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International Telecommunication Union
Radiocommunication Sector

Recommendation ITU-R BT.2111-3

(05/2025)

BT Series: Broadcasting service (television)

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

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SM	Spectrum management
SNG	Satellite news gathering
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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, 2025

RECOMMENDATION ITU-R BT.2111-3

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

(2017-2019-2020-2025)

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,

further recommends

that manufacturers should indicate which edition of a Recommendation ITU-R BT.2111 test pattern is implemented in a pattern generator.

Annex 1
(normative)

Specifications of test pattern

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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 hybrid log-gamma (HLG) system with narrow range coding are shown in Fig. 1; the pattern for the perceptual quantization (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 to Annex 1.

5 Test pattern code value precision

Both 10-bit and 12-bit code values are provided for each signal level comprising the test pattern.

Broadcast production and distribution is in general known to be based around signal flows with 10-bit precision, although there are situations and processes where 10-bit signals are converted to 12-bits.

To ensure interoperability of test pattern usage between 10-bit and 12-bit narrow-range signal paths, 10-bit code values are defined as the primary code values from which all derived 12-bit code values maintain 10-bit precision.

[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

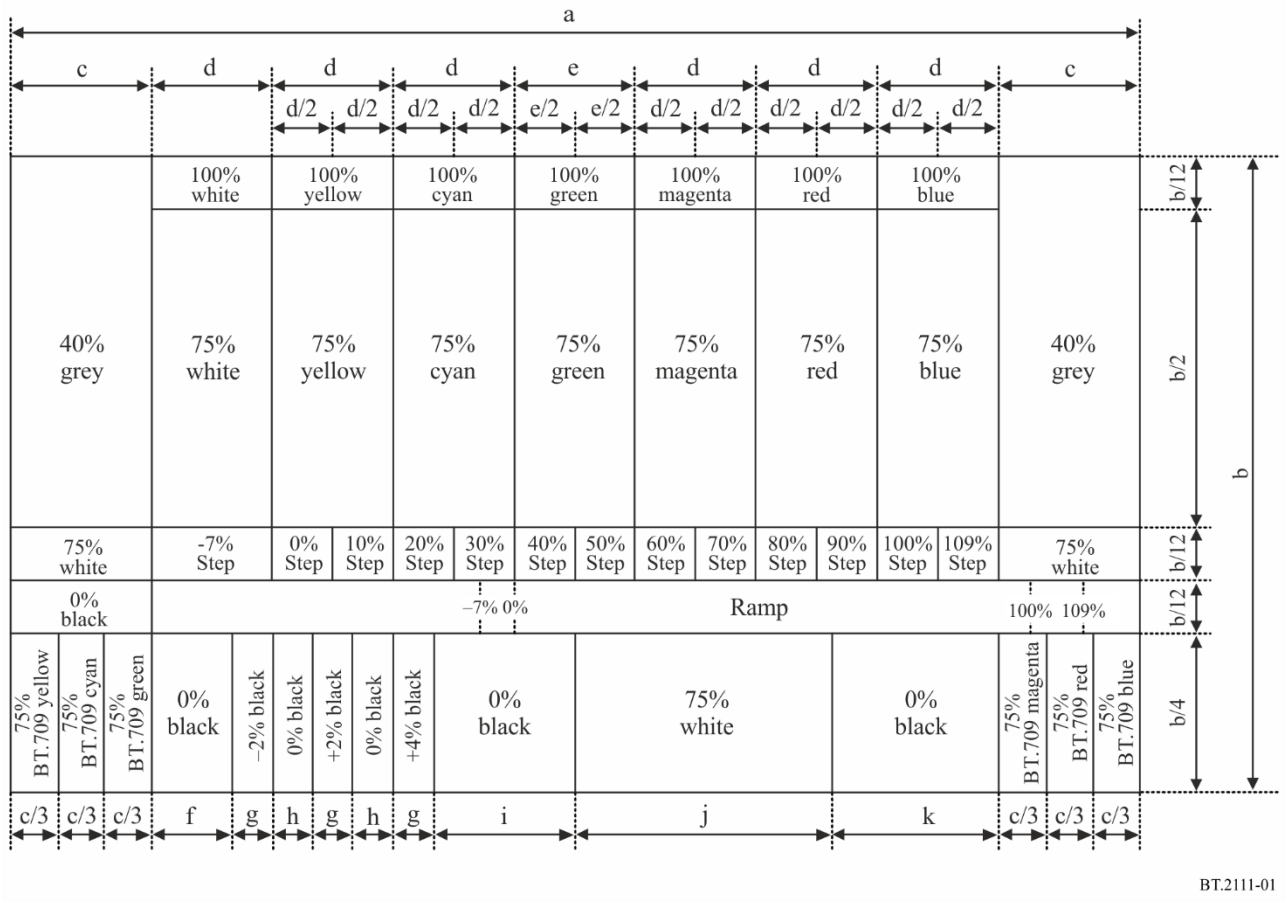


FIGURE 2

Test pattern details for PQ narrow range

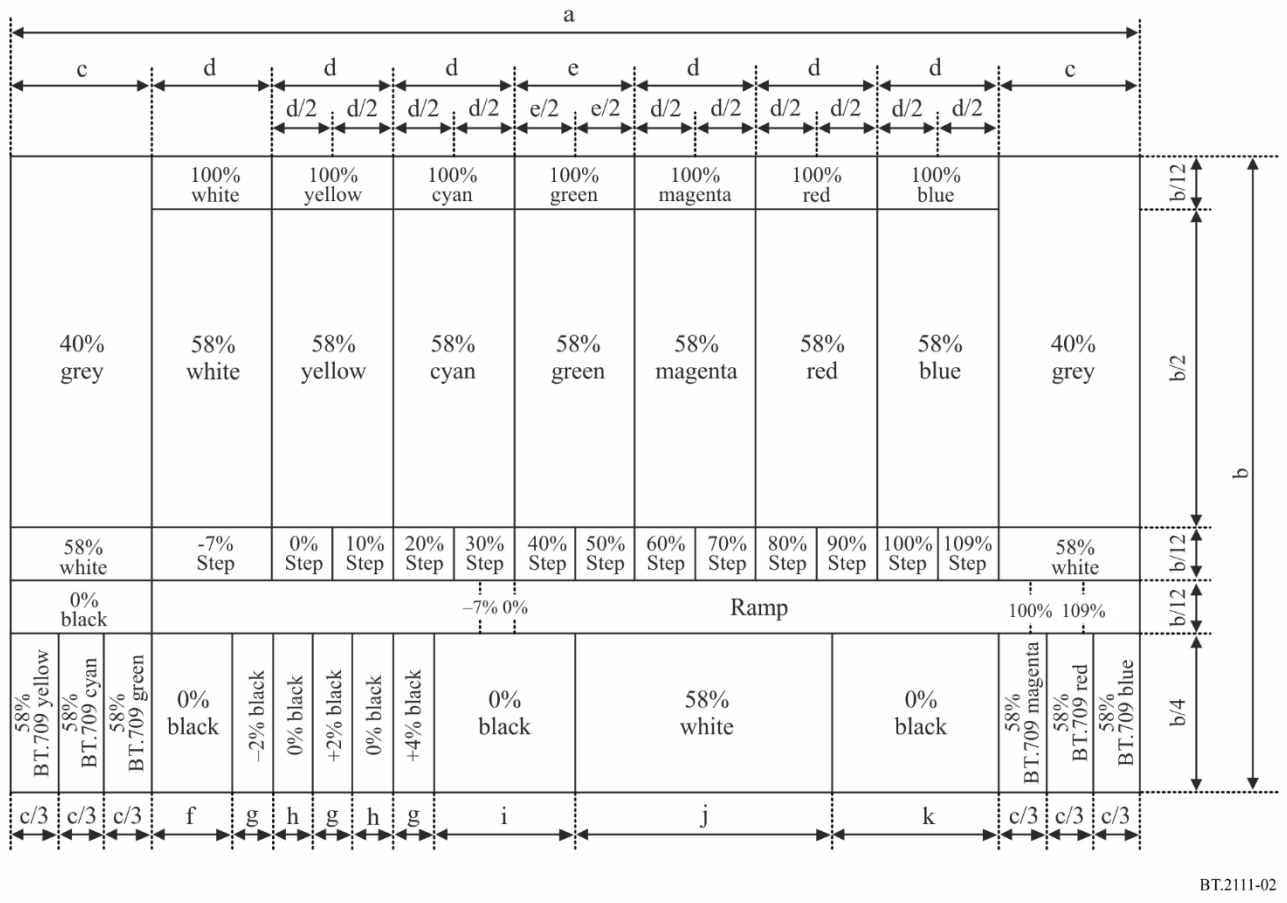
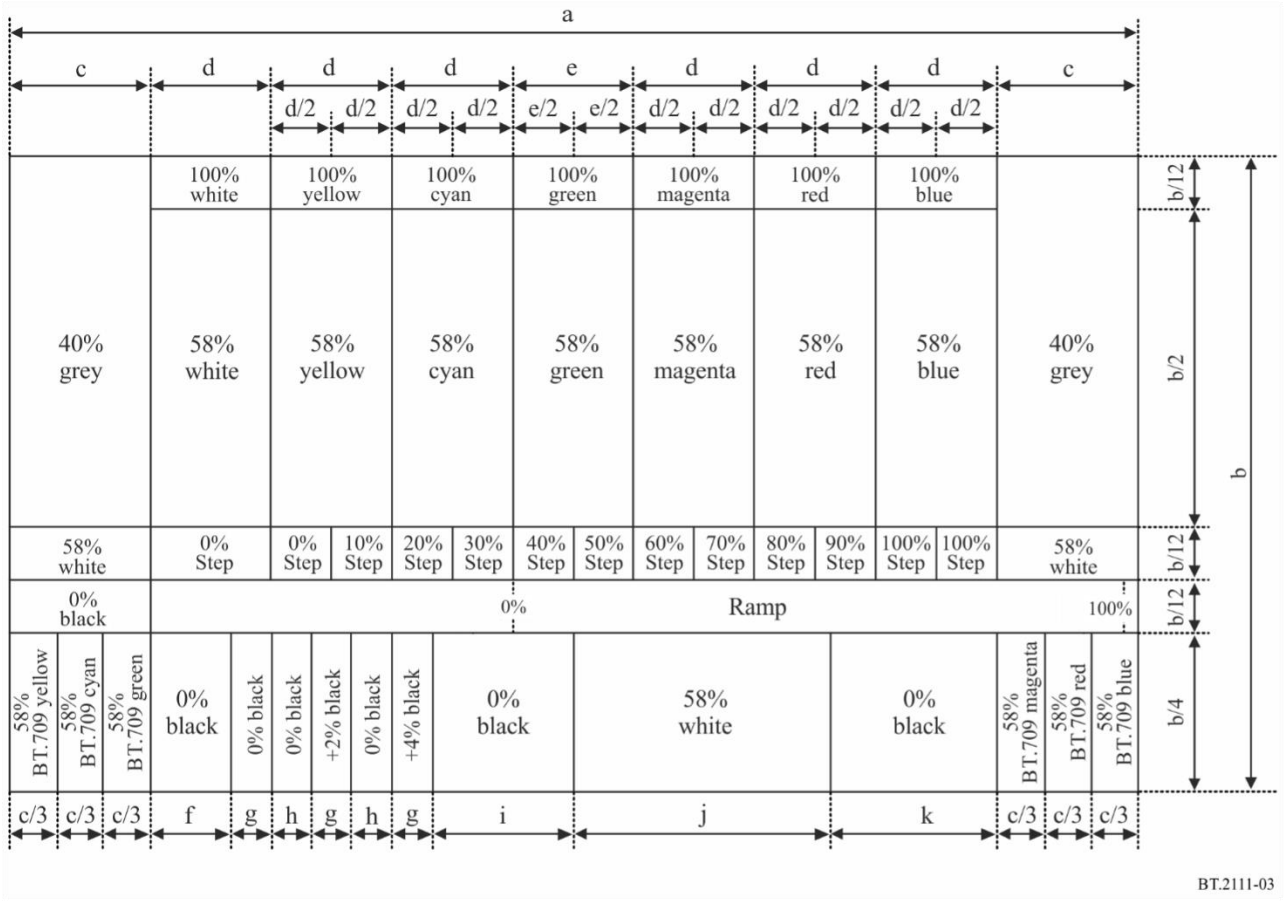


FIGURE 3

Test pattern details for PQ full range



NOTE – The position of the ramp section of the PQ full range test pattern aligns the 0% level with the left edge of the green colour bar, see Table 6. This positioning differs slightly from earlier editions of this Recommendation.

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 [(1)]	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 [2]	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 [3]	48	48	48	192	192	192
+2% Black [4]	80	80	80	320	320	320
+4% Black	99	99	99	396	396	396

[1] The code value of the approximate −7% Step is the minimum permitted value of the video data range specified in Rec. ITU-R BT.2100 for narrow range signals.

