BBC | Research & Development

Release Notes for HLG Format Conversion LUTs v1.4

Part of the HDR-TV series. Last updated April 2020, for LUT release v1.4.

These notes should be read in conjunction with the "Implementation Guidelines for HLG Format Conversion LUTs" and the "Guidance on Format Conversion in HLG Production".

Summary

To facilitate the introduction of ITU-R Recommendation BT.2100 Hybrid Log-Gamma (HLG) production, BBC R&D are licensing a package of look-up tables (LUTs) that implement a range of key format conversions.

The principal differences between this v1.4 and the previous v1.3.2 release are as follows:

1. The display-light HLG to SDR down-mapping (LUT8) is now brighter so that the BT.709 equivalent colour bars, within the EBU Tech 3373 HLG HDR colour bars, are correctly-mapped to 75% BT.709. There are also colour saturation improvements, relative to the v1.3.2 release;
2. Corresponding changes are made to the SDR-to-HLG direct-mapping (LUT3) and up-mapping (LUT5), so that round-trip losses are minimised;
3. A new luminance-based tone-mapping curve is used for the PQ4000-to-HLG conversion (LUT2), so that hue-shifts are eliminated on very bright saturated colours;
4. A new HLG-to-SDR display-light LUT - LUT9 - has been added. It replaces the Dolby PRM4200/4220 HLG LUT, which is still available upon request. LUT9 minimises round-trip losses for directly-mapped LUT3 SDR content, by placing most of the HDR image highlights within the SDR "super-white"[1] region. Note that LUT9 should only be used where super-white signals are not expected to be clipped by downstream processing;
5. More "65-cubed" versions of some key LUTs have been included for critical applications.

The HLG outputs of LUTs 1, 2, 3, 4, 5, 6, 10 & 11 are also now clipped to the EBU R103 "preferred" signal range (-5% to + 105%) for SDR signals. The clipping level may be revised once more is known about the impact of the use of HDR sub-blacks[2] and super-whites on video compression.

[1] signals above nominal peak-white (BT.709 10-bit code value 940)

[2] signals below black (BT.709 10-bit code value 64)

LUT Details

The complete set of conversion LUTs provided to licensees as part of the v1.4 release is given below.

Table 1 – Licensed Conversion LUTs

BBC **LUT Number**	**Conversion**
1	BT.2100 PQ 1000 cd/m2 to BT.2100 HLG
2	BT.2100 PQ 4000 cd/m2 to BT.2100 HLG
3	BT.709 to BT.2100 direct-mapping (display-light)
4	BT.709 to BT.2100 direct-mapping (scene-light)
5	BT.709 to BT.2100 up-mapping (display-light)
6	BT.709 to BT.2100 up-mapping (scene-light)
7	BT.2100 HLG to BT.2100 PQ 1000 cd/m2
8	BT.2100 HLG to BT.709 down-mapping (display-light)
9	BT.2100 HLG to BT.709 down-mapping (display-light) with SDR super-whites[3]
10	S-Log3 (BT.2020) to BT.2100 HLG (scene-light)
11	S-Log3 "SR Live" to BT.2100 HLG (scene-light)
12	BT.2100 HLG to BT.709 down-mapping (scene-light)
13	Test LUTs
14	PQ P3D65 1000 cd/m^2 to BT.2100 HLG
15	BT.2100 HLG to PQ P3D65 1000 cd/m^2
16	BT.2100 HLG to X′Y′Z′ PQ at 108 cd/m^2

These are described in detail in Annex 1 of this document. The annex tabulates the expected output values for SMPTE RP 219 BT.709 colour bars, BT.2111 HDR colour bars and the new EBU Tech 3373 HLG HDR colour bars. The EBU colour bars, with their embedded 75% BT.709 equivalent bars, are designed to be more robust to HDR/SDR format-conversion than the BT.2111 colour bars.

Changes between this and the previous v1.3.2 release are highlighted.

[3] signals above nominal peak-white (BT.709 10-bit code value 940)

LUT Revision History

LUT Release	Date	Comments
1.0	22/12/17	• Initial release
1.1	27/03/18	• Adds S-Log3 to HLG conversion • Adds several Type III LUTs to pass sub-blacks and super-whites • Corrects a small black-level offset for PQ LUTs 1c, 1d and 2c, 2d, 7a and 7b
1.2	20/07/18	• SDR scene-light mapping to HLG (LUT 4) now maps 100% SDR to 75% HLG rather than 73%, to align with recommendations in ITU-R Report BT.2390. • Improves the "round-tripping" performance of the display-light SDR to HLG up-mapping (LUT 5) and HLG to SDR down-mapping (LUT 8). • Improves the colour-space conversion of the display-light HLG to SDR down-mapping (LUT 8) • Adds LUT 12 for scene-light HLG-to-SDR conversion, to mimic the SDR output of a camera CCU. • Adds LUTs 13a, 13b, 13c and 13d for testing LUT hardware. • Minor improvement to the accuracy of all full-range LUT conversions.
1.3	09/04/19	• Reduced hue-shifts in the HLG to SDR BT.709 display-light conversion; • Adds scene-light LUTs for different types of SDR cameras (square-root and strict BT.709 OETFs); • Reduces the scene-light inverse-tone mapping signal level to cope with a wider range of SDR signals in live production; • Adds conversions to/from PQ with P3D65 colorimetry; • Adds 65-cube LUTs for critical workflows; • Adds an HLG to HDR X′Y′Z′ PQ 110 cd/m^2 HDR projector LUT.
1.3.1	20/06/19	• Corrects a sub-black clipping problem in LUT 8c
1.3.2	17/10/19	• Corrects a scaling issue in the PQ to HLG Type III conversions, LUT s 7c & 7d
1.4	11/02/20	• LUT2, a new luminance-based tone-mapping curve is used for the PQ4000-to-HLG conversion, so that hue shifts on very bright saturated colours are eliminated. • LUT3, minor accuracy improvements. • LUT5, changes are made to the SDR to HLG up-mapping to minimise round-trip losses with LUTs 8 and 9.

		• LUT8, the display-light HLG to SDR down-mapping is brighter than previous releases, to correctly-map the BT.709 equivalent colour bars within the EBU Tech 3373 HLG HDR colour bars to 75% BT.709. There are also colour-saturation improvements over the v1.3.1 release. • LUT9, a new HLG-to-SDR display-light LUT has been added (replacing the original LUT9, Dolby PRM4200/4220 HLG LUT – still available upon request). The new LUT minimises round-trip losses for directly-mapped SDR content (using LUT3) by shifting most of the HDR image-highlights to the SDR super-white region. • More 65-cubed versions of some of the key LUTs have been included for critical applications. • In addition, the HLG output is now clipped at EBU R103 "preferred" levels for LUTs 1, 2, 3, 4, 5, 6, 10 and 11

Licensing Options

Two licences are available. The first is intended for manufacturers wishing to either embed the LUTs within their products, or include the LUTs with their products. The second is intended for broadcasters and production facilities, where the LUTs are to be loaded into existing equipment or software tools.

Please email transfer.rd@bbc.co.uk for details.

Annex 1- Details of new or changed LUTs

Target Output Values

For the majority of LUTs, we provide tables of the ideal output values for defined input test signals. Please note that within the tables, the R′G′B′ output signals are normalised in the range 0.0 to 1.0, over the *nominal* signal range. They do not represent the output values from the look-up tables themselves, which will be different for each LUT variant. Furthermore, the values are derived from floating-point algorithmic implementations of the conversions. The tables of ideal values take no account of 3D-LUT interpolation errors, which will vary between implementations. Nor do they factor in the signal-clipping associated with Type I (narrow range mode) LUTs that do not process sub-blacks and super-whites. In addition, the 10-bit $Y'C'_BC'_R$ code values have been calculated from the floating-point R′G′B′ output values, rather than being rounded after 10-bit R′G′B′ hardware processing. The tables of ideal output values have been provided as an indication for implementers that they have chosen the correct LUT variant, for their particular LUT implementation. The tables are not intended to help debug hardware or software. Differences of +/- two 10-bit data levels should be expected between the tabulated 'ideal' values, and real-world 33-cubed and 65-cubed 3D-LUT implementations.

For the display-light and scene-light down-mapping LUTs (LUTs 8, 9 and 12), the 3D-LUT interpolation errors tend to be higher than for the other LUTs. That is because the output signals extend to the extremities of the R′G′B′ signal range, where one or more of the index values (between which others are interpolated) may have been clipped to lie within the desired output signal range. So, we also provide tables of the expected output values from a 33-cubed trilinear interpolator. The errors are generally smaller with tetrahedral interpolation and the 65-cubed LUTs, but the very worst-case errors may be similar.

LUT 1: Graded Content – BT.2100 PQ 1000 cd/m^2 to BT.2100 HLG

Changes in v1.4: HLG output is now clipped at EBU R103 "preferred" signal range levels

BT.2100 PQ signals are converted to BT.2100 HLG in the 1000 cd/m^2 "bridge" condition, so that 1000 cd/m^2 PQ maps to 100% HLG. Please refer to ITU-R report BT.2390 Section 7.2 ("Conversion concepts using a reference condition at 1000 cd/m^2"). With the Type III LUTs, PQ signals above 1000 cd/m^2 are mapped into the HLG "super-white" signal range up to 105% signal, equivalent to 1398 cd/m^2.

The table illustrates the expected output signals from an ideal algorithmic converter, presented with a BT.2111 PQ colour bar input. It takes no account of the expected interpolation or rounding errors.

