International Telecommunication Union

ITU-R

Radiocommunication Sector of ITU

Recommendation ITU-R BT.2111-2

(12/2020)

Specification of colour bar test pattern for high dynamic range television systems

BT Series

Broadcasting service (television)

International Telecommunication Union

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Series	Title
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BS	Broadcasting service (sound)
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P	Radiowave propagation
RA	Radio astronomy
RS	Remote sensing systems
S	Fixed-satellite service
SA	Space applications and meteorology
SF	Frequency sharing and coordination between fixed-satellite and fixed service systems
SM	Spectrum management
SNG	Satellite news gathering
TF	Time signals and frequency standards emissions
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Note: *This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.*

Electronic Publication
Geneva, 2020

RECOMMENDATION ITU-R BT.2111-2

Specification of colour bar test pattern for high dynamic range television systems

(2017-2019-2020)

Scope

This Recommendation specifies reference test patterns for the high dynamic range television systems specified in Recommendation ITU-R BT.2100.

Keywords

Colour bars, HDR, HDR-TV, HLG, PQ, test pattern, test signal

The ITU Radiocommunication Assembly,

considering

a) that test patterns provide a convenient means of assessing chrominance and luminance performance in a television system;

b) that such a test pattern may be useful when broadcasting in multiple formats or when converting between formats;

c) that the use of a test pattern can simplify test procedures and reduce the opportunity for misinterpretation of signal parameters and misalignment of systems,

noting

that Recommendation ITU-R BT.2100 specifies image parameter values for high dynamic range television for use in production and international programme exchange,

recommends

that the test patterns defined in Annex 1 should be implemented and may be used for production and distribution purposes in high dynamic range television (HDR-TV) systems.

Annex 1
(normative)

Specifications of test pattern

1 Normative references

Recommendation ITU-R BT.471 – Nomenclature and description of colour bar signals

Recommendation ITU-R BT.709 – Parameter values for the HDTV standards for production and international programme exchange.

Recommendation ITU-R BT.2100 – Image parameter values for high dynamic range television for use in production and international programme exchange

2 Purpose

The reference test pattern has several purposes:

– quality control of chrominance and luminance through the production chain;

– checking and adjusting the chrominance and luminance alignment of broadcast equipment, particularly video monitors;

– general testing of equipment for video production, emission and presentation;

– establishing that a video circuit is active and that associated audio is available.

It is not intended that this test pattern be used for black level adjustment, which is best set using a PLUGE signal.

3 System types

The pattern described in this Recommendation is intended for use with Recommendation ITU-R BT.2100. These systems are distinguished by the proportions of their colour encoding (or "colorimetry") and by their resolution.

4 Sections of test pattern[1]

The various sections of the test pattern for the HLG system with narrow range coding are shown in Fig. 1; the pattern for the PQ system with narrow range coding is shown in Fig. 2, and the pattern for the PQ system with full range coding is shown in Fig. 3. A colour diagram is shown in Fig. 4. See also Attachments 1 and 2.

[1] It is desirable that implementers should include in this test signal some visual identification of the signal format (HLG narrow range, PQ narrow range, or PQ full range). The test pattern includes grey bars (top right and top left) that may optionally be used for this and/or other purposes.