[2] The code value of the approximate +109% image area is the maximum permitted value of the video data range specified in Rec. ITU-R BT.2100 for narrow range signals.

[3] The code value of the approximate −2% Black level narrow range signal corresponds to that of the “Slightly darker level” of Rec. ITU-R BT.814.

[4] The code value of the approximate +2% Black level narrow range signal corresponds to that of the “Slightly lighter level” of Rec. ITU-R BT.814.

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
58% White (1)	573	573	573	2 292	2 292	2 292
58% Yellow (1)	573	573	64	2 292	2 292	256
58% Cyan (1)	64	573	573	256	2 292	2 292
58% Green (1)	64	573	64	256	2 292	256
58% Magenta (1)	573	64	573	2 292	256	2 292
58% Red (1)	573	64	64	2 292	256	256
58% Blue (1)	64	64	573	256	256	2 292
40% Grey	414	414	414	1 656	1 656	1 656
–7% Step (2)	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 (1)	569	572	381	2 276	2 288	1 524
58% BT.709 Cyan (1)	485	566	571	1 940	2 264	2 284
58% BT.709 Green (1)	474	565	368	1 896	2 260	1 472
58% BT.709 Magenta (1)	537	362	564	2 148	1 448	2 256
58% BT.709 Red (1)	531	351	257	2 124	1 404	1 028
58% BT.709 Blue (1)	318	236	563	1 272	944	2 252

TABLE 3 (*end*)

	10 bits			12 bits		
Image area	**R´**	**G´**	**B´**	**R´**	**G´**	**B´**
0% Black	64	64	64	256	256	256
−2% Black [3]	48	48	48	192	192	192
+2% Black [4]	80	80	80	320	320	320
+4% Black	99	99	99	396	396	396

[1] The code values of the approximate 58% levels correspond to 75% HLG at the 1 000 cd/m^2 reference level (203.15 cd/m^2). Code values differ slightly from those specified in earlier editions of this Recommendation.

[2] The code value of the approximate −7% Step is the minimum permitted value of the video data range specified in Rec. ITU-R BT.2100 for narrow range signals.

[3] The code value of the approximate −2% Black level narrow range signal corresponds to that of the "Slightly darker level" of Rec. ITU-R BT.814.

[4] The code value of the approximate +2% Black level narrow range signal corresponds to that of the "Slightly lighter level" of Rec. ITU-R BT.814.

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 [1]	594	594	594	2 378	2 378	2 378
58% Yellow [1]	594	594	0	2 378	2 378	0
58% Cyan [1]	0	594	594	0	2 378	2 378
58% Green [1]	0	594	0	0	2 378	0
58% Magenta [1]	594	0	594	2 378	0	2 378
58% Red [1]	594	0	0	2 378	0	0
58% Blue [1]	0	0	594	0	0	2 378
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

TABLE 4 (*end*)

	10 bits			12 bits		
Image area	**R´**	**G´**	**B´**	**R´**	**G´**	**B´**
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 (1)	589	593	370	2 359	2 373	1 483
58% BT.709 Cyan (1)	491	586	592	1 967	2 348	2 371
58% BT.709 Green (1)	479	585	355	1 918	2 342	1 423
58% BT.709 Magenta (1)	552	348	584	2 209	1 391	2 339
58% BT.709 Red (1)	545	335	225	2 181	1 339	901
58% BT.709 Blue (1)	296	201	582	1 186	806	2 331
0% Black	0	0	0	0	0	0
+2% Black (2)	19	19	19	75	75	75
+4% Black	41	41	41	164	164	164

(1) The code values of the approximate 58% levels correspond to 75% HLG at the 1 000 cd/m^2 reference level (203.15 cd/m^2). Code values differ slightly from those specified in earlier editions of this Recommendation.

(2) The code value of the approximate +2% Black level corresponds to that of the ‘Slightly lighter level’ of Rec. ITU-R BT.814. Code values differ slightly from those specified in earlier editions of this Recommendation.