LUT 1: Graded Content - PQ 1000 cd/m2 to BT.2100 HLG						
Test Input:	**Ideal BT.2100 HLG Output**					
BT.2111 PQ	**Nominal Range [0.0 ... 1.0]**			**10-Bit SDI**		
Colour bars	**R'**	**G'**	**B'**	**Y'**	**C'$_B$**	**C'$_R$**
100% White	1.0502	1.0502	1.0502	984	512	512
100% Yellow	1.0502	1.0502	0.0000	929	41	550
100% Cyan	0.0000	1.0502	1.0502	742	643	41
100% Green	0.0000	1.0502	0.0000	688	173	79
100% Magenta	1.0502	0.0000	1.0502	360	851	945
100% Red	1.0502	0.0000	0.0000	306	381	983
100% Blue	0.0000	0.0000	1.0502	119	983	474
58% White	0.7487	0.7487	0.7487	720	512	512
58% Yellow	0.7507	0.7507	0.0000	683	176	539
58% Cyan	0.0000	0.7586	0.7586	554	607	172
58% Green	0.0000	0.7613	0.0000	516	266	198
58% Magenta	0.7855	0.0000	0.7855	286	766	836
58% Red	0.7920	0.0000	0.0000	246	413	867
58% Blue	0.0000	0.0000	0.8394	108	888	482
40% Grey	0.4143	0.4143	0.4143	427	512	512
−7% Step	-0.0410	-0.0410	-0.0410	28	512	512
0% Step	0.0000	0.0000	0.0000	64	512	512
10% Step	0.0613	0.0613	0.0613	118	512	512
20% Step	0.1408	0.1408	0.1408	187	512	512
30% Step	0.2549	0.2549	0.2549	287	512	512
40% Step	0.4143	0.4143	0.4143	427	512	512
50% Step	0.6152	0.6152	0.6152	603	512	512
60% Step	0.7805	0.7805	0.7805	748	512	512
70% Step	0.9265	0.9265	0.9265	876	512	512
80% Step	1.0502	1.0502	1.0502	984	512	512
90% Step	1.0502	1.0502	1.0502	984	512	512
100% Step	1.0502	1.0502	1.0502	984	512	512
109% Step	1.0502	1.0502	1.0502	984	512	512
58% BT.709 Yellow	0.7425	0.7489	0.2897	695	307	526
58% BT.709 Cyan	0.5483	0.7434	0.7542	671	541	424
58% BT.709 Green	0.5247	0.7425	0.2717	640	328	431
58% BT.709 Magenta	0.7113	0.2797	0.7724	434	679	688
58% BT.709 Red	0.7076	0.2658	0.1290	391	395	715
58% BT.709 Blue	0.2298	0.1179	0.8123	229	809	537
0% Black	0.0000	0.0000	0.0000	64	512	512
−2% Black	-0.0125	-0.0125	-0.0125	53	512	512
+2% Black	0.0125	0.0125	0.0125	75	512	512
+4% Black	0.0245	0.0245	0.0245	85	512	512

LUT 1 Details						
Variant	**LUT Type**	**LUT Cube Size**	**SDI LUT Mode Narrow: 64 - 940 (10-bit) Full: 0 – 1023 (10-bit)**	**Input Range [Min Input .. Max input]**	**Output Range [0.0 .. 1.0]**	**BT.709 colour matrix comp.**
1a	I	33	Narrow	Nominal	Nominal	No
1a65	I	65	Narrow	Nominal	Nominal	No
1b	I	33	Narrow	Nominal	Nominal	Yes
1c	II	33	Full	Full/Nominal	Headroom	No
1d	II	33	Full	Full/Nominal	Headroom	Yes
1e	III	33	Full	Headroom	Headroom	No
1f	III	33	Full	Headroom	Headroom	Yes

LUT 2: Graded Content – BT.2100 PQ 4000 cd/m^2 to BT.2100 HLG

Changes in v1.4: improved tone-mapping in this release and HLG output now clipped at EBU R103 "preferred" signal range levels.

4000 cd/m^2 BT.2100 PQ signals are converted to BT.2100 HLG by first tone-mapping to the 1000 cd/m^2 "bridge" condition, and then converting to HLG. The tone-mapping is applied to the luminance component so that hue distortions are avoided; note that 4000 cd/m^2 PQ maps to 100% HLG. For more information, please refer to ITU-R report BT.2390 Section 7.4 ("Handling PQ signals with greater than 1000 cd/m^2 peak-luminance"). With Type III LUTs, PQ signals above 4000 cd/m^2 are mapped into the HLG "super-white" signal range.

The table below illustrates the output signals expected from an "ideal" algorithmic converter, presented with a BT.2111 PQ colour bar input. It takes no account of the expected interpolation or rounding errors.

LUT 2: PQ 4000 cd/m2 to BT.2100 HLG						
Test Input : BT.2111 PQ Bars	**Ideal BT.2100 HLG Output**					
	Nominal Range [0.0 … 1.0]			**10-Bit SDI**		
	R'	**G'**	**R'**	**Y'**	**C'$_B$**	**C'$_R$**
100% White	1.0380	1.0380	1.0380	973	512	512
100% Yellow	1.0469	1.0469	0.0000	927	43	550
100% Cyan	0.0000	1.0502	1.0502	742	643	41
100% Green	0.0000	1.0502	0.0000	688	173	79
100% Magenta	1.0502	0.0000	1.0502	360	851	945
100% Red	1.0502	0.0000	0.0000	306	381	983
100% Blue	0.0000	0.0000	1.0502	119	983	474
58% White	0.7487	0.7487	0.7487	720	512	512
58% Yellow	0.7507	0.7507	0.0000	683	176	539
58% Cyan	0.0000	0.7586	0.7586	554	607	172
58% Green	0.0000	0.7613	0.0000	516	266	198
58% Magenta	0.7855	0.0000	0.7855	286	766	836
58% Red	0.7920	0.0000	0.0000	246	413	867
58% Blue	0.0000	0.0000	0.8394	108	888	482
40% Grey	0.4143	0.4143	0.4143	427	512	512
−7% Step	-0.0410	-0.0410	-0.0410	28	512	512
0% Step	0.0000	0.0000	0.0000	64	512	512
10% Step	0.0613	0.0613	0.0613	118	512	512
20% Step	0.1408	0.1408	0.1408	187	512	512
30% Step	0.2549	0.2549	0.2549	287	512	512
40% Step	0.4143	0.4143	0.4143	427	512	512
50% Step	0.6152	0.6152	0.6152	603	512	512
60% Step	0.7785	0.7785	0.7785	746	512	512

LUT 2: PQ 4000 cd/m2 to BT.2100 HLG						
Test Input : BT.2111 PQ Bars	**Ideal BT.2100 HLG Output**					
	Nominal Range [0.0 ... 1.0]			**10-Bit SDI**		
	R'	**G'**	**R'**	**Y'**	**C'_B**	**C'_R**
70% Step	0.8822	0.8822	0.8822	837	512	512
80% Step	0.9503	0.9503	0.9503	896	512	512
90% Step	0.9992	0.9992	0.9992	939	512	512
100% Step	1.0380	1.0380	1.0380	973	512	512
109% Step	1.0502	1.0502	1.0502	984	512	512
58% BT.709 Yellow	0.7425	0.7489	0.2897	695	307	526
58% BT.709 Cyan	0.5483	0.7434	0.7542	671	541	424
58% BT.709 Green	0.5247	0.7425	0.2717	640	328	431
58% BT.709	0.7113	0.2797	0.7724	434	679	688
58% BT.709 Red	0.7076	0.2658	0.1290	391	395	715
58% BT.709 Blue	0.2298	0.1179	0.8123	229	809	537
0% Black	0.0000	0.0000	0.0000	64	512	512
−2% Black	-0.0125	-0.0125	-0.0125	53	512	512
+2% Black	0.0125	0.0125	0.0125	75	512	512
+4% Black	0.0245	0.0245	0.0245	85	512	512

LUT 2 Details						
Variant	**LUT Type**	**LUT Cube Size**	**SDI LUT Mode Narrow: 64 - 940 (10-bit) Full: 0 – 1023 (10-bit)**	**Input Range [Min Input .. Max input]**	**Output Range [0.0 .. 1.0]**	**BT.709 colour matrix comp.**
2a	I	33	Narrow	Nominal	Nominal	No
2a65	I	65	Narrow	Nominal	Nominal	No
2b	I	33	Narrow	Nominal	Nominal	Yes
2c	II	33	Full	Full/Nominal	Headroom	No
2d	II	33	Full	Full/Nominal	Headroom	Yes
2e	III	33	Full	Headroom	Headroom	No
2f	III	33	Full	Headroom	Headroom	Yes

LUT 3: SDR Graphics - BT.709 to BT.2100 HLG, Direct-Mapping (Display-Light)

Changes in v1.4: minor accuracy improvements and HLG output now clipped at EBU R103 "preferred" signal range levels.

BT.709 signals are directly-mapped into BT.2100 HLG at the BT.2408 signal levels using a display-light conversion. The "look" of the original BT.709 content is therefore preserved on conversion. A 100% SDR signal is mapped to 75% HLG ("HDR Reference White").

The table below illustrates the output signals expected from an "ideal" algorithmic converter, presented with a SMPTE RP 219 colour bar input. The expected interpolation errors have not been factored in.

LUT 3: BT.709 to BT.2100 HLG, Direct Mapping (Display-Light)						
Test Input: SMPTE 219 75% Colour bars	**Ideal BT.2100 HLG Output**					
	Nominal Range [0.0 … 1.0]			**10-Bit SDI**		
	R'	**G'**	**B'**	**Y'**	**C'_B**	**C'_R**
75% White	0.6145	0.6145	0.6145	602	512	512
75% Yellow	0.6055	0.6127	0.2073	578	331	523
75% Cyan	0.3930	0.6011	0.6131	543	543	418
75% Green	0.3702	0.5993	0.1914	515	358	424
75% Magenta	0.5363	0.1866	0.6060	330	656	654
75% Red	0.5233	0.1740	0.0848	292	428	672
75% Blue	0.1409	0.0722	0.6147	171	746	523
40% Grey	0.3107	0.3107	0.3107	336	512	512
15% Grey	0.1004	0.1004	0.1004	152	512	512
0% Black	0.0000	0.0000	0.0000	64	512	512
−2% Black	-0.0103	-0.0103	-0.0103	55	512	512
+2% Black	0.0103	0.0103	0.0103	73	512	512
100% White	0.7500	0.7500	0.7500	721	512	512

LUT 3 Details						
Variant	**LUT Type**	**LUT Cube Size**	**SDI LUT Mode Narrow: 64 - 940 (10-bit) Full: 0 – 1023 (10-bit)**	**Input Range [Min Input .. Max input]**	**Output Range [0.0 .. 1.0]**	**BT.709 colour matrix comp.**
3a	I	33	Narrow	Nominal	Nominal	No
3a65	I	65	Narrow	Nominal	Nominal	No
3b	I	33	Narrow	Nominal	Nominal	Yes
3c	III	33	Full	Headroom	Headroom	No
3d	III	33	Full	Headroom	Headroom	Yes

LUT 4-1: SDR Compact Cameras – BT.709 to BT.2100 HLG, Direct Mapping (Scene-Light)

Changes in v1.4: HLG output now clipped at EBU R103 “preferred” signal range levels.