FIGURE 1

Test pattern details for HLG narrow range

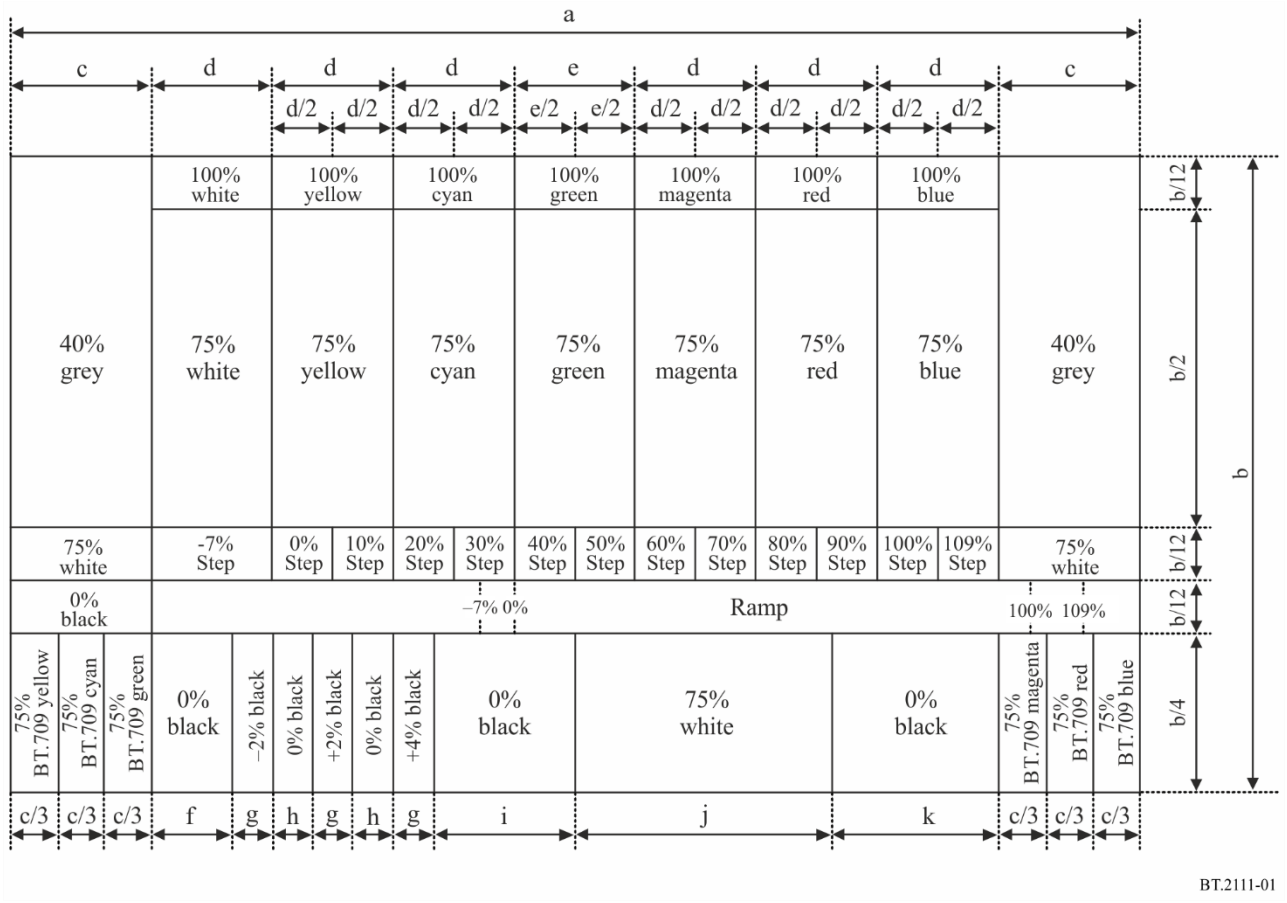


FIGURE 2

Test pattern details for PQ narrow range

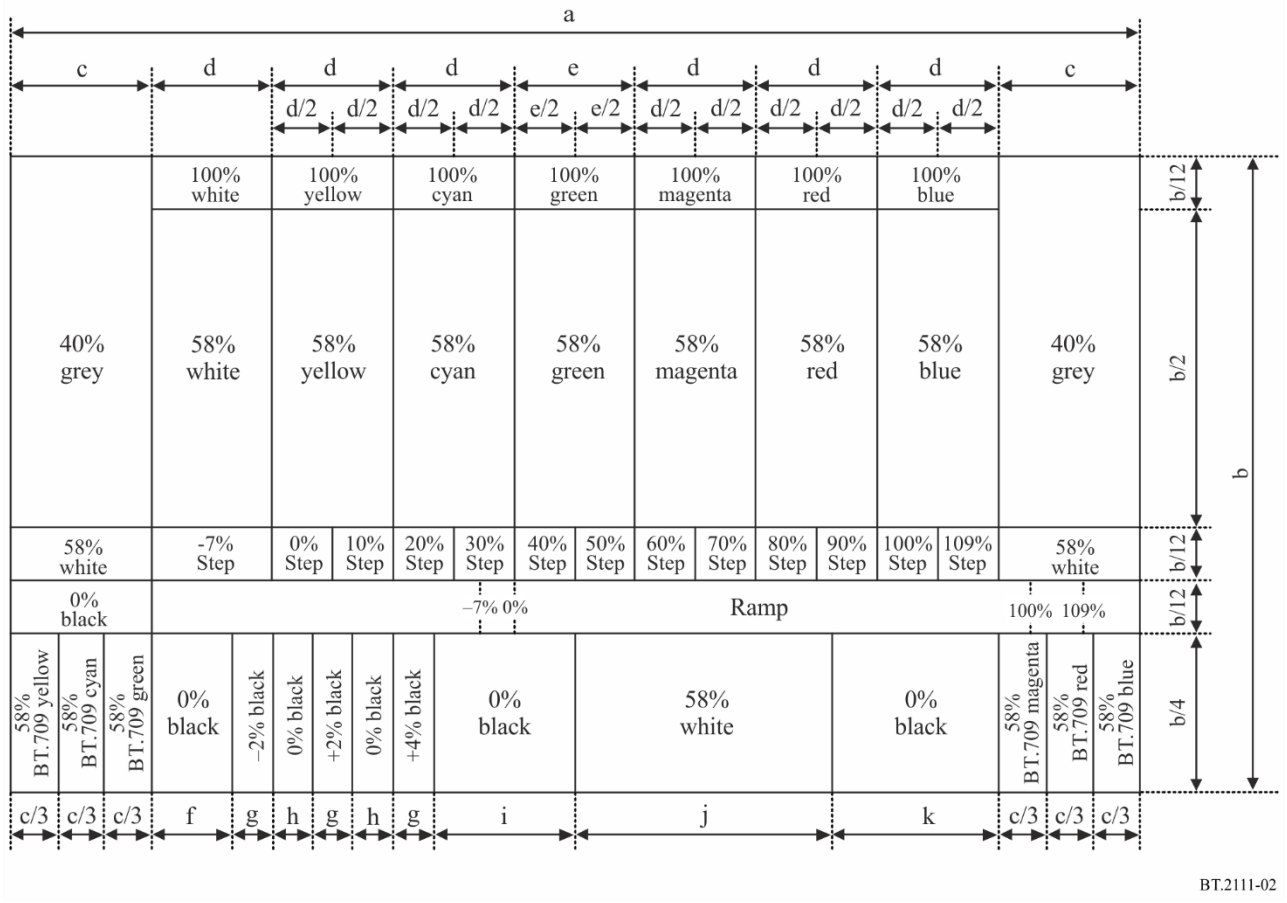


FIGURE 3

Test pattern details for PQ full range