FIGURE 5

HLG/PQ narrow range signal levels of the ramp

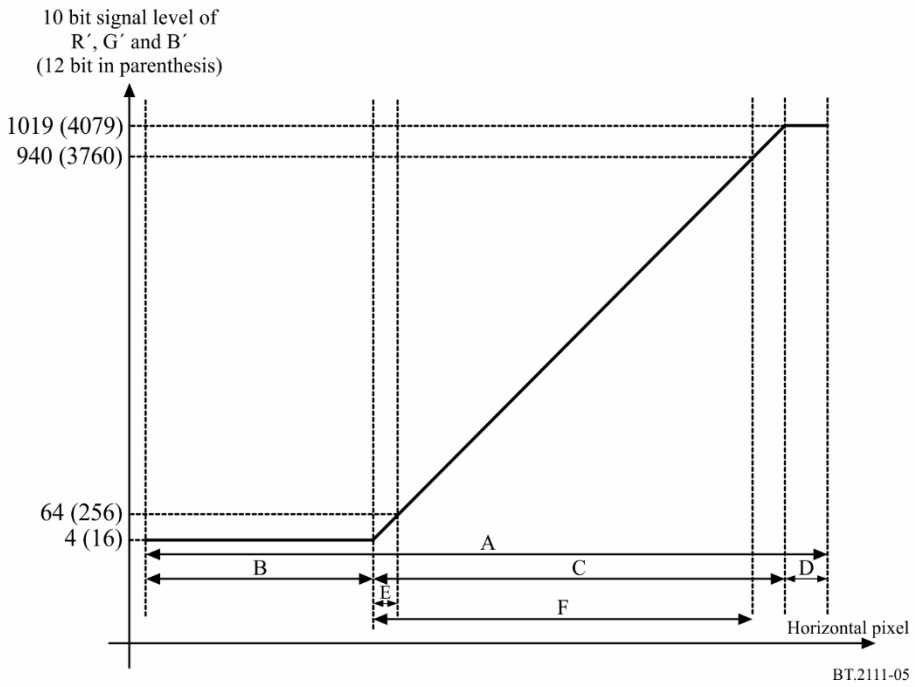


TABLE 5

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

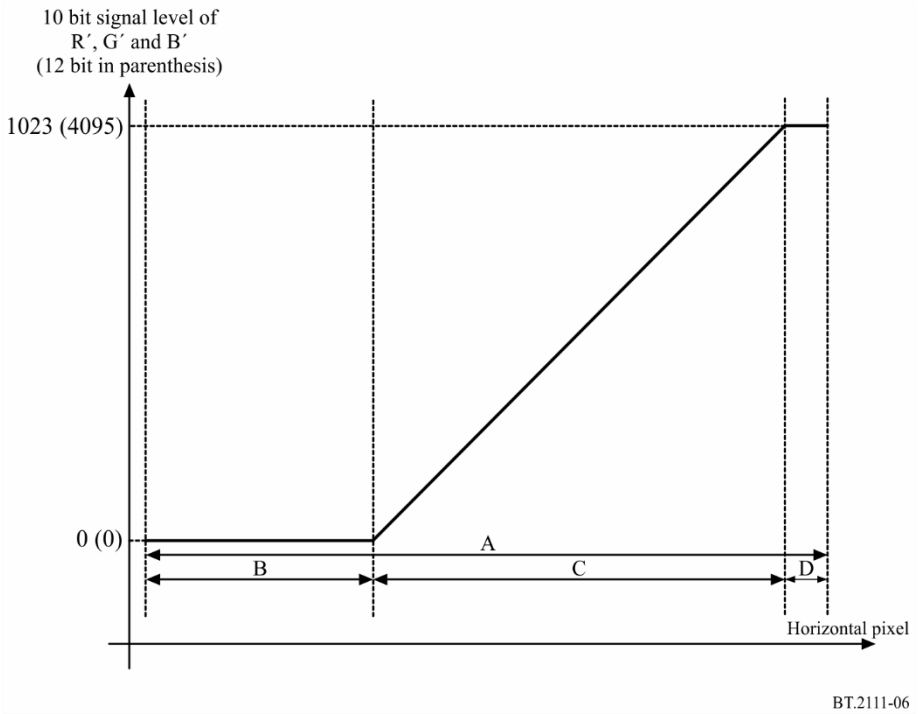


TABLE 6

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 [2]	618	618	1 236	1 236	2 472	2 472
C [1]	1 022	1 023	2 044	2 047	4 088	4 094
D [2]	40	39	80	77	160	154

