SMPTE ST 2136-10:202x

WD SMPTE STANDARD

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| Common LUT Format: 10-bit Broadcast Profile | A picture containing text, clipart  Description automatically generated |

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10E-Input-ST-2136-10-Common-LUT-Format-2024-09-04.docx

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Foreword

SMPTE (the Society of Motion Picture and Television Engineers) is an internationally-recognized standards developing organization. Headquartered and incorporated in the United States of America, SMPTE has members in over 80 countries on six continents. SMPTE's Engineering Documents, including Standards, Recommended Practices, and Engineering Guidelines, are prepared by SMPTE's Technology Committees. Participation in these Committees is open to all with a bona fide interest in their work. SMPTE cooperates closely with other standards-developing organizations, including ISO, IEC and ITU.

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 TC-10E Essence.

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 clause or subclause explicitly labeled as "Informative".
* Individual paragraphs that start with "NOTE", "NOTE x" or "Note x to entry:", where "x" is the number of the note. Additional paragraphs in a note are indented to match indent of the note text.

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.

The use of color in text, tables, figures, formulae, or code is considered informative, unless explicitly stated that it is normative for that specific element.

Introduction

Look-Up Tables (LUTs) are a common implementation for transformations from one set of color values to another. Many LUT formats are designed for a particular use case only and lack the quality, flexibility, and metadata needed to meet modern requirements.

The Common LUT Format (CLF) can communicate an arbitrary chain of color operators, called process nodes, which are sequentially processed to achieve an end result. The set of available operator types includes matrices, 1D LUTs, 3D LUTs, ASC-CDL, log and exponential shaper functions, and more. This document provides multiple profiles for use in 10-bit live broadcast applications limiting the process node types and the order in which they can be used.

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.

# Scope

Three sub-profiles are described in this section for Broadcast use of CLF:

* Live\_Broadcast\_LUT33\_10-bit,
* Live\_Broadcast\_LUT65\_10-bit, and
* Live\_Broadcast\_Advanced\_10-bit.

The Use Case Description and Additional XML Elements are common to all three sub-profiles.

# Normative references

The following standards contain provisions that, through reference in this text, constitute provisions of this standard. Dated references require that the specific edition cited shall be used as the reference. Undated citations refer to the edition of the referenced document (including any amendments) current at the date of publication of this document. All standards are subject to revision, and users of this engineering document are encouraged to investigate the possibility of applying the most recent edition of any undated reference.

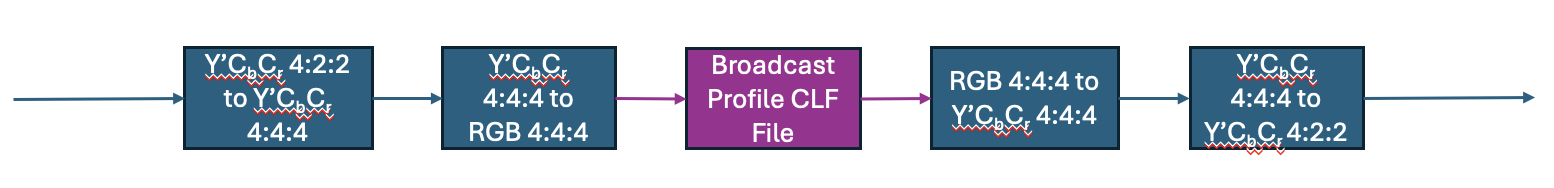
SMPTE ST 2136-1:2024, Common LUT Format

# Use Case Description

For use in real-time processing of baseband video signals in 10-bit Y’CbCr 4:2:2 format e.g. SMPTE ST 2082.  This limited profile is intended to replace Adobe Cube format files, operate on FPGA and ASIC based hardware and provide a more automated experience for users.

