SMPTE STANDARD

Free Scale Gamut and Free Scale Log Characteristics of Camera Signals

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Foreword

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SMPTE Engineering Documents are drafted in accordance with the rules given in its Standards Operations Manual. This SMPTE Engineering Document was prepared by Technology Committee 10E.

Intellectual Property

At the time of publication no notice had been received by SMPTE claiming patent rights essential to the implementation of this Engineering Document. However, attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. SMPTE shall not be held responsible for identifying any or all such patent rights.

Introduction

This section is entirely informative and does not form an integral part of this Engineering Document.

FS-Gamut and the FS-Log curve, as well as an associated Color VANC packet carrying camera parameters, are specified in SMPTE ST 2048-1, which is an image format standard for digital cinematography production. FS-Gamut and FS-Log are also useful as sets describing camera parameters used in broadcast production.

Using the definitions in SMPTE ST 2048-1, this standard specifies the more general application of FS-Gamut and FS-Log and provides definitions of parameter sets commonly used in cameras for broadcast production.

1 Scope

This standard specifies the Free Scale Gamut (FS-Gamut) and the Free Scale logarithmic transfer characteristics (FS-Log) for camera signals. The FS-Gamut consists of chromaticity coordinates of red, green, and blue primaries and a white point. The FS-Gamut and FS-Log are specified in accordance with SMPTE ST 2048-1, in which these are originally specified for digital cinematography production.

This standard also specifies names for specific sets of parameter values for FS-Gamut and FS-Log, and associated transfer characteristics for professional cameras that make use of FS-Gamut and FS-Log.

2 Conformance Notation

Normative text is text that describes elements of the design that are indispensable or contains the conformance language keywords: "shall", "should", or "may". Informative text is text that is potentially helpful to the user, but not indispensable, and can be removed, changed, or added editorially without affecting interoperability. Informative text does not contain any conformance keywords.

All text in this document is, by default, normative, except: the Introduction, any section explicitly labeled as "Informative" or individual paragraphs that start with "Note:”

The keywords "shall" and "shall not" indicate requirements strictly to be followed in order to conform to the document and from which no deviation is permitted.

The keywords, "should" and "should not" indicate that, among several possibilities, one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required; or that (in the negative form) a certain possibility or course of action is deprecated but not prohibited.

The keywords "may" and "need not" indicate courses of action permissible within the limits of the document.

The keyword “reserved” indicates a provision that is not defined at this time, shall not be used, and may be defined in the future. The keyword “forbidden” indicates “reserved” and in addition indicates that the provision will never be defined in the future.

A conformant implementation according to this document is one that includes all mandatory provisions ("shall") and, if implemented, all recommended provisions ("should") as described. A conformant implementation need not implement optional provisions ("may") and need not implement them as described.

Unless otherwise specified, the order of precedence of the types of normative information in this document shall be as follows: Normative prose shall be the authoritative definition; Tables shall be next; then formal languages; then figures; and then any other language forms.

3 Normative References

The following standards contain provisions which, through reference in this text, constitute provisions of this engineering document. At the time of publication, the editions indicated were valid. All standards are subject

to revision, and parties to agreements based on this engineering document are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

ISO 11664-3:2012 (CIE S014-3/E:2011), Colorimetry – Part 3: CIE tristimulus values

SMPTE ST 2048-1:2011, 2048 x 1080 and 4096 x 2160 Digital Cinematography Production Image Formats FS/709

4 Terms and Definitions

For the purposes of this document, the following terms and definitions apply.

4.1 chromaticity coordinates

chromaticity coordinates (x, y) as defined in ISO 11664-3:2012

4.2 Free Scale Gamut
FS-Gamut

color gamut identified by a parameter set consisting of chromaticity coordinates of red, green, and blue primaries and a white point

4.3 Free Scale Log
FS-Log

logarithmic transfer characteristic identified by a parameter set consisting of the parameters shown in Table 1

5 FS Colorimetry

This section specifies Free Scale Gamut and Free Scale Log.

5.1 Free Scale Gamut (FS-Gamut)

FS-Gamut shall be as defined in SMPTE ST 2048-1:2011 section 6.1.1.