For use with most compact SDR cameras that approximate the BT.709 OETF with a square-root

BT.709 signals are directly-mapped into BT.2100 HLG at the BT.2408 signal levels using a scene-light conversion. The “look” of the original BT.709 content is changed to match the subjective look of “native” BT.2100 HLG cameras. 100% SDR signal is directly-mapped to 75% HLG (“HDR Reference White”).

This LUT is intended to be used with compact SDR cameras with a limited dynamic-range, so no highlight “boost” is applied.

The table illustrates the output signals expected from an “ideal” converter, presented with a SMPTE RP 219 colour bar input. The expected interpolation errors have not been factored in.

LUT 4-1: BT.709 to BT.2100 HLG, Direct Mapping (Scene-Light)						
Test Input: SMPTE 219 75% Colour bars	**Ideal BT.2100 HLG Output**					
	Nominal Range [0.0 … 1.0]			**10-Bit SDI**		
	R'	**G'**	**B'**	**Y'**	**C'_B**	**C'_R**
75% White	0.6329	0.6329	0.6329	618	512	512
75% Yellow	0.6234	0.6304	0.2161	593	327	524
75% Cyan	0.4081	0.6175	0.6294	557	543	418
75% Green	0.3837	0.6149	0.1984	528	354	423
75% Magenta	0.5440	0.1897	0.6131	334	657	655
75% Red	0.5282	0.1758	0.0856	294	428	673
75% Blue	0.1391	0.0713	0.6092	170	744	523
40% Grey	0.3562	0.3562	0.3562	376	512	512
15% Grey	0.1333	0.1333	0.1333	181	512	512
0% Black	0.0000	0.0000	0.0000	64	512	512
−2% Black	-0.0183	-0.0183	-0.0183	48	512	512
+2% Black	0.0183	0.0183	0.0183	80	512	512
100% White	0.7500	0.7500	0.7500	721	512	512

LUT 4-1 Details						
Variant	**LUT Type**	**LUT Cube Size**	**SDI LUT Mode Narrow: 64 - 940 (10-bit) Full: 0 – 1023 (10-bit)**	**Input Range [Min Input .. Max input]**	**Output Range [0.0 .. 1.0]**	**BT.709 colour matrix comp.**
4-1a	III	33	Full	Headroom	Headroom	No
4-1b	III	33	Full	Headroom	Headroom	Yes

LUT 4-2: SDR Compact Cameras – BT.709 to BT.2100 HLG, Direct Mapping (Scene-Light)

Changes in v1.4: HLG output now clipped at EBU R103 "preferred" signal range levels.

For use with compact SDR cameras that implement a strict BT.709 OETF

BT.709 signals are directly-mapped into BT.2100 HLG at the BT.2408 signal levels, using a scene-light conversion. The "look" of the original BT.709 content is changed to match the subjective look of "native" BT.2100 HLG cameras. 100% SDR signal is mapped to 75% HLG ("HDR Reference White").

This LUT is intended to be used with compact SDR cameras with a limited dynamic-range, so no highlight "boost" is applied.

NOTE: Unlike BT.2100 HLG, SDR cameras that implement a strict BT.709 OETF tend to crush detail in the shadows of a scene. Such detail will become more evident after applying this conversion. It is often better to adjust the SDR camera's native OETF to approximate a square-root (which provides a better match to HLG) and then use LUT 4-1 rather than this LUT.

The table below illustrates the output signals expected from an "ideal" converter, presented with a SMPTE RP 219 colour bar input. The expected interpolation errors have not been factored in.

LUT 4-2: BT.709 to BT.2100 HLG, Direct Mapping (Scene-Light)						
Test Input: SMPTE 219 75% Colour bars	**Ideal BT.2100 HLG Output**					
	Nominal Range [0.0 … 1.0]			**10-Bit SDI**		
	R'	**G'**	**B'**	**Y'**	**C'_B**	**C'_R**
75% White	0.6333	0.6333	0.6333	619	512	512
75% Yellow	0.6238	0.6309	0.2163	593	327	524
75% Cyan	0.4085	0.6180	0.6298	558	543	418
75% Green	0.3841	0.6153	0.1986	528	354	423
75% Magenta	0.5445	0.1899	0.6135	334	657	656
75% Red	0.5287	0.1760	0.0857	295	427	673
75% Blue	0.1393	0.0713	0.6096	170	745	523
40% Grey	0.3706	0.3706	0.3706	389	512	512
15% Grey	0.1711	0.1711	0.1711	214	512	512
0% Black	0.0000	0.0000	0.0000	64	512	512
−2% Black	-0.0602	-0.0602	-0.0602	11	512	512
+2% Black	0.0602	0.0602	0.0602	117	512	512
100% White	0.7500	0.7500	0.7500	721	512	512

LUT 4-2 Details						
Variant	**LUT Type**	**LUT Cube Size**	**SDI LUT Mode Narrow: 64 - 940 (10-bit) Full: 0 – 1023 (10-bit)**	**Input Range [Min Input .. Max input]**	**Output Range [0.0 .. 1.0]**	**BT.709 colour matrix comp.**
4-2a	III	33	Full	Headroom	Headroom	No
4-2b	III	33	Full	Headroom	Headroom	Yes

LUT 5: SDR Graded Content – BT.709 to BT.2100 HLG, Up-Mapping (Display-Light)

Changes in v1.4: up-mapping changed in this release, to complement the new LUT8. HLG output also clipped at EBU R103 "preferred" signal range levels.

BT.709 signals are up-mapped (inverse tone-mapped) to BT.2100 HLG using a display-light conversion. This LUT is designed to complement LUTs 8 and 9 (BT.2100 HLG to BT.709 down-mapping) so that losses associated with 'round-tripping' (i.e. SDR-to-HDR-to-SDR conversion) are minimised.

Whilst the ITU-R BT.2408 signal levels are taken into account, a modest boost is applied to the SDR highlights so that there is a closer match to natively-produced HDR content. The LUT does, however, attempt to preserve the artistic intent of the original BT.709 content. 100% SDR signal is up-mapped to 82% HLG.

The table below illustrates the output signals expected from an "ideal" converter, presented with a SMPTE RP 219 colour-bar input. The expected interpolation errors have not been factored in.

LUT 5: BT.709 to BT.2100 HLG, Up-Mapping (Display-Light)						
Test Input: SMPTE 219 75% Colour bars	**Ideal BT.2100 HLG Output**					
	Nominal Range [0.0 … 1.0]			**10-Bit SDI**		
	R'	**G'**	**B'**	**Y'**	**C'_B**	**C'_R**
75% White	0.6145	0.6145	0.6145	602	512	512
75% Yellow	0.6055	0.6127	0.2073	578	331	523
75% Cyan	0.3930	0.6011	0.6131	543	543	418
75% Green	0.3702	0.5993	0.1914	515	358	424
75% Magenta	0.5363	0.1866	0.6060	330	656	654
75% Red	0.5233	0.1740	0.0848	292	428	672
75% Blue	0.1409	0.0722	0.6147	171	746	523
40% Grey	0.3107	0.3107	0.3107	336	512	512
15% Grey	0.1004	0.1004	0.1004	152	512	512
0% Black	0.0000	0.0000	0.0000	64	512	512
−2% Black	-0.0103	-0.0103	-0.0103	55	512	512
+2% Black	0.0103	0.0103	0.0103	73	512	512
100% White	0.8200	0.8200	0.8200	782	512	512

LUT 5 Details						
Variant	**LUT Type**	**LUT Cube Size**	**SDI LUT Mode Narrow: 64 - 940 (10-bit) Full: 0 – 1023 (10-bit)**	**Input Range [Min Input .. Max input]**	**Output Range [0.0 .. 1.0]**	**BT.709 colour matrix comp.**
5a	I	33	Narrow	Nominal	Nominal	No
5a65	I	65	Narrow	Nominal	Nominal	No
5b	I	33	Narrow	Nominal	Nominal	Yes
5c	III	33	Full	Headroom	Headroom	No
5d	III	33	Full	Headroom	Headroom	Yes

LUT 6-1: SDR High Quality Cameras – BT.709 to BT.2100 HLG, Up-Mapping (Scene-Light)

Changes in v1.4: HLG output now clipped at EBU R103 "preferred" signal range levels.

For use with SDR cameras that approximate the BT.709 OETF with a square root

BT.709 signals are up-mapped (inverse tone-mapped) to BT.2100 HLG, using a scene-light conversion. The "look" of the original BT.709 content is changed to match the "look" of native BT.2100 HLG cameras. Whilst the ITU-R BT.2408 signal levels are taken into account, a small boost is applied to the SDR highlights so that there's a close match to natively-produced HDR content. 100% SDR signal is up-mapped to 79% HLG. 105% SDR signals (EBU R.103 "preferred range" signals) are up-mapped to 83% HLG.

The table below illustrates the output signals expected from an "ideal" converter, presented with a SMPTE RP 219 colour bar input. The expected interpolation errors have not been factored in.