This LUT profile operates on R’G’B’ 4:4:4 inputs and outputs and operates over the entire signal range (10-bit code values 0-1023). It can be used for nominal range signals (Black 10-bit code value 64 maps to 64.0/1023.0 and White 10-bit code value 940 maps to 940.0/1023.0) with processing of sub-black and super-white values, or for full range signals.

As the baseband video format is Y’CbCr 4:2:2, a matrix conversion and reconstruction/destruction filter to and from R’G’B’ 4:4:4 is required at both the input and output. Additional XML tags are included within the info block to allow automatic Y’CbCr <-> R’G’B’ parameter setting. The Broadcast CLF listed within a conformant file expects the hardware to produce an R’G’B’ 4:4:4 input and provides a R’G’B’ 4:4:4 output. These additional XML tags also allow for correct format signaling via, for example, SMPTE SDI VPIDs.



**Figure 1: Block diagram showing required hardware modules required before and after CLF processing module. These modules’ parameters are set based on metadata stored in the <info> tags of the CLF file.**

# Additional XML Elements

Additional metadata can be added within the <info> tags to allow automation of the Y’CbCr <-> R’G’B’ conversions and video format signaling.

* InputCharacteristics
* OutputCharacteristics
* VideoRange
* ColorPrimaries
* CodingEquations
* TransferCharacteristic
* Keywords
  + Human readable keywords which are used to explain the operation of this CLF file, non-exhaustive examples include:
    - Down-map
    - Direct-map
    - Up-map
    - Scene-referred
    - Display-referred
    - HDR type conversion
    - SDR type conversion
    - Test LUT

The linear input scaling shall be undertaken such that input code value 0 is mapped to 0.0/1023.0 and input code value 1023 is mapped to 1023.0/1023.0, i.e. the entire signal range is always processed.

Definitions of VideoRange labels are given in Table 1 – VideoRange labels.

Table 1 – VideoRange labels

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Label Name** | **Black Level** | **White Level** | **Low Clip** | **High Clip** |
| st2136\_full\_range | 0 | 1 | 0 | 1 |
| st2136\_full\_range\_sdi | 0 | 1 | 4/1023 | 1019/1023 |
| st2136\_nominal\_range | 64/1023 | 940/1023 | 0 | 1 |
| st2136\_nominal\_range\_sdi | 64/1023 | 940/1023 | 4/1023 | 1019/1023 |
| st2136\_nominal\_range\_ebur103 | 64/1023 | 940/1023 | 20/1023 | 984/1023 |

When ColorPrimaries, CodingEquations, TransferCharacteristic and VideoRange are present within an InputCharacteristics clause:

* the values shall be used to correctly convert the input Y’CbCr 4:2:2 signal to RGB 4:4:4 as required by the ProcessList, and
* the values should be used to validate the signaling present in the input video.

The linear output scaling shall be undertaken such that 0.0/1023.0 is mapped to output code value 0 and 1023.0/1023.0 is mapped to output code value 1023.

When ColorPrimaries, CodingEquations, TransferCharacteristic and VideoRange are present within an OutputCharacteristics clause:

* the values shall be used to correctly convert the ProcessList output RGB 4:4:4 to Y’CbCr 4:2:2 as required by the baseband video output, and
* the values should be used to generate the signaling to be inserted in the output video.

## Warning – Conversion between Linear and Non-Linear using a 1D LUT

When converting between linear and non-linear formats using 1D LUTs in hardware implementations that don’t use floating point arithmetic, it is possible that quantization noise can cause visible artefacts, especially in shadow regions. Care should be taken to ensure that such artefacts are not visible in LUTs being created.

# Sub Profile 1: Live\_Broadcast\_LUT33\_10-bit

**URI:** <http://www.smpte-ra.org/ns/2136/2023#Live_Broadcast_LUT33_10-bit>

## Constraints on XML elements

The ProcessList is limited to the following ProcessNodes in the following order:

* LUT1D (optional, inBitDepth and outBitDepth 32f)
* LUT3D (mandatory, array dim 33 33 33 3, interpolation tetrahedral, inBitDepth and outBitDepth 32f, range 0.0 – 1.0)
* LUT1D (optional, inBitDepth and outBitDepth 32f)

Where used, inverseOf should link to the preferred inverse conversion which may not necessarily be the mathematical inverse.

