



**Recommendation ITU-R BT.2020**  
(08/2012)

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

**BT Series**  
**Broadcasting service**  
**(television)**

## Foreword

The role of the Radiocommunication Sector is to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radiocommunication services, including satellite services, and carry out studies without limit of frequency range on the basis of which Recommendations are adopted.

The regulatory and policy functions of the Radiocommunication Sector are performed by World and Regional Radiocommunication Conferences and Radiocommunication Assemblies supported by Study Groups.

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### Series of ITU-R Recommendations

(Also available online at <http://www.itu.int/publ/R-REC/en>)

Series	Title
<b>BO</b>	Satellite delivery
<b>BR</b>	Recording for production, archival and play-out; film for television
<b>BS</b>	Broadcasting service (sound)
<b>BT</b>	<b>Broadcasting service (television)</b>
<b>F</b>	Fixed service
<b>M</b>	Mobile, radiodetermination, amateur and related satellite services
<b>P</b>	Radiowave propagation
<b>RA</b>	Radio astronomy
<b>RS</b>	Remote sensing systems
<b>S</b>	Fixed-satellite service
<b>SA</b>	Space applications and meteorology
<b>SF</b>	Frequency sharing and coordination between fixed-satellite and fixed service systems
<b>SM</b>	Spectrum management
<b>SNG</b>	Satellite news gathering
<b>TF</b>	Time signals and frequency standards emissions
<b>V</b>	Vocabulary and related subjects

*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

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

(2012)

**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.

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;
- 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*

1 that for UHD TV programme production and international exchange, the specifications described in this Recommendation should be used<sup>1</sup>,

*and further recommends*

2 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.	

TABLE 2

**Picture temporal characteristics**

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

<sup>1</sup> Both 3 840 × 2 160 and 7 680 × 4 320 systems of UHD TV 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.

TABLE 3  
System colorimetry

Parameter	Values		
Opto-electronic transfer characteristics before non-linear pre-correction	Assumed linear <sup>(1)</sup>		
Primary colours and reference white <sup>(2)</sup>	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

<sup>(1)</sup> Picture information can be linearly indicated by the tristimulus values of RGB in the range of 0-1.

<sup>(2)</sup> 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	$R'G'B'^2$	
	Constant luminance $Y'_cC'_{BC}C'_{RC}$ <sup>3</sup>	Non-constant luminance $Y'C'_BC'_R$ <sup>4</sup>
Non-linear transfer function	$E' = \begin{cases} 4.5E, & 0 \leq E < \beta \\ \alpha E^{0.45} - (\alpha - 1), & \beta \leq E \leq 1 \end{cases}$ <p>where <math>E</math> 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 <math>R, G, B</math>; <math>E'</math> is the resulting non-linear signal.  <math>\alpha = 1.099</math> and <math>\beta = 0.018</math> for 10-bit system  <math>\alpha = 1.0993</math> and <math>\beta = 0.0181</math> for 12-bit system</p>	

<sup>2</sup>  $R'G'B'$  may be used for programme exchange when the best quality programme production is of primary importance.

<sup>3</sup> Constant luminance  $Y'_cC'_{BC}C'_{RC}$  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).

<sup>4</sup> Conventional non-constant luminance  $Y'C'_BC'_R$  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).



TABLE 4 (end)

Parameter	Values	
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	$C'_{BC} = \begin{cases} \frac{B'-Y'_C}{1.9404}, & -0.9702 \leq B'-Y'_C \leq 0 \\ \frac{B'-Y'_C}{1.5816}, & 0 < B'-Y'_C \leq 0.7908 \end{cases}$ $C'_{RC} = \begin{cases} \frac{R'-Y'_C}{1.7184}, & -0.8592 \leq R'-Y'_C \leq 0 \\ \frac{R'-Y'_C}{0.9936}, & 0 < R'-Y'_C \leq 0.4968 \end{cases}$	$C'_B = \frac{B'-Y'}{1.8814}$ $C'_R = \frac{R'-Y'}{1.4746}$

TABLE 5

**Digital representation**

Parameters	Values		
Coded signal	$R', G', B' \text{ or } Y', C'_B, C'_R \text{ or } Y'_C, C'_{BC}, C'_{RC}$		
Sampling lattice – $R', G', B', Y', Y'_C$	Orthogonal, line and picture repetitive co-sited		
Sampling lattice – $C'_B, C'_R \text{ or } C'_{BC}, C'_{RC}$	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 $R', G', B', Y', Y'_C, C'_B, C'_R, C'_{BC}, C'_{RC}$	$DR' = INT[(219 \times R' + 16) \times 2^{n-8}]$ $DG' = INT[(219 \times G' + 16) \times 2^{n-8}]$ $DB' = INT[(219 \times B' + 16) \times 2^{n-8}]$ $DY'(DY'_C) = INT[(219 \times Y'(Y'_C) + 16) \times 2^{n-8}]$ $DC'_B(DC'_{BC}) = INT[(224 \times C'_B(C'_{BC}) + 128) \times 2^{n-8}]$ $DC'_R(DC'_{RC}) = INT[(224 \times C'_R(C'_{RC}) + 128) \times 2^{n-8}]$		

TABLE 5 (end)

Parameters	Values	
	10-bit coding	12-bit coding
Quantization levels		
– Black level $DR', DG', DB', DY', DY'_C$	64	256
– Achromatic $DC'_B, DC'_R, DC'_{BC},$ $DC'_{RC}$	512	2 048
– Nominal Peak $DR', DG', DB', DY', DY'_C$ $DC'_B, DC'_R, DC'_{BC}, DC'_{RC}$	940 64 and 960	3 760 256 and 3 840
Quantization level assignment	10-bit coding	12-bit coding
– 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