The default values of primaries and reference white of FS-Gamut shall be as defined in SMPTE ST 2048-1:2011 Table 3.

5.2 Free Scale Log (FS-Log)

FS-Log shall be as defined in SMPTE ST 2048-1:2011 section 6.1.2.

A set of parameters representing FS-Log is defined in Table 4 "Definition of FS-Log" of SMPTE ST 2048-1:2011, repeated as Table 1 for convenience.

Table 1. Definition of FS-Log (Informative)

Exposure Range	Definition
$L_{C1} \le L \le L_{C3}$	Upper three coordinates (L_{C1}, L'_{C1}), (L_{C2}, L'_{C2}), (L_{C3}, L'_{C3})
$L_{B1} \le L \le L_{C1}$	$L' = \alpha \, \mathrm{Log}_{10} (\beta L + \delta) + \varepsilon$ (Equation 1)
$L_{B3} \le L \le L_{B1}$	Lower three coordinates (L_{B3}, L'_{B3}), (L_{B2}, L'_{B2}), (L_{B1}, L'_{B1})

Note: Under appropriate exposure conditions, L = 0.18000 denotes light coming from an 18% gray reflector and L = 1.00000 denotes light coming from a 100% reflector as stated in SMPTE ST 2048-1:2011 section 6.1.2.

5.3 Notation of parameter values

xy chromaticity coordinates representing the RGB color primaries and the white point of the FS-Gamut characteristic in section 7.1 are specified with four decimal places.

The upper and lower three coordinates of the FS-log characteristic in section 7.2 are specified with five decimal places and the four coefficients in Equation 1 are specified with six significant digits.

Parameter values mapped into the Color VANC defined in Section 6 are transformed from the decimal representation in section 7.1 and section 7.2 to the 32-bit single-precision Binary Floating-Point Arithmetic in accordance with SMPTE ST 2048-1:2011 section 6.1.3.

6 Color VANC

Color VANC shall be as defined in SMPTE ST 2048-1:2011 section 6.3.

7 Parameter values of FS-Gamut and FS-Log

This section specifies names for specific sets of parameter values for FS-Gamut and FS-Log for professional cameras that make use of FS-Gamut and FS-Log.

7.1 FS-Gamut parameter values

FS-Gamut comprises the chromaticity coordinates of red, green, and blue primaries and a white point. Attributes of specific types are defined in this sub section. The FS-Gamut types defined in this sub section are denoted by Camera Gamut S3, Camera Gamut SC, Camera Gamut V and Camera Gamut C.

Note: The white point used in the specifications of this sub section is the same as that specified in Recommendations ITU-R BT.709 and ITU-R BT.2020. Its chromaticity coordinates correspond approximately to those of CIE Standard Illuminant D65.

7.1.1 Camera Gamut S3

The chromaticity coordinates of red, green, and blue primaries and a white point of Camera Gamut S3 shall be as defined in Table 2. The Color VANC values for Camera Gamut S3 shall be as stated in Table 2. The associated SMPTE UL shall be as defined in Table 3.

Table 2. Camera Gamut S3 Color Primaries and White Point

	CIE *x*	CIE *y*
Red primary	0.7300	0.2800
Green primary	0.1400	0.8550
Blue primary	0.1000	-0.0500
Reference white (D65)	0.3127	0.3290

Table 3. Camera Gamut S3 Color Primaries Universal Label

Name	SMPTE ST 2115 Camera Gamut S3 Color Primaries
Symbol	ColorPrimaries_ST2115_CameraGamutS3
Item UL	urn:smpte:ul:060e2b34.0401010d.04010101.030b0000
Definition	Identifies the SMPTE ST 2115 Camera Gamut S3 color primaries and white point

7.1.2 Camera Gamut SC

The chromaticity coordinates of red, green, and blue primaries and a white point of Camera Gamut SC shall be as defined in Table 4. The Color VANC values for Camera Gamut SC shall be as stated in Table 4. The associated SMPTE UL shall be as defined in Table 5.