## Example XML (Informative)

<?xml version="1.0" encoding="UTF-8"?>

<ProcessList name="SMPTE Example Live Broadcast LUT33 10-bit Profile" xmlns="http://www.smpte-ra.org/ns/2136/2023" id="urn:uuid:b0454eca-cffa-4745-b85d-773d95cfba9c">

<Profile><http://www.smpte-ra.org/ns/2136/2023#Live_Broadcast_LUT33_10-bit</Profile>>

<Description>Demo 33 cubed LUT with dummy values</Description>

<Info>

<AppRelease>SMPTE\_10E\_Example</AppRelease>

<Copyright>SMPTE MMXXIV</Copyright>

<Revision>1.0</Revision>

<InputCharateristics>

<ColorPrimaries>ColorPrimaries\_ITU709</ColorPrimaries>

<TransferCharacteristic>TransferCharacteristic\_ITU709</TransferCharacteristic>

<CodingEquations>CodingEquations\_ITU709</CodingEquations>

<VideoRange>st2136\_nominal\_range\_sdi</VideoRange>

</InputCharateristics>

<OutputCharateristics>

<ColorPrimaries>ColorPrimaries\_ITU2020</ColorPrimaries>

<TransferCharacteristic>TransferCharacteristic\_SMPTEST2084</TransferCharacteristic>

<CodingEquations>CodingEquations\_ITU2100\_ICtCp</CodingEquations>

<VideoRange>st2136\_full\_range\_sdi</VideolRange>

</OutputCharateristics>

<Keywords>Test LUT, Scene Referred</Keywords>

</Info>

<LUT3D name="Linear LUT 3D" interpolation="tetrahedral" inBitDepth="32f" outBitDepth="32f" id="urn:uuid:781115c9-7c6c-4fed-8950-84bf2bdfdcb4">

<Description>3d-LUT with extended range values</Description>

<Array dim="33 33 33 3">

0.000000 0.000000 0.000000

0.000000 0.000000 0.031250

0.000000 0.000000 0.062500

0.000000 0.000000 0.093750

... ... ... <!-- Multiple rows removed for brevity in example -->

1.000000 1.000000 0.906250

1.000000 1.000000 0.937500

1.000000 1.000000 0.968750

1.000000 1.000000 1.000000

</Array>

</LUT3D>

</ProcessList>

# Sub Profile 2: Live\_Broadcast\_LUT65\_10-bit

**URI:** <http://www.smpte-ra.org/ns/2136/2023#Live_Broadcast_LUT33_10-bit>

## Constraints on XML elements

The ProcessList is limited to the following ProcessNodes in the following order:

* LUT1D (optional, inBitDepth and outBitDepth 32f)
* LUT3D (mandatory, array dim 65 65 65 3, interpolation tetrahedral, inBitDepth and outBitDepth 32f, range 0.0 – 1.0)
* LUT1D (optional, inBitDepth and outBitDepth 32f)

Where used, inverseOf should link to the preferred inverse conversion which may not necessarily be the mathematical inverse.

## Example XML (Informative)

<?xml version="1.0" encoding="UTF-8"?>

<ProcessList name="SMPTE Example Live Broadcast LUT65 10-bit Profile" xmlns="http://www.smpte-ra.org/ns/2136/2023" id="urn:uuid:b0454eca-cffa-4745-b85d-773d95cfba9d">

<Profile><http://www.smpte-ra.org/ns/2136/2023#Live_Broadcast_LUT65_10-bit</Profile>>