LUT 6-1: BT.709 to BT.2100 HLG, Up-Mapping (Scene-Light)						
Test Input: SMPTE 219 75% Colour bars	**Ideal BT.2100 HLG Output**					
	Nominal Range [0.0 … 1.0]			**10-Bit SDI**		
	R'	**G'**	**B'**	**Y'**	**C'_B**	**C'_R**
75% White	0.6329	0.6329	0.6329	618	512	512
75% Yellow	0.6234	0.6304	0.2161	593	327	524
75% Cyan	0.4081	0.6175	0.6294	557	543	418
75% Green	0.3837	0.6149	0.1984	528	354	423
75% Magenta	0.5440	0.1897	0.6131	334	657	655
75% Red	0.5282	0.1758	0.0856	294	428	673
75% Blue	0.1391	0.0713	0.6092	170	744	523
40% Grey	0.3562	0.3562	0.3562	376	512	512
15% Grey	0.1333	0.1333	0.1333	181	512	512
0% Black	0.0000	0.0000	0.0000	64	512	512
−2% Black	-0.0183	-0.0183	-0.0183	48	512	512
+2% Black	0.0183	0.0183	0.0183	80	512	512
100% White	0.7900	0.7900	0.7900	756	512	512

LUT 6-1 Details						
Variant	**LUT Type**	**LUT Cube Size**	**SDI LUT Mode Narrow: 64 - 940 (10-bit) Full: 0 – 1023 (10-bit)**	**Input Range [Min Input .. Max input]**	**Output Range [0.0 .. 1.0]**	**BT.709 colour matrix comp.**
6-1a	III	33	Full	Headroom	Headroom	No
6-1b	III	33	Full	Headroom	Headroom	Yes

LUT 6-2: SDR High Quality Cameras – BT.709 to BT.2100 HLG, Up-Mapping (Scene-Light)

Changes in v1.4: HLG output now clipped at EBU R103 "preferred" signal range levels.

For use with SDR cameras that implement a strict BT.709 OETF

BT.709 signals are up-mapped (inverse tone-mapped) to BT.2100 HLG using a scene-light conversion. The "look" of the original BT.709 content is changed, so that the native look of BT.2100 HLG cameras is achieved. Whilst the ITU-R BT.2408 signal levels are taken into account, a small boost is applied to the SDR highlights so that there is a closer match to natively-produced HDR content. A 100% SDR signal is up-mapped to 79% HLG. 105% SDR signals (EBU R.103 "preferred range" signals) are up-mapped to 83% HLG.

NOTE: Unlike BT.2100 HLG, SDR cameras that implement a strict BT.709 OETF tend to crush detail in the shadows of a scene. Such detail will become more visible after applying this conversion. It is often better to adjust the SDR camera's native OETF to approximate a square-root (which provides a better match to HLG) and then use LUT 6-1.

The table below illustrates the output signals expected from an "ideal" converter, presented with a SMPTE RP 219 colour bar input. The expected interpolation errors have not been factored in.

LUT 6-2: BT.709 to BT.2100 HLG, Up-Mapping (Scene-Light)						
Test Input: SMPTE 219 75% Colour bars	**Ideal BT.2100 HLG Output**					
	Nominal Range [0.0 … 1.0]			**10-Bit SDI**		
	R'	**G'**	**B'**	**Y'**	**C'_B**	**C'_R**
75% White	0.6333	0.6333	0.6333	619	512	512
75% Yellow	0.6238	0.6309	0.2163	593	327	524
75% Cyan	0.4085	0.6180	0.6298	558	543	418
75% Green	0.3841	0.6153	0.1986	528	354	423
75% Magenta	0.5445	0.1899	0.6135	334	657	656
75% Red	0.5287	0.1760	0.0857	295	427	673
75% Blue	0.1393	0.0713	0.6096	170	745	523
40% Grey	0.3706	0.3706	0.3706	389	512	512
15% Grey	0.1711	0.1711	0.1711	214	512	512
0% Black	0.0000	0.0000	0.0000	64	512	512
−2% Black	-0.0602	-0.0602	-0.0602	11	512	512
+2% Black	0.0602	0.0602	0.0602	117	512	512
100% White	0.7900	0.7900	0.7900	756	512	512

LUT 6-2 Details						
Variant	**LUT Type**	**LUT Cube Size**	**SDI LUT Mode Narrow: 64 - 940 (10-bit) Full: 0 – 1023 (10-bit)**	**Input Range [Min Input .. Max input]**	**Output Range [0.0 .. 1.0]**	**BT.709 colour matrix comp.**
6-2a	III	33	Full	Headroom	Headroom	No
6-2b	III	33	Full	Headroom	Headroom	Yes

LUT 7 – BT.2100 HLG to BT.2100 PQ 1000 cd/m^2

No changes in this release

BT.2100 HLG signals are converted to BT.2100 PQ at the 1000 cd/m^2 "bridge" condition, so that 100% HLG maps to 1000 cd/m^2 PQ. See ITU-R report BT.2390 Section 7.2 ("Conversion concepts using a reference condition at 1000 cd/m^2"). For Type III LUTs, HLG signals above 100% are mapped to PQ signals greater than 1000 cd/m^2, up to a maximum of 1810 cd/m^2 (corresponding to 109% HLG 'super-white', i.e. 10-bit code value 1019).

The table illustrates the output signals expected from an "ideal" converter, presented with an EBU Tech 3373 HLG colour bar input. The expected interpolation errors have not been factored in.

	LUT 7 - HLG to PQ 1000 cd/m^2						
	Test Input: BT.2100 HLG EBU Tech 3373	Ideal BT.2100 PQ (Narrow Range) Output					
		Nominal Range [0.0 ... 1.0]			10-Bit SDI		
		R'	G'	B'	Y'	C'$_B$	C'$_R$
100% HLG	100% White	0.7518	0.7518	0.7518	723	512	512
	100% Yellow	0.7505	0.7505	0.0000	682	176	539
	100% Cyan	0.0000	0.7452	0.7452	545	605	178
	100% Green	0.0000	0.7434	0.0000	506	272	206
	100% Magenta	0.7271	0.0000	0.7271	269	747	812
	100% Red	0.7227	0.0000	0.0000	230	422	836
	100% Blue	0.0000	0.0000	0.6904	100	821	487
75% HLG	75% White	0.5808	0.5808	0.5808	573	512	512
	75% Yellow	0.5795	0.5795	0.0000	542	252	533
	75% Cyan	0.0000	0.5744	0.5744	435	584	255
	75% Green	0.0000	0.5727	0.0000	404	327	276
	75% Magenta	0.5572	0.0000	0.5572	221	692	742
	75% Red	0.5530	0.0000	0.0000	191	443	760
	75% Blue	0.0000	0.0000	0.5226	91	746	493
	40% Grey	0.3916	0.3916	0.3916	407	512	512
Display Light Equivalent BT.709	DL White	0.4994	0.4994	0.4994	502	512	512
	DL Yellow	0.4939	0.4975	0.2959	489	422	518
	DL Cyan	0.4015	0.4892	0.4944	473	525	473
	DL Green	0.3890	0.4863	0.2797	457	432	476
	DL Magenta	0.4424	0.2621	0.4721	346	584	585

	LUT 7 - HLG to PQ 1000 cd/m²						
	Test Input: BT.2100 HLG EBU Tech 3373	Ideal BT.2100 PQ (Narrow Range) Output					
		Nominal Range [0.0 ... 1.0]			10-Bit SDI		
		R'	G'	B'	Y'	C'_B	C'_R
	DL Red	0.4317	0.2480	0.1589	319	449	597
	DL Blue	0.2058	0.1325	0.4501	213	645	533
Scene Light Equivalent BT.709	SL White	0.5097	0.5097	0.5097	510	512	512
	SL Yellow	0.5039	0.5071	0.3031	497	421	518
	SL Cyan	0.4102	0.4980	0.5033	480	525	472
	SL Green	0.3969	0.4951	0.2862	464	431	476
	SL Magenta	0.4463	0.2653	0.4758	349	584	586
	SL Red	0.4343	0.2502	0.1606	321	449	598
	SL Blue	0.2045	0.1308	0.4477	212	645	534
Near Black Test Signal	-4%	-0.0610	-0.0610	-0.0610	11	512	512
	-2%	-0.0287	-0.0287	-0.0287	39	512	512
	-1%	-0.0123	-0.0123	-0.0123	53	512	512
	0%	0.0000	0.0000	0.0000	64	512	512
	1%	0.0123	0.0123	0.0123	75	512	512
	2%	0.0287	0.0287	0.0287	89	512	512
	4%	0.0610	0.0610	0.0610	117	512	512

LUT 7 Details						
Variant	**LUT Type**	**LUT Cube Size**	**SDI LUT Mode Narrow: 64 - 940 (10-bit) Full: 0 – 1023 (10-bit)**	**Input Range [Min Input .. Max input]**	**Output Range [0.0 .. 1.0]**	**BT.709 colour matrix comp.**
7a	I	33	Narrow	Nominal	Nominal	No
7b	I	33	Narrow	Nominal	Nominal	Yes
7c	III	33	Full	Headroom	Headroom	No
7d	III	33	Full	Headroom	Headroom	Yes

LUT 8: HDR Graded Content and Live Programmes with Graphics - BT.2100 HLG to BT.709, Down-Mapping (Display-Light)

Changes in v1.4: improved colour saturation and brighter SDR images

BT.2100 HLG signals are down-mapped (tone-mapped) to BT.709 using a display-light conversion. Colours and the appearance of mid-tones and lowlights are maintained after conversion. The LUT, therefore, attempts to preserve the artistic intent of the original HLG content. This LUT is designed to complement LUT 5 (BT.709 to BT.2100 HLG up-mapping) so that the losses associated with 'round-tripping' (i.e. SDR-to-HDR-to-SDR conversion) are minimised.

"HDR Reference White" (75% HLG) is tone-mapped to 90% BT.709, facilitating signal headroom for compressed highlights. 100% HLG signal is tone-mapped to 100% BT.709. With Type III LUTs that process sub-blacks and super-whites, the HLG super-white signals are tone-mapped to SDR super-white signals. The LUT outputs are clipped to EBU R.103 signal levels.

The 3D-LUT interpolation errors are greatest for the HDR to SDR down-mapping LUTs, as the output signals reach the extremities of the R′G′B′ signal range. For that reason, in addition to the "ideal" output values for the EBU Tech 3373 HLG Colour Bars, we also provide the expected output values from a trilinear interpolator. Errors should be smaller with tetrahedral interpolation, the 65-cubed LUTs and also with real pictures.