Table 4. Camera Gamut SC Color Primaries and White Point

	CIE *x*	CIE *y*
Red primary	0.7660	0.2750
Green primary	0.2250	0.8000
Blue primary	0.0890	-0.0870
Reference white (D65)	0.3127	0.3290

Table 5. Camera Gamut SC Color Primaries Universal Label

Name	SMPTE ST 2115 Camera Gamut SC Color Primaries
Symbol	ColorPrimaries_ST2115_CameraGamutSC
Item UL	urn:smpte:ul:060e2b34.0401010d.04010101.030c0000
Definition	Identifies the SMPTE ST 2115 Camera Gamut SC color primaries and white point

7.1.3 Camera Gamut V

The chromaticity coordinates of red, green, and blue primaries and a white point of Camera Gamut V shall be as defined in Table 6. The Color VANC values for Camera Gamut V shall be as stated in Table 6. The associated SMPTE UL shall be as defined in Table 7.

Table 6. Camera Gamut V Color Primaries and White Point

	CIE *x*	CIE *y*
Red primary	0.7300	0.2800
Green primary	0.1650	0.8400
Blue primary	0.1000	-0.0300
Reference white (D65)	0.3127	0.3290

Table 7. Camera Gamut V Color Primaries Universal Label

Name	SMPTE ST 2115 Camera Gamut V Color Primaries
Symbol	ColorPrimaries_ST2115_CameraGamutV
Item UL	urn:smpte:ul:060e2b34.0401010d.04010101.030d0000
Definition	Identifies the SMPTE ST 2115 Camera Gamut V color primaries and white point

7.1.4 Camera Gamut C

The chromaticity coordinates of red, green, and blue primaries and a white point of Camera Gamut C shall be as defined in Table 8. The Color VANC values for Camera Gamut C shall be as stated in Table 8. The associated SMPTE UL shall be as defined in Table 9.

Table 8. Camera Gamut C Color Primaries and White Point

	CIE *x*	CIE *y*
Red primary	0.7400	0.2700
Green primary	0.1700	1.1400
Blue primary	0.0800	-0.1000
Reference white (D65)	0.3127	0.3290

Table 9. Camera Gamut C Color Primaries Universal Label

Name	SMPTE ST 2115 Camera Gamut C Color Primaries
Symbol	ColorPrimaries_ST2115_CameraGamutC
Item UL	urn:smpte:ul:060e2b34.0401010d.04010101.030e0000
Definition	Identifies the SMPTE ST 2115 Camera Gamut C color primaries and white point

7.2 FS-Log parameter values

FS-Log comprises 16 values listed in Table 1. Attributes of specific types and the associated transfer characteristics are defined in this sub section. The FS-Log types defined in this sub section are denoted by Camera Log S3, Camera Log V, Camera Log C2 and Camera Log C3.

7.2.1 Camera Log S3

The transfer characteristic of Camera Log S3 shall be,

$$L' = \left(\left(\frac{a - 95}{0.01125}\right) \times L + 95\right)/1023 \qquad L < 0.01125$$

$$L' = \left(261.5 \times \log_{10}\left(\frac{L + 0.01}{0.18 + 0.01}\right) + 420\right)/1023 \qquad L \geq 0.01125$$

where

$$a = 261.5 \times \log_{10}\left(\frac{0.01125 + 0.01}{0.18 + 0.01}\right) + 420$$

The Color VANC values for Camera Log S3 shall be as stated in Table 10.

The associated SMPTE UL shall be as defined in Table 11.

Table 10. Camera Log S3 attributes

Coefficients			
α	β	δ	ε
0.255621	5.26316	0.0526316	0.410557
Lower three coordinates			
(L_{B1}, L'_{B1})	(L_{B2}, L'_{B2})		(L_{B3}, L'_{B3})
(0.01125, 0.16736)	(0.00000, 0.09286)		(-0.01402, 0.00000)
The upper nonlinear curve is inactive.			

Note:
0.255621 is the rounded value of 261.5/1023.
5.26316 is the rounded value of 1/(0.18 + 0.01).
0.0526316 is the rounded value of 0.01/(0.18 + 0.01).
0.410557 is the rounded value of 420/1023.

