simultaneous equations:    The simultaneous equations provide the condition required to connect two curve segments smoothly and yield *α* = 1.09929682680944... and *β* = 0.018053968510807.... For practical purposes, following values can be used:  *α* = 1.099 and *β* = 0.018 for 10-bit systems  *α* = 1.0993 and *β* = 0.0181 for 12‑bit systems |
| Derivation of *Y’* |  |
| Derivation of colour difference signals |  |
| 1 When *r* = 0.5, the peak luminance level is about 6.4 times higher than the reference white luminance level. If the reference white luminance level is assumed to be a peak luminance level of the typical end-user Standard Dynamic Range (SDR) display of about 300 cd/m2, the peak luminance level of an EIDRTV display is about 2,000 cd/m2.  2 In typical production practice, the encoding function of image sources is adjusted so that the final picture has the desired look as viewed on a reference monitor having the reference decoding function of Recommendation ITU-R BT.1886 in the reference viewing environment defined in Recommendation ITU-R BT.2035.  3 In the region where  > 1, the relative scene luminance can be compressed by using a “knee” curve as used in conventional practice. | |

TABLE 5

Digital representation

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Parameters | Values | | | |
| Coded signal | *R', G', B'* or *Y', C'B, C'R* | | | |
| Sampling lattice  – *R', G', B', Y'* | Orthogonal, line and picture repetitive co-sited | | | |
| Sampling lattice  – *C'B, C'R* | Orthogonal, line and picture repetitive co-sited with each other.  The first (top-left) sample is co-sited with the first *Y’* samples. | | | |
| 4:4:4 system | 4:2:2 system | | 4:2:0 system |
| Each has the same number of horizontal samples as the *Y'* component. | Horizontally  subsampled by a factor of two with respect to  the *Y'* component. | | Horizontally and vertically subsampled by a factor of two with respect to the *Y'* component. |
| Coding format 1 | 10 or 12 bits per component | | | |
| Quantization of *R', G', B', Y',C'B, C'R* |  | | | |
| Quantization levels | 10-bit coding | | 12-bit coding | |
| Black  *DR', DG', DB', DY'* | 64 | | 256 | |
| Achromatic  *DC'B, DC'R* | 512 | | 2 048 | |
| White  *DR', DG', DB', DY'* | [502] | | [2 008] | |
| Nominal Peak  *DR', DG', DB', DY'* | 940 | | 3 760 | |
| Nominal Peak  *DC'B, DC'R* | 64 and 960 | | 256 and 3 840 | |
| Video data | 4 through 1 019 | | 16 through 4 079 | |
| Timing Reference | 0 - 3 and 1 020 – 1 023 | | 0 - 15 and 4 080 – 4 095 | |
| 1 To avoid visual contouring of worst-case signals, content should be created and delivered using at least 12 bits. However, in some situations, 10-bit interfaces may need to be used. Production at 14 or more bits provides additional headroom. The digital code values shown in the table may be scaled up proportionately (i.e., ×4 for 14 bits, ×16 for 16 bits). | | | | |

### Relative representation of luminance

Current television signals represent relative luminance of the images finally presented on the display screen although the viewing environment including the screen luminance for production and quality evaluation of video programmes are standardized. This make it possible for viewers to watch the same television programmes with different and appropriate screen luminance under various circumstances, such as in-door/outdoor, and day/night. This is a quite natural practice in broadcasting and should also be retained in EIDRTV to satisfy Requirements 2 and 3.

### Non-linear transfer functions

Non-linear transfer functions in modern television systems have three major roles although they were originally introduced to compensate for the non-linear transfer characteristics of cathode ray tube displays. The first role is to define the end-to-end transfer characteristics that greatly affect the picture look. Using a combination of current OETF and EOTF provides an end-to-end gamma of around 1.2 and level compression in dark areas. We believe this practice should be retained to satisfy Requirements 2 and 3.The second role of non-linear transfer functions is to reduce the bit rate of digital signals by changing the quantization steps so that the viewer perceives the quantization error as little as possible. This is related to Requirement 1. The required bit rate reduction depends on the dynamic range of displayed images, i.e., the range between the maximum and minimum luminance. Our investigation suggests that current practice as specified in Recommendation BT.1886 is sufficient. The third role is to make the signal magnitude distribution uniform against the perceptual luminance. The tone scale of the encoded signal with a power function is perceived as linear. This enables the encoded signals to be manipulated in a look-based manner. This practice has made the work flow of usual television programme production simple and should be retained to satisfy Requirement 2.

Consequently, we conclude that non-linear encoding of the signals at origination and decoding at presentation should be used, and the current practice should be retained. The non-linear encoding for highlight parts above 100% video level has not been specified in the current practice. A combination of non-linear and higher compression functions may be applied to the highlight parts as used in the current practice.

The nonlinear transfer function (OETF) specified in Table 4 is depicted in Figure 1, where video level for reference white level is set to 0.5. Figure 2 shows the EOTF for a reference monitor specified in Recommendation ITU-R BT.1866. With these OETF and EOTF, the overall transfer characteristic is as shown in Figure 3.

Figure 1

Transfer function for relative scene luminance to video (as per Table 4)



Figure 2

Transfer function for video to relative display luminance (as per Rec. ITU-R BT.1866)



Figure 3

Overall transfer characteristics for scene to display



### Guideline for scene to video tone mapping

Programmes of current television services are exchanged between broadcasters without difficulty in terms of tone mapping although there is no written practice for scene to video tone mapping in programme production. This is because all programme producers have similar understandings on how to map the scene from 0 to 100% video level. A typical example is to identify which object in a scene should be mapped to 100% video level, which is called the “reference white level”. This practice would be invalid when operating within a high dynamic range and a new practical guideline is needed to satisfy Requirement 4. One possible way is to define the video level for the scene corresponding to the reference white level in the current practice. In this way, setting the video level for the reference white 50 %, for example, provides the luminance ratio of about 6 times between the reference white and the peak. Our experience shows that a value for maximum luminance several times higher than that of the reference white level provides a "step-change" improvement in viewer experience and satisfies the Requirement 1.

## Proposed addition to VUI parameter values

The proposed EIDRTV can be signalled with the existing VUI parameter values except for the transfer characteristics. We propose that a new entry corresponding to our proposal be included in Table E 4 – Transfer characteristics of the HEVC standard as a matter of urgency. A suggested delta document (JCTVC-T0035\_delta\_Table\_E4\_changes.docx) for Table E4 and the relevant text is attached to the .zip archive of this proposal.

# Conclusion

A set of parameter values for EIDRTV systems is proposed. The proposal meets the requirements for EIDRTV identified by ITU-R Working Party 6C and can be regarded as a simple extension to the UHDTV systems specified in Recommendation ITU-R BT.2020. It is also proposed that a VUI parameter value for transfer characteristics be added to signal the proposed EIDRTV system.

# Patent rights declaration(s)

**NHK does not have any current or pending patent rights relating to the technology described in this contribution.**