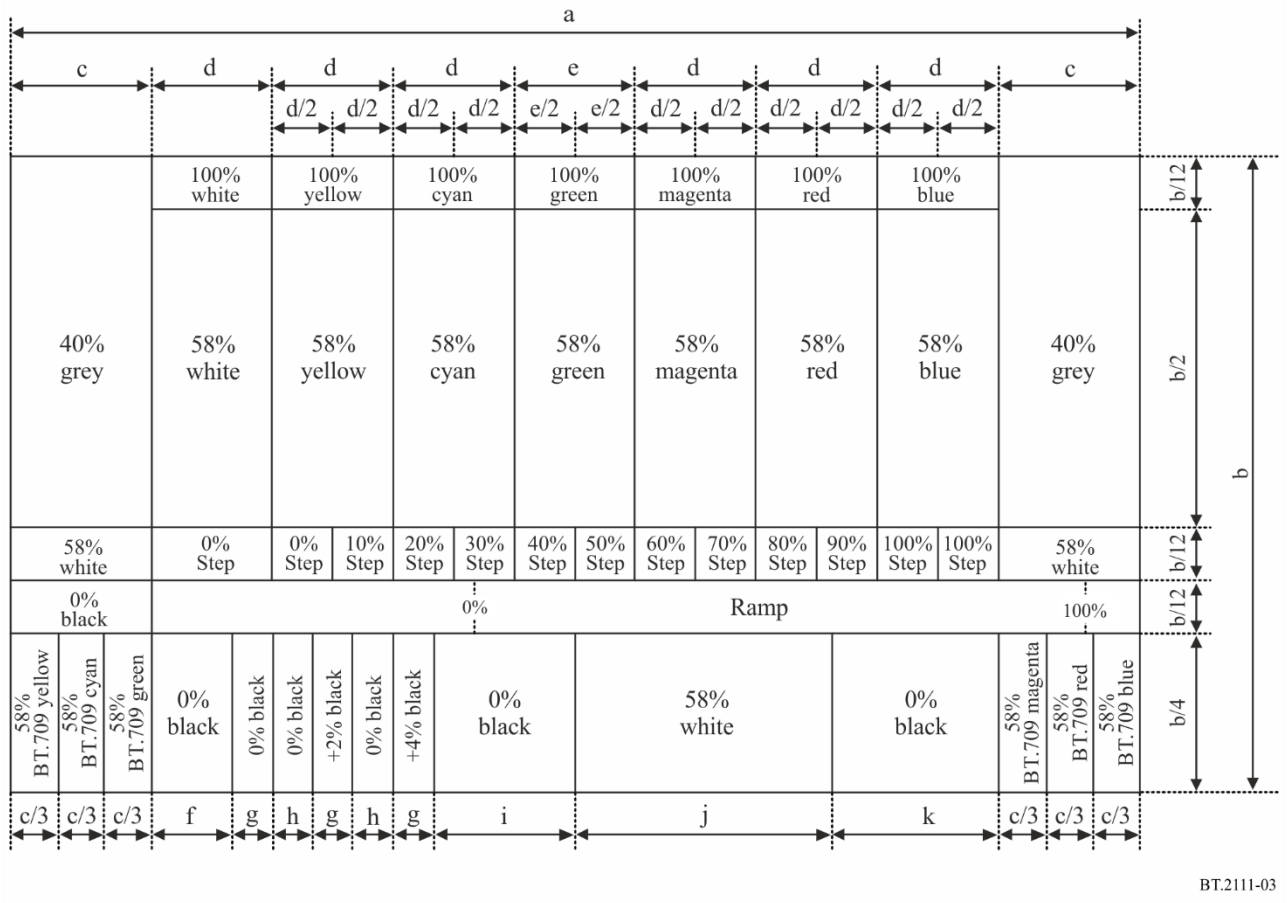


TABLE 1

Bar size to 2K, 4K and 8K format

Bar size (pixel)	2K	4K	8K
a	1920	3840	7680
b	1080	2160	4320
c	240	480	960
d	206	412	824
e	204	408	816
f	136	272	544
g	70	140	280
h	68	136	272
i	238	476	952
j	438	876	1752
k	282	564	1128