NOTE: Neither the EBU Tech 3373 HLG colour bars nor the ITU-R BT.2111 HLG colour bars will look like standard BT.709 colour bars after conversion, as the BT.2100 colour-primaries are quite different to those of BT.709. Furthermore, the converted colour bars will not look like BT.2111 colour bars displayed on a current reference display as their colour-primaries tend to be closer to DCI-P3 than BT.2100. Most noticeable might be the BT.2100 green, which is much more cyan in colour than the DCI-P3 and BT.709 greens.

	LUT 8 - BT.2100 HLG to BT.709, Down-Mapping (Display-Light)						
	Test Input: BT.2100 HLG EBU Tech 3373	Ideal BT.709 Output					
		Nominal Range [0.0 ... 1.0]			10-Bit SDI		
		R'	G'	B'	Y'	C'_B	C'_R
100% HLG	100% White	0.9983	0.9986	0.9987	938	512	511
	100% Yellow	0.9495	0.9759	-0.0284	850	64	541
	100% Cyan	0.0302	1.0329	0.9927	779	596	64
	100% Green	-0.0496	0.9454	0.5009	678	415	84
	100% Magenta	1.0502	0.2777	0.9122	491	716	832
	100% Red	1.0502	0.4287	0.3790	552	425	792
	100% Blue	0.4302	0.6286	1.0502	604	721	405
75% HLG	75% White	0.8979	0.8979	0.8979	850	512	511
	75% Yellow	0.9208	0.9153	-0.0496	805	79	554
	75% Cyan	-0.0487	0.9160	0.8819	684	595	81
	75% Green	-0.0502	0.8090	0.4350	589	432	142
	75% Magenta	0.9802	-0.0502	0.8485	268	808	936
	75% Red	0.9788	-0.0456	0.1995	230	516	960
	75% Blue	0.1140	-0.0495	0.9722	115	952	543
	40% Grey	0.4974	0.4974	0.4974	499	512	512
Display Light Equivalent BT.709	DL White	0.7495	0.7495	0.7495	720	512	512
	DL Yellow	0.7485	0.7506	0.0279	675	188	540
	DL Cyan	-0.0496	0.7507	0.7497	572	593	153
	DL Green	-0.0435	0.7501	0.0279	527	269	186
	DL Magenta	0.7504	-0.0342	0.7502	229	782	831
	DL Red	0.7494	-0.0250	-0.0132	187	437	858
	DL Blue	-0.0260	-0.0106	0.7492	99	853	473
Scene Light Equivalent BT.709	SL White	0.7778	0.7778	0.7778	745	512	512
	SL Yellow	0.7774	0.7770	-0.0225	694	153	545
	SL Cyan	0.0538	0.7752	0.7745	608	585	188
	SL Green	-0.0500	0.7744	0.0137	540	255	173
	SL Magenta	0.7615	-0.0278	0.7606	236	784	833
	SL Red	0.7571	-0.0161	-0.0085	194	436	858
	SL Blue	0.0157	-0.0214	0.7424	100	850	497
Near Black Test Signal	-4%	-0.0401	-0.0402	-0.0402	28	511	512
	-2%	-0.0211	-0.0211	-0.0211	45	511	512
	-1%	-0.0116	-0.0116	-0.0116	53	511	512
	0%	0.0000	0.0000	0.0000	64	512	512
	1%	0.0116	0.0116	0.0116	74	512	511
	2%	0.0211	0.0211	0.0211	82	512	511
	4%	0.0403	0.0404	0.0404	99	512	511

	LUT 8 - BT.2100 HLG to BT.709, Down-Mapping (Display-Light)						
	Test Input: BT.2100 HLG EBU Tech 3373	**Expected BT.709 Output with trilinear interpolation**					
		Nominal Range [0.0 ... 1.0]			**10-Bit SDI**		
		R'	**G'**	**B'**	**Y'**	**C'B**	**C'R**
100% HLG	100% White	0.9840	1.0046	0.9909	939	508	503
	100% Yellow	0.9509	0.9737	-0.0297	849	65	543
	100% Cyan	0.0285	1.0320	0.9920	779	597	64
	100% Green	-0.0491	0.9452	0.5011	679	415	85
	100% Magenta	1.0502	0.2797	0.9144	493	717	831
	100% Red	1.0502	0.4304	0.3813	553	426	792
	100% Blue	0.4304	0.6279	1.0502	604	721	406
75% HLG	75% White	0.8950	0.8973	0.8973	850	512	511
	75% Yellow	0.9189	0.9132	-0.0491	804	80	554
	75% Cyan	-0.0491	0.9144	0.8801	683	596	82
	75% Green	-0.0502	0.8082	0.4349	589	433	143
	75% Magenta	0.9806	-0.0502	0.8493	269	809	937
	75% Red	0.9795	-0.0320	0.1998	239	512	956
	75% Blue	0.1130	-0.0411	0.9703	121	949	539
	40% Grey	0.4966	0.4966	0.4977	499	513	512
Display Light Equivalent BT.709	DL White	0.7489	0.7500	0.7500	721	512	511
	DL Yellow	0.7477	0.7500	0.0628	677	204	539
	DL Cyan	0.0639	0.7489	0.7466	592	581	205
	DL Green	0.0970	0.7454	0.0765	554	279	249
	DL Magenta	0.7466	0.0057	0.7443	254	767	814
	DL Red	0.7443	0.0708	0.0285	249	424	815
	DL Blue	0.0605	-0.0091	0.7477	117	844	512
Scene Light Equivalent BT.709	SL White	0.7763	0.7785	0.7785	746	512	511
	SL Yellow	0.7774	0.7774	0.0502	699	186	542
	SL Cyan	0.0354	0.7740	0.7717	604	587	181
	SL Green	0.1062	0.7671	0.1107	571	286	243
	SL Magenta	0.7580	0.0023	0.7557	254	772	820
	SL Red	0.7500	0.0731	0.0228	251	420	817
	SL Blue	0.0616	-0.0034	0.7420	120	839	511
Near Black Test Signal	-4%	-0.0400	-0.0400	-0.0400	29	512	512
	-2%	-0.0080	-0.0148	-0.0114	52	513	515
	-1%	0.0000	-0.0057	-0.0034	60	512	514
	0%	0.0000	0.0000	0.0000	64	512	512
	1%	0.0023	0.0023	0.0023	66	512	512
	2%	0.0114	0.0103	0.0114	73	512	512
	4%	0.0400	0.0400	0.0400	99	512	512

LUT 8 Details						
Variant	**LUT Type**	**LUT Cube Size**	**SDI LUT Mode Narrow: 64 - 940 (10-bit) Full: 0 – 1023 (10-bit)**	**Input Range [Min Input .. Max input]**	**Output Range [0.0 .. 1.0]**	**BT.709 colour matrix comp.**
8a	I	33	Narrow	Nominal	Nominal	No
8a65	I	65	Narrow	Nominal	Nominal	No
8b	I	33	Narrow	Nominal	Nominal	Yes
8c	III	33	Full	Headroom	Headroom	No
8d	III	33	Full	Headroom	Headroom	Yes

LUT 9: HDR-graded content and live programmes with graphics - BT.2100 HLG to BT.709, down-mapping (display-light) using SDR "super-whites"

New in this release

BT.2100 HLG signals are down-mapped (tone-mapped) to BT.709 using a display-light conversion. Colours and the appearance of mid-tones and lowlights are maintained after conversion. The LUT, therefore, attempts to preserve the artistic intent of the original HLG content.

"HDR Reference White" (75% HLG) is mapped to 95% BT.709 and HDR highlights extend into the SDR super-white region; for that reason, only "Full-Range Mode" Type III LUTs are made available. 94% HLG signal is mapped to the EBU R103 preferred maximum of 105% BT.709. HLG signals above 94% are clipped.

This LUT is recommended for use in scenarios where minimising SDR>HDR>SDR "round-trip" losses is of the utmost importance. Minimal round-trip losses are achieved when used with the display-light up-mapping LUT5. Better overall results are, however, usually achieved with the LUT8 down-mapper, which does not rely on the SDR super-white signal ranges being maintained through the programme delivery and distribution chains.

The 3D-LUT interpolation errors are greatest for the HDR to SDR down-mapping LUTs, as the output signals reach the extremities of the R′G′B′ signal range. For that reason, in addition to the "ideal" output values for the EBU Tech 3373 HLG Colour Bars, we also provide the expected output values from a trilinear interpolator. Errors should be smaller with tetrahedral interpolation, the 65-cubed LUTs and also with real pictures.

NOTE: Neither the EBU Tech 3373 HLG colour bars nor the ITU-R BT.2111 HLG colour bars will look like standard BT.709 colour bars after conversion, as the BT.2100 colour primaries are quite different from those of BT.709. Furthermore, the converted colour bars will not look like BT.2111 colour bars displayed on a current reference display, as their colour primaries tend to be closer to DCI-P3 than BT.2100. Of these, the most noticeable might be the BT.2100 green. This contains more cyan content than the DCI-P3 and BT.709 greens.