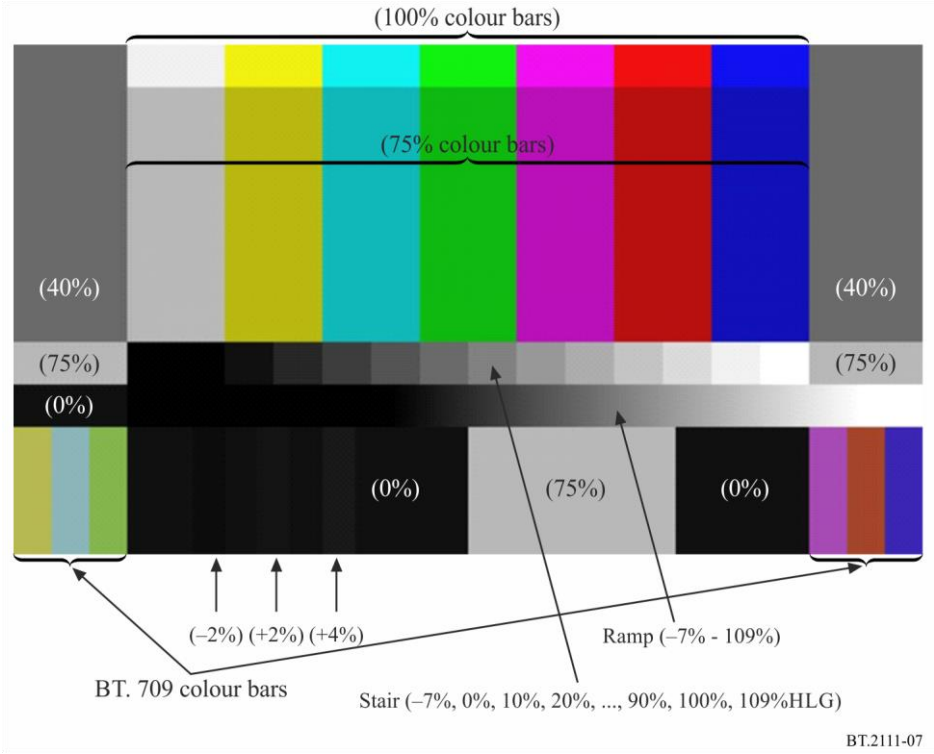
[1] C corresponds to the signal level range from 1 to 1 022 in 10 bits and from 1 to 4 094 in 8K 12 bit, 2 to 4094 in 4K 12 bit, and 4 to 4092 in 2K 12 bits.

[2] Pixel widths of B and D differ slightly from those specified in earlier editions of this Recommendation.

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 limited precision matrix shown in Recommendation ITU-R BT.2087. It should be noted that if these bars were generated using higher precision colour conversion matrices, slightly different levels would result in some cases. 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.

NOTE – The approximate −7%HLG and 109%HLG levels are the minimum and maximum permitted values respectively of the video data range specified in Recommendation ITU-R BT.2100 for narrow range signals. The code values of the approximate −2% and +2% video levels correspond to those of ‘Slightly darker level’ and ‘Slightly lighter level’ respectively of Recommendation ITU-R BT.814.

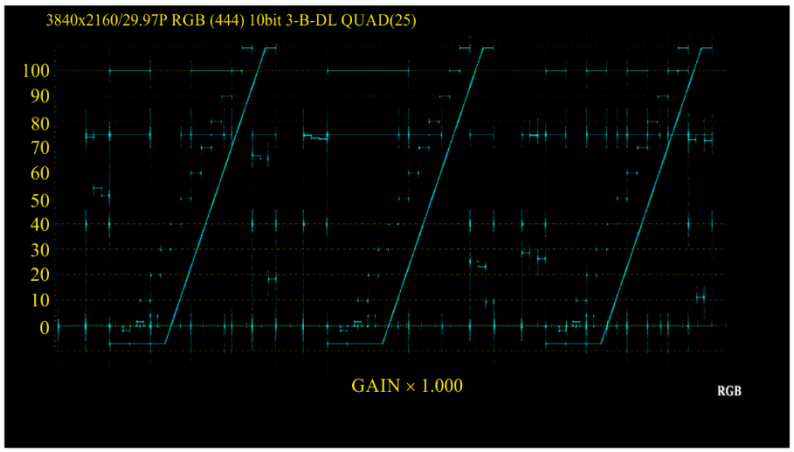
Attachment 2
to Annex 1
(informative)