FIGURE 4

Colour diagram of the test pattern

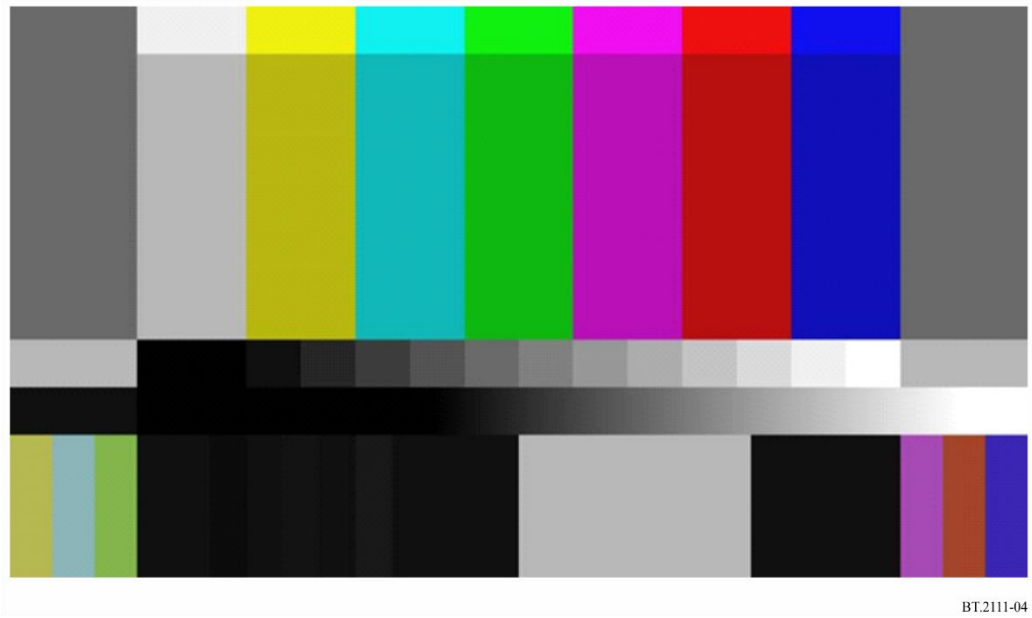


TABLE 2

Signal level for HLG narrow range

	10 bits			12 bits		
Image Area	**R´**	**G´**	**B´**	**R´**	**G´**	**B´**
100% White	940	940	940	3 760	3 760	3 760
100% Yellow	940	940	64	3 760	3 760	256
100% Cyan	64	940	940	256	3 760	3 760
100% Green	64	940	64	256	3 760	256
100% Magenta	940	64	940	3 760	256	3 760
100% Red	940	64	64	3 760	256	256
100% Blue	64	64	940	256	256	3 760
75% White	721	721	721	2 884	2 884	2 884
75% Yellow	721	721	64	2 884	2 884	256
75% Cyan	64	721	721	256	2 884	2 884
75% Green	64	721	64	256	2 884	256
75% Magenta	721	64	721	2 884	256	2 884
75% Red	721	64	64	2 884	256	256
75% Blue	64	64	721	256	256	2 884
40% Grey	414	414	414	1 656	1 656	1 656
−7% Step	4	4	4	16	16	16
0% Step	64	64	64	256	256	256
10% Step	152	152	152	608	608	608
20% Step	239	239	239	956	956	956

TABLE 2 (*end*)

	10 bits			12 bits		
Image Area	**R´**	**G´**	**B´**	**R´**	**G´**	**B´**
30% Step	327	327	327	1 308	1 308	1 308
40% Step	414	414	414	1 656	1 656	1 656
50% Step	502	502	502	2 008	2 008	2 008
60% Step	590	590	590	2 360	2 360	2 360
70% Step	677	677	677	2 708	2 708	2 708
80% Step	765	765	765	3 060	3 060	3 060
90% Step	852	852	852	3 408	3 408	3 408
100% Step	940	940	940	3 760	3 760	3 760
109% Step	1 019	1 019	1 019	4 076	4 076	4 076
	See Fig. 5 and Table 5					
75% BT.709 Yellow	713	719	316	2 852	2 876	1 264
75% BT.709 Cyan	538	709	718	2 152	2 836	2 872
75% BT.709 Green	512	706	296	2 048	2 824	1 184
75% BT.709 Magenta	651	286	705	2 604	1 144	2 820
75% BT.709 Red	639	269	164	2 556	1 076	656
75% BT.709 Blue	227	147	702	908	588	2 808
0% Black	64	64	64	256	256	256
−2% Black	48	48	48	192	192	192
+2% Black	80	80	80	320	320	320
+4% Black	99	99	99	396	396	396

TABLE 3

Signal level for PQ narrow range

	10 bits			12 bits		
Image Area	**R´**	**G´**	**B´**	**R´**	**G´**	**B´**
100% White	940	940	940	3 760	3 760	3 760
100% Yellow	940	940	64	3 760	3 760	256
100% Cyan	64	940	940	256	3 760	3 760
100% Green	64	940	64	256	3 760	256
100% Magenta	940	64	940	3 760	256	3 760
100% Red	940	64	64	3 760	256	256
100% Blue	64	64	940	256	256	3 760

TABLE 3 (*end*)

	10 bits			12 bits		
Image Area	**R´**	**G´**	**B´**	**R´**	**G´**	**B´**
58% White	572	572	572	2 288	2 288	2 288
58% Yellow	572	572	64	2 288	2 288	256
58% Cyan	64	572	572	256	2 288	2 288
58% Green	64	572	64	256	2 288	256
58% Magenta	572	64	572	2 288	256	2 288
58% Red	572	64	64	2 288	256	256
58% Blue	64	64	572	256	256	2 288
40% Grey	414	414	414	1 656	1 656	1 656
−7% Step	4	4	4	16	16	16
0% Step	64	64	64	256	256	256
10% Step	152	152	152	608	608	608
20% Step	239	239	239	956	956	956
30% Step	327	327	327	1 308	1 308	1 308
40% Step	414	414	414	1 656	1 656	1 656
50% Step	502	502	502	2 008	2 008	2 008
60% Step	590	590	590	2 360	2 360	2 360
70% Step	677	677	677	2 708	2 708	2 708
80% Step	765	765	765	3 060	3 060	3 060
90% Step	852	852	852	3 408	3 408	3 408
100% Step	940	940	940	3 760	3 760	3 760
109% Step	1 019	1 019	1 019	4 076	4 076	4 076
Ramp	See Fig. 5 and Table 5					
58% BT.709 Yellow	568	571	381	2 272	2 284	1 524
58% BT.709 Cyan	484	566	571	1 936	2 264	2 284
58% BT.709 Green	474	564	368	1 896	2 256	1 472
58% BT.709 Magenta	536	361	564	2 144	1 444	2 256
58% BT.709 Red	530	350	256	2 120	1 400	1 024
58% BT.709 Blue	317	236	562	1 268	944	2 248
0% Black	64	64	64	256	256	256
−2% Black	48	48	48	192	192	192
+2% Black	80	80	80	320	320	320
+4% Black	99	99	99	396	396	396

