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(06/2014)

Parameter values for ultra-high definition television systems for production and international programme exchange

BT Series
Broadcasting service (television)

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Note: *This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.*

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RECOMMENDATION ITU-R BT.2020-1*

Parameter values for ultra-high definition television systems for production and international programme exchange

(2012-2014)

Scope

Ultra-high definition television (UHDTV) will provide viewers with an enhanced visual experience primarily by having a wide field of view both horizontally and vertically with appropriate screen sizes relevant to usage at home and in public places. UHDTV applications require system parameters that go beyond the levels of HDTV. This Recommendation specifies UHDTV image system parameters for production and international programme exchange.

Keywords

UHDTV, image system parameters, wide field of view, television system, international programme exchange.

The ITU Radiocommunication Assembly,

considering

a) that digital terrestrial television broadcasting (DTTB) service has been introduced by some administrations since 1997 and can provide high quality television programmes through HDTV systems;

b) that viewers expect future TV systems beyond HDTV to provide improved characteristics compared with the current HDTV systems in terms of a more realistic sensation, greater transparency to the real world, and more accurate visual information;

c) that ultra-high definition television (UHDTV) is expected to become available in the near future with, *inter alia*, larger screens, higher spatial/temporal resolution, wider colour gamut, wider dynamic range, etc. taking into account developments of display technology;

d) that ITU-R has been studying extremely high-resolution imagery (EHRI) and an expanded hierarchy of large screen digital imagery (LSDI) image formats and has established ITU-R Recommendations: Recommendation ITU-R BT.1201-1 providing the guidelines of image characteristics for extremely high-resolution imagery, and Recommendation ITU-R BT.1769 offering the parameter values for an expanded hierarchy of LSDI image formats;

e) that LSDI is a system providing a display on a very large screen, typically for public viewing. This can be used in a wide variety of applications including programme presentations such as dramas, plays, sporting events, concerts, etc.;

f) that EHRI is a system offering higher resolution than HDTV and can be used for both broadcasting and non-broadcasting applications (e.g. computer graphics, printing and medical applications);

g) that UHDTV provides viewers with an enhanced visual experience primarily by a wider field of view that covers a considerable part of the human natural visual field with appropriate screen sizes relevant to usage at home and in public places;

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* Radiocommunication Study Group 6 made editorial amendments to this Recommendation in February 2015 in accordance with Resolution ITU-R 1.

h) that signal formats contributing to increasing the compression efficiency are desirable for UHDTV systems since they have a larger number of pixels than HDTV systems,

recommends

that for UHDTV programme production and international exchange, the specifications described in this Recommendation should be used[1],

and further recommends

that if it is shown that an alternative electro-optical transfer function (EOTF) will provide significant benefits without also imposing significant disadvantages, then this Recommendation should be extended to enable use with an improved EOTF.

NOTE – Future consideration should be given to extend this Recommendation in a complementary manner to include extended image parameters.

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.	

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[1] Both 3 840 × 2 160 and 7 680 × 4 320 systems of UHDTV will find their main applications for the delivery of television programming to the home where they will provide viewers with an increased sense of "being there" and increased sense of realness by using displays with a screen diagonal of the order of 1.5 metres or more and for large screen (LSDI) presentations in theatres, halls and other venues such as sports venues or theme parks.

Presentation on tablet displays with extremely high resolution will also be attractive for viewers.

The 7 680 × 4 320 system will provide a more enhanced visual experience than the 3 840 × 2 160 system for a wider range of viewing environments.

An increase in the efficiency of video source coding and/or in the capacity of transmission channels, compared to those currently in use, will likely be needed to deliver such programs by terrestrial or satellite broadcasting to the home. Research is under way to achieve this goal. The delivery of such programming will initially be possible by cable or fibre.

The choice of frame frequency may be influenced by the frequency of the mains power and the type of scene lighting in use, as well as by considerations related to the conversion of programme material between higher frame rates and lower frame rates (see Report ITU-R BT.2246).

TABLE 2

Picture temporal characteristics

Parameter	Values
Frame frequency (Hz)[(1), (2)]	120, 60, 60/1.001, 50, 30, 30/1.001, 25, 24, 24/1.001
Scan mode	Progressive

(1) The additional frame rate of 100 Hz is used in a number of 50 Hz countries.

(2) The additional frame rate of 120/1.001 Hz is used in a number of 60 Hz countries, while it is still under study in a number of other countries.