	LUT 9 - BT.2100 HLG to BT.709, Down-Mapping (Display-Light)						
	Test Input: BT.2100 HLG EBU Tech 3373	**Ideal BT.709 Output**					
		Nominal Range [0.0 ... 1.0]			**10-Bit SDI**		
		R'	**G'**	**B'**	**Y'**	**C'B**	**C'R**
100% HLG	100% White	1.0502	1.0502	1.0502	984	512	512
	100% Yellow	0.9832	1.0102	0.0136	880	68	540
	100% Cyan	0.0251	1.0230	0.9831	771	596	66
	100% Green	-0.0502	0.8616	0.4551	623	423	120
	100% Magenta	1.0502	0.2514	0.9456	476	741	841
	100% Red	1.0502	0.4301	0.3817	553	426	791
	100% Blue	0.3088	0.5377	1.0502	524	765	388
75% HLG	75% White	0.9516	0.9516	0.9516	897	512	511
	75% Yellow	0.9720	0.9657	-0.0311	848	64	555
	75% Cyan	-0.0502	0.9061	0.8723	677	595	84
	75% Green	-0.0502	0.7750	0.4156	566	435	157
	75% Magenta	1.0055	-0.0502	0.8704	274	816	947
	75% Red	1.0123	-0.0089	0.2099	260	505	960
	75% Blue	0.1136	-0.0502	0.9736	115	953	543
	40% Grey	0.4974	0.4974	0.4974	499	512	512
Display Light Equivalent BT.709	DL White	0.7495	0.7495	0.7495	720	512	512
	DL Yellow	0.7485	0.7506	0.0279	675	188	540
	DL Cyan	-0.0502	0.7508	0.7499	572	593	153
	DL Green	-0.0435	0.7501	0.0279	527	269	186
	DL Magenta	0.7504	-0.0342	0.7502	229	782	831
	DL Red	0.7494	-0.0250	-0.0132	187	437	858
	DL Blue	-0.0260	-0.0106	0.7492	99	853	473
Scene Light Equivalent BT.709	SL White	0.7778	0.7778	0.7778	745	512	512
	SL Yellow	0.7774	0.7770	-0.0225	694	153	545
	SL Cyan	0.0538	0.7752	0.7745	608	585	188
	SL Green	-0.0500	0.7744	0.0137	540	255	173
	SL Magenta	0.7615	-0.0278	0.7606	236	784	833
	SL Red	0.7571	-0.0161	-0.0085	194	436	858
	SL Blue	0.0157	-0.0214	0.7424	100	850	497
Near Black Test Signal	-4%	-0.0401	-0.0402	-0.0402	28	511	512
	-2%	-0.0211	-0.0211	-0.0211	45	511	512
	-1%	-0.0116	-0.0116	-0.0116	53	511	512
	0%	0.0000	0.0000	0.0000	64	512	512
	1%	0.0116	0.0116	0.0116	74	512	511
	2%	0.0211	0.0211	0.0211	82	512	511
	4%	0.0403	0.0404	0.0404	99	512	511

	LUT 9 - BT.2100 HLG to BT.709, Down-Mapping (Display-Light)						
	Test Input: BT.2100 HLG EBU Tech 3373	Expected BT.709 Output with trilinear interpolation					
		Nominal Range [0.0 ... 1.0]			10-Bit SDI		
		R'	G'	B'	Y'	C'_B	C'_R
100% HLG	100% White	1.0502	1.0502	1.0491	984	511	512
	100% Yellow	0.9852	1.0080	0.0114	880	68	543
	100% Cyan	0.0228	1.0228	0.9840	771	597	66
	100% Green	-0.0491	0.8642	0.4566	625	423	120
	100% Magenta	1.0502	0.3927	0.9212	564	681	785
	100% Red	1.0502	0.4897	0.4349	594	430	765
	100% Blue	0.3379	0.5537	1.0502	540	757	395
75% HLG	75% White	0.9486	0.9509	0.9509	897	512	511
	75% Yellow	0.9692	0.9623	-0.0342	845	65	556
	75% Cyan	-0.0491	0.9053	0.8721	677	595	86
	75% Green	-0.0502	0.7740	0.4155	566	436	157
	75% Magenta	1.0057	-0.0491	0.8710	276	816	947
	75% Red	1.0137	-0.0080	0.2100	261	505	961
	75% Blue	0.1119	-0.0434	0.9680	119	949	540
	40% Grey	0.4966	0.4966	0.4977	499	513	512
Display Light Equivalent BT.709	DL White	0.7489	0.7500	0.7500	721	512	511
	DL Yellow	0.7477	0.7500	0.0628	677	204	539
	DL Cyan	0.0639	0.7489	0.7466	592	581	205
	DL Green	0.0970	0.7454	0.0765	554	279	249
	DL Magenta	0.7489	0.0057	0.7477	254	768	814
	DL Red	0.7443	0.0708	0.0285	249	424	815
	DL Blue	0.0605	-0.0091	0.7477	117	844	512
Scene Light Equivalent BT.709	SL White	0.7774	0.7785	0.7785	746	512	511
	SL Yellow	0.7774	0.7774	0.0502	699	186	542
	SL Cyan	0.0354	0.7740	0.7717	604	587	181
	SL Green	0.1062	0.7671	0.1107	571	286	243
	SL Magenta	0.7603	0.0011	0.7580	254	773	821
	SL Red	0.7500	0.0731	0.0228	251	420	817
	SL Blue	0.0616	-0.0034	0.7420	120	839	511
Near Black Test Signal	-4%	-0.0400	-0.0400	-0.0400	29	512	512
	-2%	-0.0080	-0.0148	-0.0114	52	513	515
	-1%	0.0000	-0.0057	-0.0034	60	512	514
	0%	0.0000	0.0000	0.0000	64	512	512
	1%	0.0034	0.0034	0.0034	67	512	512
	2%	0.0114	0.0103	0.0114	73	512	512
	4%	0.0400	0.0400	0.0400	99	512	512

LUT 9 Details						
Variant	**LUT Type**	**LUT Cube Size**	**SDI LUT Mode Narrow: 64 - 940 (10-bit) Full: 0 – 1023 (10-bit)**	**Input Range [Min Input .. Max input]**	**Output Range [0.0 .. 1.0]**	**BT.709 colour matrix comp.**
9c	III	33	Full	Headroom	Headroom	No
9d	III	33	Full	Headroom	Headroom	Yes

LUT 10: Sony S-Log3 cameras in non-live workflows - S-Log3 (100%) to BT.2100 HLG (Scene-Light)

Changes in v1.4: HLG output now clipped at EBU R103 "preferred" signal range levels.

S-Log3 (BT.2020 colour) signals produced using the Sony's "100%" workflow (i.e. 100% IRE input equals 90% reflectance) are converted to BT.2100 HLG with ITU-R BT.2408 signal levels. A 100% IRE input signal (90% reflectance) thus maps to 73% HLG.

A scene-light conversion is used, so that the converted S-Log3 signal is a close subjective-match to the "look" of BT.2100 HLG cameras.

LUT 10: S-Log3 (100%) to BT.2100 HLG (Scene-Light)							
Test Input: S-Log3		**Ideal BT.2100 HLG Output**					
		Nominal Range [0.0 … 1.0]			**10-Bit SDI**		
Reflectance	**S-Log3 Signal**	**R'**	**G'**	**B'**	**Y'**	**C'_B**	**C'_R**
0%	9%	0.0000	0.0000	0.0000	64	512	512
90%	58%	0.7292	0.7292	0.7292	703	512	512
100%	60%	0.7500	0.7500	0.7500	721	512	512

LUT 10 Details						
Variant	**LUT Type**	**LUT Cube Size**	**SDI LUT Mode Narrow: 64 - 940 (10-bit) Full: 0 – 1023 (10-bit)**	**Input Range [Min Input .. Max input]**	**Output Range [0.0 .. 1.0]**	**BT.709 colour matrix comp.**
10a	II	33	Full	Footroom	Headroom	No
10b	II	33	Full	Footroom	Headroom	Yes

LUT 11: Sony S-Log3 cameras in "SR Live" workflows – S-Log3 (200%) to BT.2100 HLG (Scene-Light)

Changes in v1.4: HLG output now clipped at EBU R103 "preferred" signal range levels.

S-Log3 (BT.2020 colour) signals produced using Sony's "SR Live" "200%" workflow (i.e. 200% IRE input equals 90% reflectance) are converted to BT.2100 HLG with ITU-R BT.2408 signal levels. A 200% IRE input signal (90% reflectance) thus maps to 73% HLG. 200% workflows are commonly-encountered whenever the S-Log3 curve has been used in live productions.

A scene-light conversion is used, so that the converted S-Log3 signal matches the "look" of BT.2100 HLG cameras.

LUT 11: S-Log3 SR Live (200%) to BT.2100 HLG (Scene-Light)							
Test Input: S-Log3 SR Live		**Ideal BT.2100 HLG Output**					
		Nominal Range [0.0 … 1.0]			**10-Bit SDI**		
Reflectance	**S-Log3 Signal**	**R'**	**G'**	**B'**	**Y'**	**C'_B**	**C'_R**
0%	9%	0.0000	0.0000	0.0000	64	512	512
90%	66%	0.7292	0.7292	0.7292	703	512	512
100%	67%	0.7500	0.7500	0.7500	721	512	512

LUT 11 Details						
Variant	**LUT Type**	**LUT Cube Size**	**SDI LUT Mode Narrow: 64 - 940 (10-bit) Full: 0 – 1023 (10-bit)**	**Input Range [Min Input .. Max input]**	**Output Range [0.0 .. 1.0]**	**BT.709 colour matrix comp.**
11a	II	33	Full	Footroom	Headroom	No
11b	II	33	Full	Footroom	Headroom	Yes

LUT 12-1: "Clean" (i.e. without graphics) feeds to match SDR BT.709 cameras – BT.2100 HLG to BT.709, down-mapping (scene-light)

No changes in this release

For matching downstream SDR cameras that approximate the BT.709 OETF with a square-root function

BT.2100 HLG signals are down-mapped (tone-mapped) to BT.709, using scene-light conversion. The "look" of the original BT.2100 HLG content is changed to match "native" BT.709 cameras with a square-root approximation of the BT.709 OETF.

This LUT is the *exact inverse* of LUT 6-1 (BT.709 to BT.2100 up-mapping, scene-light), so that the losses associated with 'round-tripping' (i.e. SDR-to-HDR-to-SDR conversion) are minimised.

"HDR Reference White" (75% HLG) is tone-mapped to 95% BT.709, allowing for some soft-clipping of highlights. A 79% HLG signal is tone-mapped to 100% BT.709. With Type III LUTs that process sub-blacks and super-whites, the LUT outputs are clipped to EBU R.103 signal levels.

The 3D-LUT interpolation errors are greatest for the HDR to SDR down-mapping LUTs, as the output signals reach the extremities of the R′G′B′ signal range. For that reason, in addition to the "ideal" output values for the EBU Tech 3373 HLG Colour Bars, we also provide the expected output values from a trilinear interpolator. Errors should be smaller with tetrahedral interpolation, the 65-cubed LUTs and also with real pictures.