TABLE 4

Signal level for PQ full range

	10 bits			12 bits		
Image Area	**R´**	**G´**	**B´**	**R´**	**G´**	**B´**
100% White	1 023	1 023	1 023	4 095	4 095	4 095
100% Yellow	1 023	1 023	0	4 095	4 095	0
100% Cyan	0	1 023	1 023	0	4 095	4 095
100% Green	0	1 023	0	0	4 095	0
100% Magenta	1 023	0	1 023	4 095	0	4 095
100% Red	1 023	0	0	4 095	0	0
100% Blue	0	0	1 023	0	0	4 095
58% White	593	593	593	2 375	2 375	2 375
58% Yellow	593	593	0	2 375	2 375	0
58% Cyan	0	593	593	0	2 375	2 375
58% Green	0	593	0	0	2 375	0
58% Magenta	593	0	593	2 375	0	2 375
58% Red	593	0	0	2 375	0	0
58% Blue	0	0	593	0	0	2 375
40% Grey	409	409	409	1 638	1 638	1 638
0% Step	0	0	0	0	0	0
10% Step	102	102	102	410	410	410
20% Step	205	205	205	819	819	819
30% Step	307	307	307	1 229	1 229	1 229
40% Step	409	409	409	1 638	1 638	1 638
50% Step	512	512	512	2 048	2 048	2 048
60% Step	614	614	614	2 457	2 457	2 457
70% Step	716	716	716	2 867	2 867	2 867
80% Step	818	818	818	3 276	3 276	3 276
90% Step	921	921	921	3 686	3 686	3 686
100% Step	1 023	1 023	1 023	4 095	4 095	4 095
Ramp	See Fig. 6 and Table 6					
58% BT.709 Yellow	589	592	370	2 356	2 370	1 480
58% BT.709 Cyan	491	586	592	1 964	2 345	2 368
58% BT.709 Green	478	584	355	1 915	2 339	1 420
58% BT.709 Magenta	551	347	584	2 206	1 389	2 336
58% BT.709 Red	544	334	225	2 178	1 337	900
58% BT.709 Blue	296	201	582	1 184	805	2 328
0% Black	0	0	0	0	0	0
+2% Black	20	20	20	82	82	82
+4% Black	41	41	41	164	164	164

FIGURE 5

HLG/PQ narrow range signal levels of the ramp

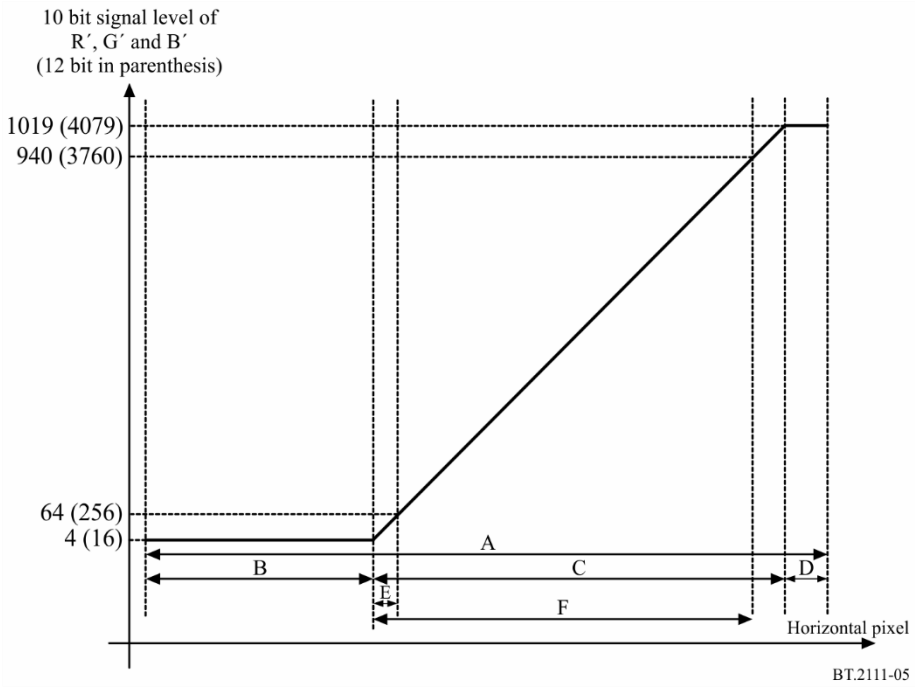


TABLE 5

HLG/PQ Narrow Range Ramp width to 2K, 4K and 8K format

Width (pixel)	2K		4K		8K	
	10 bits	**12 bits**	**10 bits**	**12 bits**	**10 bits**	**12 bits**
A	1 680	1 680	3 360	3 360	6 720	6 720
B	559	559	1 118	1 117	2 236	2 233
C[(1)]	1 014	1 015	2 028	2 031	4 056	4 062
D	107	106	214	212	428	425
E[(2)]	59	59	118	119	236	239
F[(3)]	935	935	1 870	1 871	3 740	3 743

(1) C corresponds to the signal level range from 5 to 1 018 in 10 bits and from 17 to 4 078 in 8K 12 bit, 18 to 4078 in 4K 12 bit, and 20 to 4076 in 2K 12 bits.