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

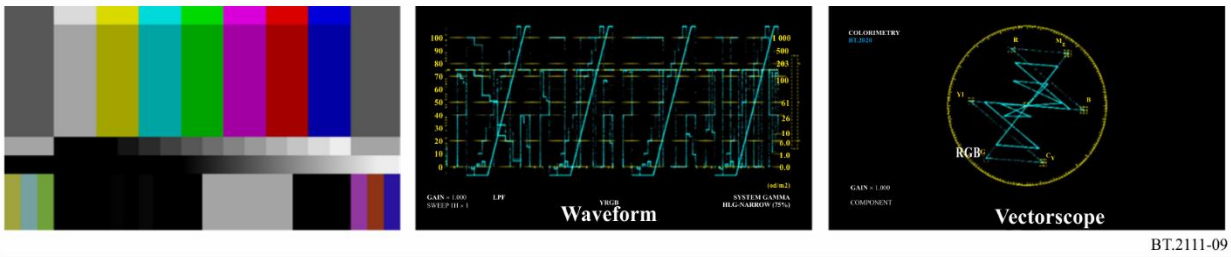
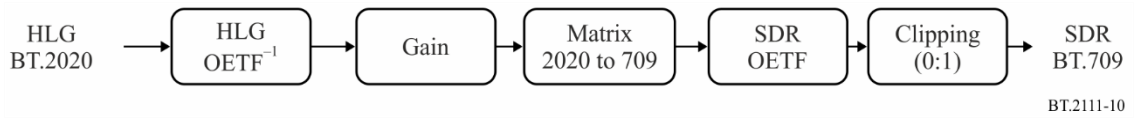


FIGURE 10

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

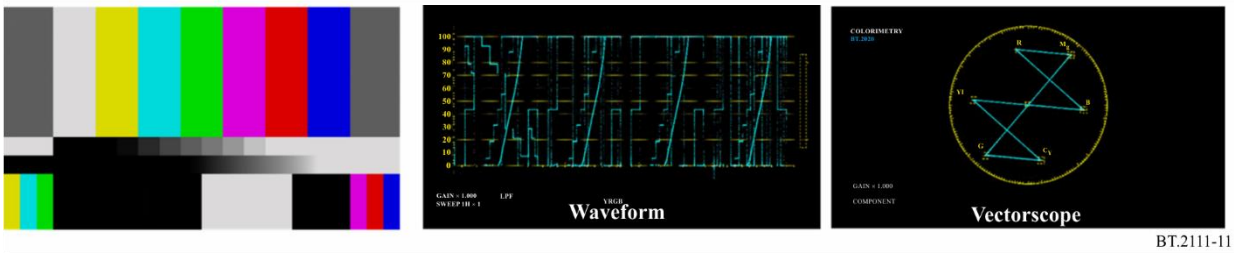
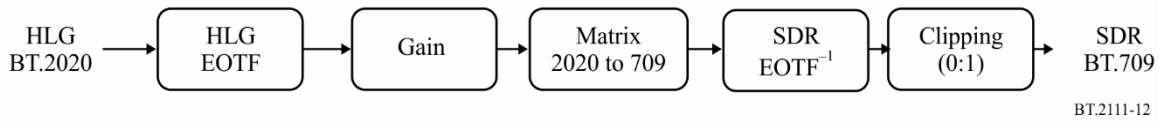


FIGURE 12

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

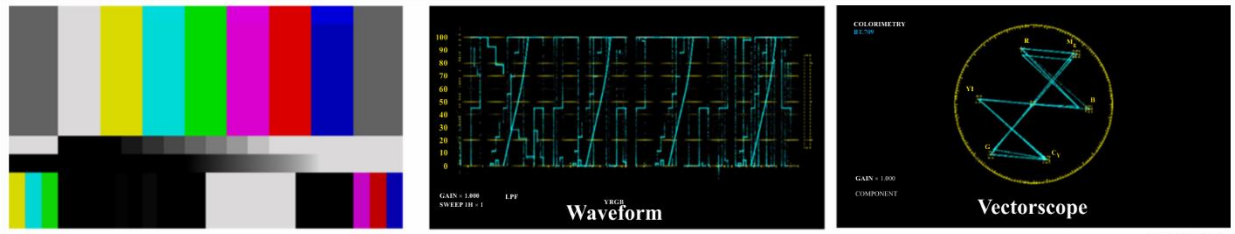


TABLE 7

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