	LUT 12-1 - BT.2100 HLG to BT.709, Down-Mapping (Scene-Light)						
	Test Input: BT.2100 HLG EBU Tech 3373	**Ideal BT.709 Output**					
		Nominal Range [0.0 ... 1.0]			**10-Bit SDI**		
		R'	**G'**	**B'**	**Y'**	**C'_B**	**C'_R**
100% HLG	100% White	1.050	1.050	1.050	984	512	512
	100% Yellow	1.050	1.050	-0.050	914	18	557
	100% Cyan	-0.050	1.050	1.050	779	624	18
	100% Green	-0.050	1.050	-0.050	709	131	64
	100% Magenta	1.050	-0.050	1.050	294	892	959
	100% Red	1.050	-0.050	-0.050	224	399	1005
	100% Blue	-0.050	-0.050	1.050	89	1005	466
75% HLG	75% White	0.946	0.947	0.947	893	512	511
	75% Yellow	0.992	0.962	-0.050	848	55	567
	75% Cyan	-0.050	1.050	1.002	776	603	20
	75% Green	-0.050	1.050	-0.050	709	131	64
	75% Magenta	1.050	-0.050	1.049	294	891	959
	75% Red	1.050	-0.050	-0.050	224	399	1005
	75% Blue	-0.050	-0.050	1.050	89	1005	466
	40% Grey	0.448	0.448	0.448	456	512	511
Display Light Equivalent BT.709	DL White	0.718	0.718	0.718	692	512	511
	DL Yellow	0.718	0.720	0.014	649	195	539
	DL Cyan	-0.034	0.723	0.722	556	589	172
	DL Green	-0.024	0.724	0.014	513	270	206
	DL Magenta	0.738	-0.018	0.738	236	773	819
	DL Red	0.742	-0.012	-0.006	194	437	849
	DL Blue	-0.014	-0.005	0.759	106	854	476
Scene Light Equivalent BT.709	SL White	0.749	0.749	0.749	720	512	511
	SL Yellow	0.750	0.749	-0.010	672	171	543
	SL Cyan	0.030	0.750	0.749	586	585	189
	SL Green	-0.029	0.751	0.007	529	258	193
	SL Magenta	0.751	-0.014	0.750	242	775	823
	SL Red	0.751	-0.007	-0.003	199	436	851
	SL Blue	0.007	-0.011	0.751	106	851	488
Near Black Test Signal	-4%	-0.041	-0.041	-0.041	28	511	512
	-2%	-0.020	-0.020	-0.020	46	511	512
	-1%	-0.010	-0.010	-0.010	55	511	512
	0%	0.000	0.000	0.000	64	512	512
	1%	0.010	0.010	0.010	72	512	511
	2%	0.020	0.020	0.020	81	512	511
	4%	0.041	0.041	0.041	99	512	511

	LUT 12-1 - BT.2100 HLG to BT.709, Down-Mapping (Scene-Light)						
	Test Input: BT.2100 HLG EBU Tech 3373	**Expected BT.709 Output with trilinear interpolation**					
		Nominal Range [0.0 ... 1.0]			**10-Bit SDI**		
		R'	**G'**	**B'**	**Y'**	**C'_B**	**C'_R**
100% HLG	100% White	1.0502	1.0502	1.0502	984	512	512
	100% Yellow	1.0502	1.0502	-0.0502	914	19	557
	100% Cyan	-0.0502	1.0502	1.0502	779	625	19
	100% Green	-0.0502	1.0502	-0.0502	709	132	64
	100% Magenta	1.0502	-0.0502	1.0502	295	892	960
	100% Red	1.0502	-0.0502	-0.0502	225	399	1005
	100% Blue	-0.0502	-0.0502	1.0502	90	1005	467
75% HLG	75% White	0.9441	0.9463	0.9463	893	512	511
	75% Yellow	0.9806	0.9612	-0.0502	846	57	562
	75% Cyan	-0.0502	1.0297	0.9989	763	609	29
	75% Green	-0.0502	1.0320	-0.0502	698	138	72
	75% Magenta	1.0502	-0.0502	1.0263	293	881	961
	75% Red	1.0502	-0.0502	-0.0502	225	399	1005
	75% Blue	-0.0502	-0.0502	1.0297	88	996	468
	40% Grey	0.4475	0.4475	0.4475	456	512	512
Display Light Equivalent BT.709	DL White	0.7180	0.7180	0.7180	693	512	512
	DL Yellow	0.7180	0.7203	0.0365	651	206	539
	DL Cyan	0.0422	0.7249	0.7226	572	581	206
	DL Green	0.0639	0.7249	-0.0011	530	255	246
	DL Magenta	0.7386	-0.0068	0.7363	244	768	815
	DL Red	0.7432	0.0228	-0.0091	216	424	836
	DL Blue	0.0365	-0.0011	0.7580	118	848	498
Scene Light Equivalent BT.709	SL White	0.7489	0.7500	0.7500	721	512	511
	SL Yellow	0.7500	0.7500	0.0263	675	188	542
	SL Cyan	0.0194	0.7511	0.7500	586	587	184
	SL Green	0.0662	0.7511	0.0183	548	254	235
	SL Magenta	0.7523	-0.0091	0.7500	246	774	822
	SL Red	0.7500	0.0194	-0.0091	215	424	840
	SL Blue	0.0377	0.0011	0.7523	119	845	498
Near Black Test Signal	-4%	-0.0411	-0.0411	-0.0411	28	512	512
	-2%	-0.0137	-0.0171	-0.0171	50	512	514
	-1%	-0.0046	-0.0080	-0.0080	58	512	514
	0%	0.0000	0.0000	0.0000	64	512	512
	1%	0.0046	0.0068	0.0080	70	513	511
	2%	0.0137	0.0171	0.0171	78	512	510
	4%	0.0411	0.0411	0.0411	100	512	512

LUT 12-1 Details						
Variant	**LUT Type**	**LUT Cube Size**	**SDI LUT Mode Narrow: 64 - 940 (10-bit) Full: 0 – 1023 (10-bit)**	**Input Range [Min Input .. Max input]**	**Output Range [0.0 .. 1.0]**	**BT.709 colour matrix comp.**
12-1a	I	33	Narrow	Nominal	Nominal	No
12-1b	I	33	Narrow	Nominal	Nominal	Yes
12-1c	III	33	Full	Headroom	Headroom	No
12-1d	III	33	Full	Headroom	Headroom	Yes

LUT 12-2: "Clean" (i.e. without graphics) feeds to match SDR BT.709 cameras – BT.2100 HLG to BT.709 down-mapping (scene-light)

No changes in this release.

For use with SDR cameras that implement a strict BT.709 OETF

BT.2100 HLG signals are down-mapped (tone-mapped) to BT.709, using a scene-light conversion. The "look" of the original BT.2100 HLG content is changed to match "native" BT.709 cameras, with a strict implementation of the BT.709 OETF.

This LUT is the *exact inverse* of LUT6-2 (BT.709 to BT.2100 HLG inverse tone-mapping, scene-light), so that the losses associated with 'round-tripping' (i.e. SDR-to-HDR-to-SDR conversion) are minimised.

"HDR Reference White" (75% HLG) is tone-mapped to 95% BT.709, allowing for some soft-clipping of highlights. 79% HLG signal is tone-mapped to 100% BT.709. With Type III LUTs that process sub-blacks and super-whites, the LUT outputs are clipped to EBU R.103 signal levels.

NOTE: Unlike BT.2100 HLG, SDR cameras that implement a strict BT.709 OETF tend to crush detail in the shadows of a scene. Shadow-detail visible in the HDR image will, as a result, become less evident after applying this conversion.

The 3D-LUT interpolation errors are greatest for the HDR to SDR down-mapping LUTs, as the output signals reach the extremities of the R′G′B′ signal range. For that reason, in addition to the "ideal" output values for the EBU Tech 3373 HLG Colour Bars, we also provide the expected output values from a trilinear interpolator. Errors should be smaller with tetrahedral interpolation, the 65-cubed LUTs and also with real pictures.

	LUT 12-2 - BT.2100 HLG to BT.709, Down-Mapping (Scene-Light)						
	Test input: BT.2100 HLG EBU Tech 3373	Ideal BT.709 Output					
		Nominal Range [0.0 ... 1.0]			10-Bit SDI		
		R'	G'	B'	Y'	C'_B	C'_R
100% HLG	100% White	1.050	1.050	1.050	984	512	512
	100% Yellow	1.050	1.050	-0.050	914	18	557
	100% Cyan	-0.050	1.050	1.050	779	624	18
	100% Green	-0.050	1.050	-0.050	709	131	64
	100% Magenta	1.050	-0.050	1.050	294	892	959
	100% Red	1.050	-0.050	-0.050	224	399	1005
	100% Blue	-0.050	-0.050	1.050	89	1005	466
75% HLG	75% White	0.947	0.947	0.947	893	512	511
	75% Yellow	0.992	0.962	-0.050	848	55	567
	75% Cyan	-0.050	1.050	1.002	776	603	20
	75% Green	-0.050	1.050	-0.050	709	131	64
	75% Magenta	1.050	-0.050	1.049	294	891	959
	75% Red	1.050	-0.050	-0.050	224	399	1005
	75% Blue	-0.050	-0.038	1.050	97	1000	461
	40% Grey	0.434	0.435	0.435	444	512	511
Display Light Equivalent BT.709	DL White	0.717	0.717	0.717	691	512	511
	DL Yellow	0.716	0.719	0.001	647	190	540
	DL Cyan	-0.005	0.722	0.721	560	586	186
	DL Green	-0.003	0.722	0.001	516	263	216
	DL Magenta	0.737	-0.001	0.737	247	767	812
	DL Red	0.741	-0.001	0.000	201	436	844
	DL Blue	-0.001	0.000	0.758	111	851	480
Scene Light Equivalent BT.709	SL White	0.748	0.748	0.749	719	512	511
	SL Yellow	0.749	0.749	0.000	672	176	542
	SL Cyan	0.004	0.749	0.749	581	588	178
	SL Green	-0.004	0.750	0.000	533	253	205
	SL Magenta	0.750	-0.001	0.749	250	770	817
	SL Red	0.750	0.000	0.000	203	435	847
	SL Blue	0.000	-0.001	0.750	111	848	481
Near Black Test Signal	-4%	-0.008	-0.008	-0.008	57	511	512
	-2%	-0.002	-0.002	-0.002	62	511	512
	-1%	0.000	0.000	0.000	63	511	512
	0%	0.000	0.000	0.000	64	512	512
	1%	0.000	0.000	0.000	64	512	511
	2%	0.002	0.002	0.002	65	512	511
	4%	0.008	0.008	0.008	70	512	511