(2) E corresponds to the signal level range from 5 to 63 in 10 bits and from 17 to 255 in 8K 12 bit, 18 to 254 in 4K 12 bit, and 20 to 252 in 2K 12 bits.

(3) F corresponds to the signal level range from 5 to 939 in 10 bits and from 17 to 3 759 in 8K 12 bit, 18 to 3758 in 4K 12 bit, and 20 to 3756 in 2K 12 bits.

FIGURE 6

PQ full range signal levels of the ramp

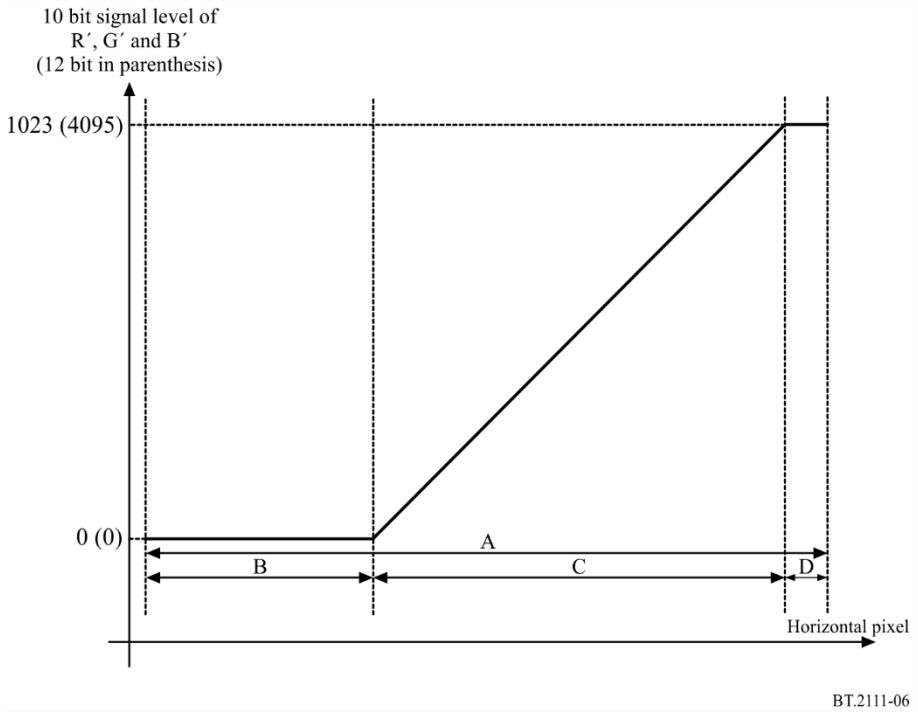


TABLE 6

PQ Full Range Ramp width to 2K, 4K and 8K format

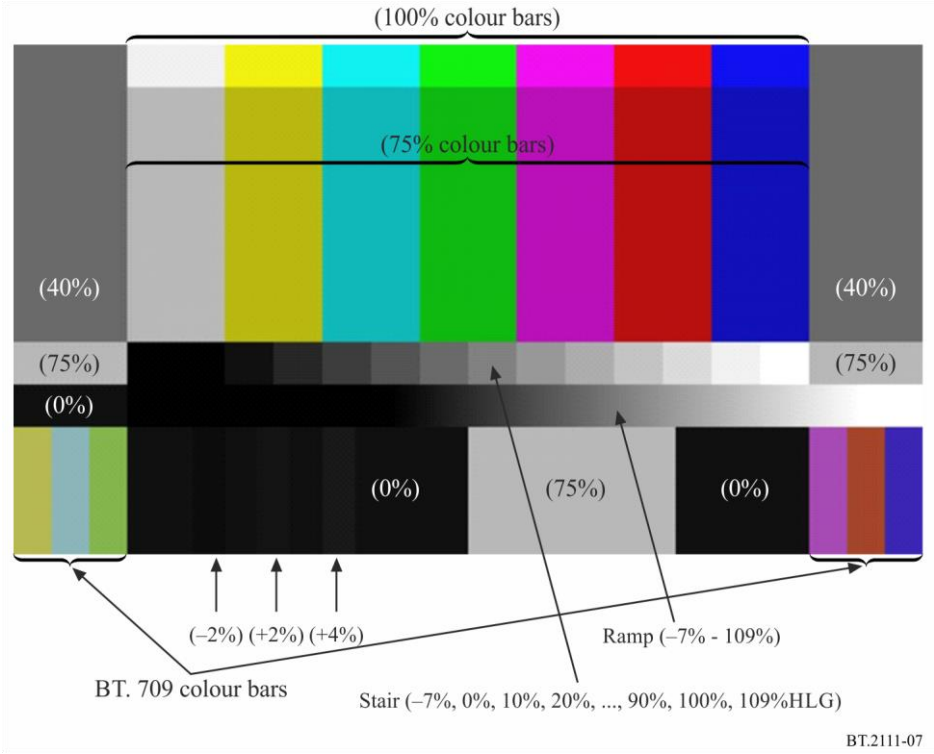
Width (pixel)	2K		4K		8K	
	10 bits	**12 bits**	**10 bits**	**12 bits**	**10 bits**	**12 bits**
A	1 680	1 680	3 360	3 360	6 720	6 720
B	551	551	1 102	1 101	2 204	2 201
C[(1)]	1 022	1 023	2 044	2 047	4 088	4 094
D	107	106	214	212	428	425

(1) C corresponds to the signal level range from 1 to 1 022 in 10 bits and from 1 to 4 094 in 8K 12 bit, 2 to 4094 in 4K 12 bit, and 4 to 4092 in 2K 12 bits.