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**	
Signal format	$R'G'B'$(1)	
	Constant luminance $Y'_C C'_{BC} C'_{RC}$(2)	Non-constant luminance $Y'C'_B C'_R$(3)
Non-linear transfer function(4)	$$E' = \begin{cases} 4.5E, & 0 \le E < \beta \\ \alpha E^{0.45} - (\alpha - 1), & \beta \le E \le 1 \end{cases}$$ where E is voltage normalized by the reference white level and proportional to the implicit light intensity that would be detected with a reference camera colour channel R, G, B; E' is the resulting non-linear signal. α and β are the solutions to the following simultaneous equations: $$\begin{cases} 4.5\beta = \alpha\beta^{0.45} - \alpha + 1 & (1) \\ 4.5 = 0.45\alpha\beta^{-0.55} & (2) \end{cases}$$ The simultaneous equations provide the required condition to connect the two curve segments smoothly and yield α = 1.09929682680944... and β = 0.018053968510807.... For practical purpose, the 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'_C and Y'	$Y'_C = (0.2627R + 0.6780G + 0.0593B)'$	$Y' = 0.2627R' + 0.6780G' + 0.0593B'$
Derivation of colour difference signals	$$C'_{BC} = \begin{cases} \frac{B' - Y'_C}{-2N_B}, & N_B \le B' - Y'_C \le 0 \\ \frac{B' - Y'_C}{2P_B}, & 0 < B' - Y'_C \le P_B \end{cases}$$ $$C'_{RC} = \begin{cases} \frac{R' - Y'_C}{-2N_R}, & N_R \le R' - Y'_C \le 0 \\ \frac{R' - Y'_C}{2P_R}, & 0 < R' - Y'_C \le P_R \end{cases}$$ where $P_B = \alpha(1 - 0.0593^{0.45}) = 0.7909854...$ $N_B = \alpha(1 - 0.9407^{0.45}) - 1 = -0.9701716...$ $P_R = \alpha(1 - 0.2627^{0.45}) = 0.4969147...$ $N_R = \alpha(1 - 0.7373^{0.45}) - 1 = -0.8591209...$ For practical purpose, the following values can be used: $P_B = 0.7910, \; N_B = -0.9702$ $P_R = 0.4969, \; N_R = -0.8591$	$$C'_B = \frac{B' - Y'}{1.8814}$$ $$C'_R = \frac{R' - Y'}{1.4746}$$

TABLE 4 (*end*)

Notes to Table 4:

(1) *R'G'B'* may be used for programme exchange when the best quality programme production is of primary importance.

(2) Constant luminance $Y'_C C'_{BC} C'_{RC}$ may be used when the most accurate retention of luminance information is of primary importance or where there is an expectation of improved coding efficiency for delivery (see Report ITU-R BT.2246).

(3) Conventional non-constant luminance $Y'C'_B C'_R$ may be used when use of the same operational practices as those in SDTV and HDTV environments is of primary importance through a broadcasting chain (see Report ITU-R BT.2246).

(4) 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.

TABLE 5

Digital representation

Parameters	**Values**		
Coded signal	R', G', B' or Y', C'_B, C'_R or Y'_C, C'_{BC}, C'_{RC}		
Sampling lattice – R', G', B', Y', Y'_C	Orthogonal, line and picture repetitive co-sited		
Sampling lattice – C'_B, C'_R or C'_{BC}, C'_{RC}	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' (Y'_C) component.	Horizontally subsampled by a factor of two with respect to the Y' (Y'_C) component.	Horizontally and vertically subsampled by a factor of two with respect to the Y' (Y'_C) component.
Coding format	10 or 12 bits per component		
Quantization of $R', G', B', Y', Y'_C, C'_B, C'_R, C'_{BC}, C'_{RC}$	$DR' = INT\left[(219 \times R' + 16) \times 2^{n-8}\right]$ $DG' = INT\left[(219 \times G' + 16) \times 2^{n-8}\right]$ $DB' = INT\left[(219 \times B' + 16) \times 2^{n-8}\right]$ $DY'(DY'_C) = INT\left[(219 \times Y'(Y'_C) + 16) \times 2^{n-8}\right]$ $DC'_B(DC'_{BC}) = INT\left[(224 \times C'_B(C'_{BC}) + 128) \times 2^{n-8}\right]$ $DC'_R(DC'_{RC}) = INT\left[(224 \times C'_R(C'_{RC}) + 128) \times 2^{n-8}\right]$		

TABLE 5 *(end)*

Parameters	**Values**	
Quantization levels	10-bit coding	12-bit coding
– Black level DR', DG', DB', DY', DY'_C – Achromatic DC'_B, DC'_R , DC'_{BC}, DC'_{RC} – Nominal Peak DR', DG', DB', DY', DY'_C DC'_B, DC'_R, DC'_{BC}, DC'_{RC}	64 512 940 64 and 960	256 2 048 3 760 256 and 3 840
Quantization level assignment	10-bit coding	12-bit coding
– Video data – Timing reference	4 through 1 019 0-3 and 1 020-1 023	16 through 4 079 0-15 and 4 080-4 095

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