	LUT 12-2 - BT.2100 HLG to BT.709, Down-Mapping (Scene-Light)						
	Test Input: BT.2100 HLG EBU Tech 3373	**Expected BT.709 Output with trilinear interpolation**					
		Nominal Range [0.0 ... 1.0]			**10-Bit SDI**		
		R'	**G'**	**B'**	**Y'**	**C'B**	**C'R**
100% HLG	100% White	1.0502	1.0502	1.0502	984	512	512
	100% Yellow	1.0502	1.0502	-0.0502	914	19	557
	100% Cyan	-0.0502	1.0502	1.0502	779	625	19
	100% Green	-0.0502	1.0502	-0.0502	709	132	64
	100% Magenta	1.0502	-0.0502	1.0502	295	892	960
	100% Red	1.0502	-0.0502	-0.0502	225	399	1005
	100% Blue	-0.0502	-0.0502	1.0502	90	1005	467
75% HLG	75% White	0.9452	0.9463	0.9463	893	512	511
	75% Yellow	0.9806	0.9612	-0.0502	846	57	562
	75% Cyan	-0.0502	1.0297	0.9989	763	609	29
	75% Green	-0.0502	1.0320	-0.0502	698	138	72
	75% Magenta	1.0502	-0.0502	1.0263	293	881	961
	75% Red	1.0502	-0.0502	-0.0502	225	399	1005
	75% Blue	-0.0502	-0.0377	1.0297	96	991	463
	40% Grey	0.4338	0.4338	0.4349	444	513	512
Display Light Equivalent BT.709	DL White	0.7158	0.7169	0.7169	692	512	511
	DL Yellow	0.7158	0.7192	0.0046	648	192	540
	DL Cyan	0.0263	0.7237	0.7215	568	583	200
	DL Green	0.0308	0.7226	0.0011	523	260	232
	DL Magenta	0.7374	-0.0023	0.7363	246	767	813
	DL Red	0.7420	0.0023	0.0011	204	436	843
	DL Blue	0.0034	0.0000	0.7580	113	851	482
Scene Light Equivalent BT.709	SL White	0.7477	0.7489	0.7489	720	512	511
	SL Yellow	0.7489	0.7500	0.0011	673	177	542
	SL Cyan	0.0091	0.7500	0.7489	583	588	180
	SL Green	0.0388	0.7511	0.0000	542	249	224
	SL Magenta	0.7511	0.0000	0.7489	251	770	818
	SL Red	0.7489	0.0034	0.0000	206	434	846
	SL Blue	0.0046	0.0000	0.7511	112	848	483
Near Black Test Signal	-4%	-0.0080	-0.0080	-0.0080	57	512	512
	-2%	-0.0034	-0.0034	-0.0034	61	512	512
	-1%	-0.0046	-0.0080	-0.0080	58	512	514
	0%	-0.0023	-0.0023	-0.0023	62	512	512
	1%	0.0023	0.0023	0.0023	66	512	512
	2%	0.0034	0.0034	0.0034	67	512	512
	4%	0.0080	0.0080	0.0080	71	512	512

LUT 12-2 Details						
Variant	**LUT Type**	**LUT Cube Size**	**SDI LUT Mode Narrow: 64 - 940 (10-bit) Full: 0 – 1023 (10-bit)**	**Input Range [Min Input .. Max input]**	**Output Range [0.0 .. 1.0]**	**BT.709 colour matrix comp.**
12-2a	I	33	Narrow	Nominal	Nominal	No
12-2b	I	33	Narrow	Nominal	Nominal	Yes
12-2c	III	33	Full	Headroom	Headroom	No
12-2d	III	33	Full	Headroom	Headroom	Yes

LUT 14: Graded Content with P3D65 System Colour- PQ P3D65 1000 cd/m^2 to BT.2100 HLG

No changes in this release.

P3D65 PQ signals are converted to BT.2100 HLG in the 1000 cd/m^2 "bridge" condition, so that 1000 cd/m^2 PQ maps to 100% HLG. As such signals are only encountered in file-based workflows, Type II and Type III LUTs are not supplied.

The table illustrates the expected output signals from an ideal algorithmic converter, presented with a P3D65 PQ colour bar input. It takes no account of the expected interpolation or rounding errors.

LUT 14: PQ P3D65 Colour 1000 cd/m2 to BT.2100 HLG			
Test Input:	**Ideal BT.2100 HLG Output**		
PQ	**Nominal Range [0.0 ... 1.0]**		
Colour bars	**R'**	**G'**	**B'**
100% White	1.000	1.000	1.000
100% Yellow	1.000	1.000	0.573
100% Cyan	1.000	1.000	1.000
100% Green	1.000	1.000	0.599
100% Magenta	1.000	0.865	1.000
100% Red	1.000	0.829	0.000
100% Blue	0.870	0.603	1.000
58% White	0.749	0.749	0.749
58% Yellow	0.742	0.749	0.115
58% Cyan	0.450	0.748	0.757
58% Green	0.408	0.749	0.122
58% Magenta	0.744	0.236	0.783
58% Red	0.741	0.215	0.000
58% Blue	0.239	0.123	0.827
40% Grey	0.414	0.414	0.414
0% Black	0.000	0.000	0.000
−2% Black	0.000	0.000	0.000
+2% Black	0.013	0.013	0.013
+4% Black	0.025	0.025	0.025

LUT 14 Details						
Variant	**LUT Type**	**LUT Cube Size**	**SDI LUT Mode Narrow: 64 - 940 (10-bit) Full: 0 – 1023 (10-bit)**	**Input Range [Min Input .. Max input]**	**Output Range [0.0 .. 1.0]**	**BT.709 colour matrix comp.**
14a	I	33	Narrow	Nominal	Nominal	No
14a65	I	65	Narrow	Nominal	Nominal	No

LUT 15: BT.2100 HLG to PQ 1000 cd/m^2 with P3D65 System Colorimetry

No changes in this release.

BT.2100 HLG signals are converted to PQ signals with P3D65 colour in the 1000 cd/m^2 "bridge" condition, so that 100% HLG maps to 1000 cd/m^2 PQ. As such signals are only encountered in file-based workflows, Type II and Type III LUTs are not supplied.

The table illustrates the expected output signals from an ideal algorithmic converter, presented with an EBU Tech 3373 HLG colour bar input. It takes no account of the expected interpolation or rounding errors.

	LUT 15: BT.2100 HLG to PQ P3D65 Colour 1000 cd/m2 to			
	Test Input: BT.2100 HLG EBU Tech 3373	**Ideal PQ P3D65 Output**		
		Nominal Range [0.0 ... 1.0]		
		R'	**G'**	**B'**
100% HLG	100% White	0.7518	0.7518	0.7518
	100% Yellow	0.7570	0.7516	0.0000
	100% Cyan	0.0000	0.7521	0.7449
	100% Green	0.0000	0.7513	0.0000
	100% Magenta	0.7542	0.0000	0.7293
	100% Red	0.7549	0.0000	0.1928
	100% Blue	0.0000	0.0000	0.6922

	LUT 15: BT.2100 HLG to PQ P3D65 Colour 1000 cd/m2 to			
	Test Input: BT.2100 HLG EBU Tech 3373	**Ideal PQ P3D65 Output**		
		Nominal Range [0.0 ... 1.0]		
		R'	**G'**	**B'**
75% HLG	75% White	0.5808	0.5808	0.5808
	75% Yellow	0.5857	0.5806	0.0000
	75% Cyan	0.0000	0.5810	0.5741
	75% Green	0.0000	0.5803	0.0000
	75% Magenta	0.5831	0.0000	0.5592
	75% Red	0.5837	0.0000	0.1120
	75% Blue	0.0000	0.0000	0.5243
	40% Grey	0.3916	0.3916	0.3916
Display Light Equivalent BT.709	DL White	0.4994	0.4994	0.4994
	DL Yellow	0.4982	0.4987	0.2840
	DL Cyan	0.3360	0.4930	0.4943
	DL Green	0.3350	0.4913	0.2652
	DL Magenta	0.4620	0.2015	0.4737
	DL Red	0.4575	0.1991	0.1611
	DL Blue	0.0000	0.0000	0.4517
Scene Light Equivalent BT.709	SL White	0.5097	0.5097	0.5097
	SL Yellow	0.5084	0.5082	0.2910
	SL Cyan	0.3449	0.5018	0.5032
	SL Green	0.3423	0.5001	0.2714
	SL Magenta	0.4660	0.2045	0.4775
	SL Red	0.4602	0.2012	0.1628
	SL Blue	0.0084	0.0000	0.4493
Near Black Test Signal	-4%	0.0000	0.0000	0.0000
	-2%	0.0000	0.0000	0.0000
	-1%	0.0000	0.0000	0.0000
	0%	0.0000	0.0000	0.0000
	1%	0.0123	0.0123	0.0123
	2%	0.0287	0.0287	0.0287
	4%	0.0610	0.0610	0.0610

LUT 15 Details						
Variant	**LUT Type**	**LUT Cube Size**	**SDI LUT Mode Narrow: 64 - 940 (10-bit) Full: 0 – 1023 (10-bit)**	**Input Range [Min Input .. Max input]**	**Output Range [0.0 .. 1.0]**	**BT.709 colour matrix comp.**
15a	I	33	Narrow	Nominal	Nominal	No
15a65	I	65	Narrow	Nominal	Nominal	No

LUT 16: HDR Laser Projectors - BT.2100 HLG to X′Y′Z′ PQ at 108 cd/m^2

No changes in this release.

BT.2100 HLG signals are converted to PQ at a nominal peak luminance of 108 cd/m^2 using the non-linear X′Y′Z′ colour representation (D65 white point), suitable for HDR laser projectors. The EOTF gamma is calculated using the extended range gamma formula in Footnote 2 of ITU-R BT.2100, and a further adjustment made for dark viewing environments (see ITU-R Report BT.2390 Section 6.2).