Attachment 1
to Annex 1
(informative)

Sections comprising the HLG test pattern

FIGURE 7



Colour Bars: The main colour bars are 75%HLG, with 100%HLG colour bars at the top.

BT.709 Colour Bars: Generated by using the HLG OETF and a linear matrix. BT.709 colour bars are placed at the left and right bottom to avoid overlaps with the main colour bars on a waveform monitor.

Ramp: Levels are from −7%HLG to 109%HLG. 0% video level is at the left edge of the Green bar.

Stair: Levels are from −7%HLG to 109%HLG. Left edge of the 0% step is at the left edge of the Yellow bar. 10% interval between 0%HLG and 100%HLG. The width of each step is a half of the colour bar. The step signal and the ramp signal are placed not to overlap on a waveform monitor.

Black signal: consisting of 0%, −2%, 0%, +2%, 0%, +4% and 0% video levels are placed at the lower left away from the bright areas for better visibility.

Grey bars (right and left): These areas may optionally be used to include other patterns for specific needs.

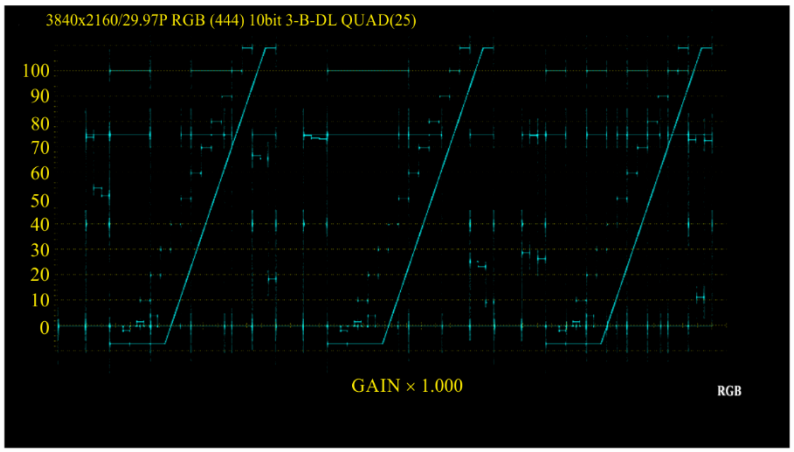
Attachment 2
to Annex 1
(informative)

HLG waveform on a waveform monitor

Figure 8 shows the HLG waveform of the test pattern on a waveform monitor.

FIGURE 8

Waveform on waveform monitor
(Red, Green, and Blue, respectively)



BT.2111-08

Attachment 3
to Annex 1
(informative)

Information on conversion of HLG/BT.2020 colour bars to SDR/BT.709

Figure 9 shows the HLG/BT.2020 colour bars including the BT.709-equivalent colour bars and their snapshots of the waveform and vectorscope set to BT.2020 colorimetry.

Figure 11 shows the colour bars converted from HLG/BT.2020 to SDR/BT.709 using the scene-referred conversion method depicted in Fig. 10, which is the inverse of the “SDR to HDR mapping (scene-referred)”. Note this method does not include tone-mapping. HDR signals are hard-clipped when converted to SDR. The BT.709-equivalent colour bars land on the vectorscope targets after the scene-referred conversion.

Figure 13 shows the colour bars converted from HLG/BT.2020 to SDR/BT.709 using the display-referred conversion method depicted in Fig. 12, which is the inverse of the “SDR to HLG mapping without gamma adjustment (display-referred)”. Note this method does not include tone-mapping. HDR signals are hard-clipped when converted to SDR. The BT.709-equivalent colour bars land on slightly different positions of the vectorscope targets.

Table 7 summarises the signal levels for input 75%HLG and BT.709-equivalent colour bars and the converted SDR/BT.709 colour bars. The BT.709-equivalent colour bars are converted to the same signal levels as the original SDR/BT.709 colour bars by the scene-referred conversion. Some of the signal levels of the resultant SDR colour bars by the scene-referred conversion are not exactly the same levels as the original SDR/BT.709, for example the signal levels of the Green bar are not (64, 940, 64) but (71, 939, 66) due to rounding errors.

FIGURE 9

HLG/BT.2020 colour bars and their snapshots of the waveform and vectorscope set to BT.2020 colorimetry

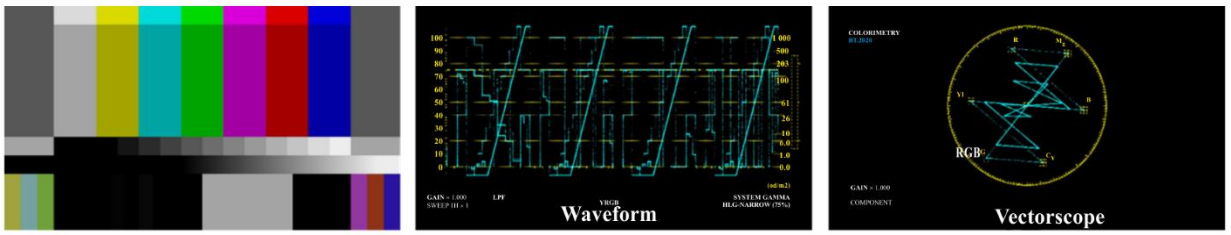
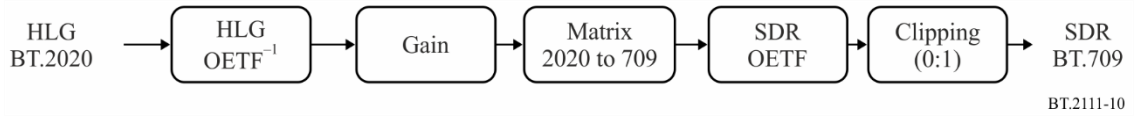