Table 11. Camera Log S3 Transfer Characteristic Universal Label

Name	`SMPTE ST 2115 Camera Log S3 Transfer Characteristic`
Symbol	`TransferCharacteristic_ST2115_CameraLogS3`
Item UL	`urn:smpte:ul:060e2b34.0401010d.04010101.010e0000`
Definition	`Identifies the SMPTE ST 2115 Camera Log S3 transfer characteristic`

7.2.2 Camera Log V

The transfer characteristic of Camera Log V shall be,

$$L' = 5.6 \times L + 0.125 \qquad L < 0.01$$

$$L' = 0.241514 \times \log_{10}(L + 0.00873) + 0.598206 \qquad L \geq 0.01$$

The Color VANC values for Camera Log V shall be as stated in Table 12.

The associated SMPTE UL shall be as defined in Table 13.

Table 12. Camera Log V attributes

Coefficients			
α	β	δ	ε
0.241514	1.00000	0.00873000	0.598206
Lower three coordinates			
(L_{B1}, L'_{B1})	(L_{B2}, L'_{B2})		(L_{B3}, L'_{B3})
(0.01000, 0.18100)	(0.00000, 0.12500)		(-0.02232, 0.00000)
The upper nonlinear curve is inactive.			

Table 13. Camera Log V Transfer Characteristic Universal Label

Name	SMPTE ST 2115 Camera Log V Transfer Characteristic
Symbol	TransferCharacteristic_ST2115_CameraLogV
Item UL	urn:smpte:ul:060e2b34.0401010d.04010101.010f0000
Definition	Identifies the SMPTE ST 2115 Camera Log V transfer characteristic

7.2.3 Camera Log C2

The transfer characteristic of Camera Log C2 shall be,

$$L' = -0.241361 \times \log_{10}(1 - 96.7771 \times L) + 0.0928641 \quad L < 0$$

$$L' = 0.241361 \times \log_{10}(96.7771 \times L + 1) + 0.0928641 \quad L \geq 0$$

The Color VANC values for Camera Log C2 shall be as stated in Table 14.

The associated SMPTE UL shall be as defined in Table 15.

Table 14. Camera Log C2 attributes

Coefficients			
α	β	δ	ε
0.241361	96.7771	1.00000	0.0928641
Lower three coordinates			
(L_{B1}, L'_{B1})	(L_{B2}, L'_{B2})		(L_{B3}, L'_{B3})
(0.00000, 0.09286)	(-0.00736, 0.03649)		(-0.01473, 0.00000)
The upper nonlinear curve is inactive.			

Table 15. Camera Log C2 Transfer Characteristic Universal Label

Name	SMPTE ST 2115 Camera Log C2 Transfer Characteristic
Symbol	TransferCharacteristic_ST2115_CameraLogC2
Item UL	urn:smpte:ul:060e2b34.0401010d.04010101.01100000
Definition	Identifies the SMPTE ST 2115 Camera Log C2 transfer characteristic

7.2.4 Camera Log C3

The transfer characteristic of Camera Log C3 shall be,

$$L' = -0.367268 \times \log_{10}(1 - 16.6481 \times L) + 0.127839 \quad L < -0.0126$$

$$L' = 2.19498 \times L + 0.125122 \quad -0.0126 \leqq L \leqq 0.0126$$

$$L' = 0.367268 \times \log_{10}(16.6481 \times L + 1) + 0.122405 \quad L > 0.0126$$

The Color VANC values for Camera Log C3 shall be as stated in Table 16.

The associated SMPTE UL shall be as defined in Table 17.

Table 16. Camera Log C3 attributes

Coefficients			
α	β	δ	ε
0.367268	16.6481	1.00000	0.122405
Lower three coordinates			
(L_{B1}, L'_{B1})	(L_{B2}, L'_{B2})		(L_{B3}, L'_{B3})
(0.01260, 0.15278)	(-0.01260, 0.09747)		(-0.07381, 0.00000)
The upper nonlinear curve is inactive.			

Table 17. Camera Log C3 Transfer Characteristic Universal Label

Name	SMPTE ST 2115 Camera Log C3 Transfer Characteristic
Symbol	TransferCharacteristic_ST2115_CameraLogC3
Item UL	urn:smpte:ul:060e2b34.0401010d.04010101.01110000
Definition	Identifies the SMPTE ST 2115 Camera Log C3 transfer characteristic

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