FIGURE 10

Scene-referred conversion method from HLG/BT.2020 to SDR/BT.709



NOTE – The gain is set so that 75%HLG corresponds to 100%SDR. The colour conversion matrix is as described in § 2 of Report ITU-R BT.2407 – "Simple conversion from BT.2020 to BT.709 based on linear matrix transformation". Note other methods may result in different signal levels for input signals outside of the BT.709 colour volume.

FIGURE 11

Colour bars converted to SDR/BT.709 using the scene-referred conversion and their snapshots of the waveform and vectorscope set to BT.709 colorimetry

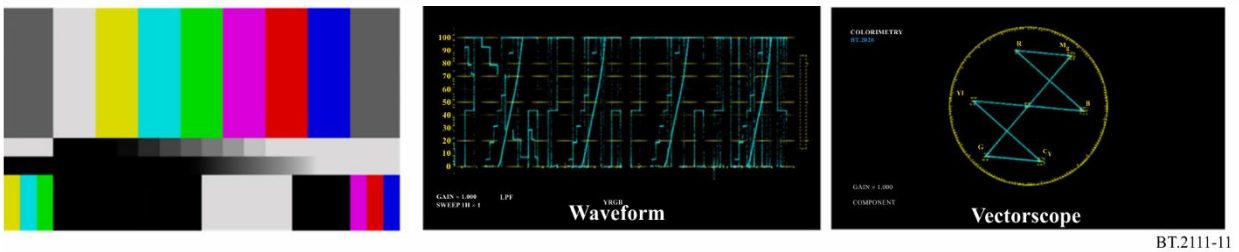
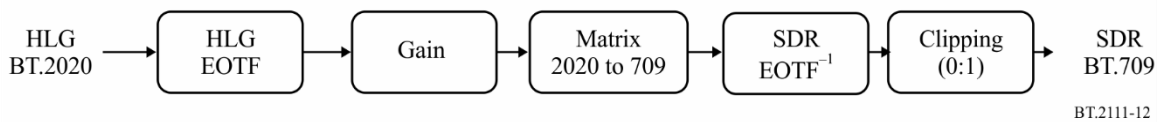


FIGURE 12

Display-referred conversion method from HLG/BT.2020 to SDR/BT.709



NOTE – The gain is set so that 75%HLG corresponds to 100%SDR. The colour conversion matrix is the same as that in Fig. 10.

FIGURE 13

Colour bars converted to SDR/BT.709 using the display-referred conversion and their snapshots of the waveform and vectorscope set to BT.709 colorimetry

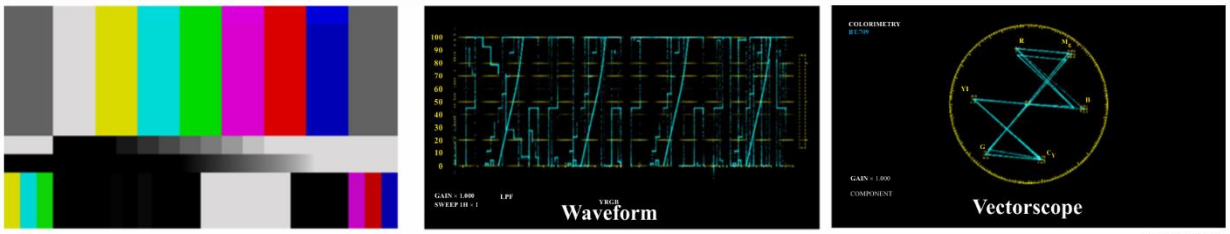


TABLE 7

Signal levels in 10 bits for input 75%HLG and BT.709-equivalent colour bars and output SDR/BT.709 colour bars converted by the methods in Figs 10 and 12

Image Area	Input signal level (HLG/BT.2020, 10 bits)			Output signal level (SDR/BT.709, 10 bits) (No tone-mapping applied, simple colour conversion)					
				Scene-referred conversion			Display-referred conversion		
	R	G	B	R	G	B	R	G	B
75% White	721	721	721	940	940	940	940	940	940
75% Yellow	721	721	64	940	940	64	940	939	64
75% Cyan	64	721	721	64	940	940	64	940	924
75% Green	64	721	64	64	940	64	64	940	64
75% Magenta	721	64	721	940	64	940	940	64	894
75% Red	721	64	64	940	64	64	940	64	64
75% Blue	64	64	721	64	64	940	64	64	789
75% BT.709 Yellow	713	719	316	939	940	64	933	934	64
75% BT.709 Cyan	538	709	718	64	940	939	64	924	922
75% BT.709 Green	512	706	296	71	939	66	124	915	99
75% BT.709 Magenta	651	286	705	940	65	940	854	89	853
75% BT.709 Red	639	269	164	940	64	64	835	64	64
75% BT.709 Blue	227	147	702	66	64	940	93	64	768