<Description>Demo 33 cubed LUT with dummy values</Description>

<Info>

<AppRelease>SMPTE\_10E\_Example</AppRelease>

<Copyright>SMPTE MMXXIV</Copyright>

<Revision>1.0</Revision>

<InputCharateristics>

<ColorPrimaries>ColorPrimaries\_ITU709</ColorPrimaries>

<TransferCharacteristic>TransferCharacteristic\_ITU709</TransferCharacteristic>

<CodingEquations>CodingEquations\_ITU709</CodingEquations>

<VideoRange>st2136\_nominal\_range\_sdi</VideoRange>

</InputCharateristics>

<OutputCharateristics>

<ColorPrimaries>ColorPrimaries\_ITU2020</ColorPrimaries>

<TransferCharacteristic>TransferCharacteristic\_SMPTEST2084</TransferCharacteristic>

<CodingEquations>CodingEquations\_ITU2100\_ICtCp</CodingEquations>

<VideoRange>st2136\_full\_range\_sdi</VideolRange>

</OutputCharateristics>

<Keywords>Test LUT, Scene Referred</Keywords>

</Info>

<LUT3D name="Linear LUT 3D" interpolation="tetrahedral" inBitDepth="32f" outBitDepth="32f" id="urn:uuid:781115c9-7c6c-4fed-8950-84bf2bdfdcb4">

<Description>3d-LUT with extended range values</Description>

<Array dim="65 65 65 3">

0.000000 0.000000 0.000000

0.000000 0.000000 0.031250

0.000000 0.000000 0.062500

0.000000 0.000000 0.093750

... ... ... <!-- Multiple rows removed for brevity in example -->

1.000000 1.000000 0.906250

1.000000 1.000000 0.937500

1.000000 1.000000 0.968750

1.000000 1.000000 1.000000

</Array>

</LUT3D>

</ProcessList>

# Sub Profile 3: Live\_Broadcast\_Advanced\_10-bit

**URI:** <http://www.smpte-ra.org/ns/2136/2023#Live_Broadcast_Advanced_10-bit>

## Constraints on XML elements

The ProcessList is limited to the following ProcessNodes in the following order:

* LUT1D (optional, inBitDepth and outBitDepth 32f)
* Matrix (optional, inBitDepth and outBitDepth 32f)
* LUT1D (optional, inBitDepth and outBitDepth 32f)
* LUT3D (optional, interpolation tetrahedral, inBitDepth and outBitDepth 32f, range 0.0 – 1.0)
* LUT1D (optional, inBitDepth and outBitDepth 32f)
* Matrix (optional, inBitDepth and outBitDepth 32f)
* LUT1D (optional, inBitDepth and outBitDepth 32f)

Where used, inverseOf should link to the preferred inverse conversion which may not necessarily be the mathematical inverse.

## Example XML (Informative)

<?xml version="1.0" encoding="UTF-8"?>

<ProcessList name="SMPTE Example Live Broadcast Advanced 10-bit Profile" xmlns="http://www.smpte-ra.org/ns/2136/2023" id="urn:uuid:b0454eca-cffa-4745-b85d-773d95cfba9c">

<Profile><http://www.smpte-ra.org/ns/2136/2023#Live_Broadcast_Advanced_10-bit</Profile>>

<Description>Demo Advanced Broadcast CLF with dummy values</Description>

<Info>

<AppRelease>SMPTE\_10E\_Example</AppRelease>

<Copyright>SMPTE MMXXIV</Copyright>

<Revision>1.0</Revision>

<InputCharateristics>

<ColorPrimaries>ColorPrimaries\_ITU709</ColorPrimaries>

<TransferCharacteristic>TransferCharacteristic\_ITU709</TransferCharacteristic>

<CodingEquations>CodingEquations\_ITU709</CodingEquations>

<VideoRange>st2136\_nominal\_range\_sdi</VideoRange>

</InputCharateristics>

<OutputCharateristics>

<ColorPrimaries>ColorPrimaries\_ITU2020</ColorPrimaries>

<TransferCharacteristic>TransferCharacteristic\_SMPTEST2084</TransferCharacteristic>

<CodingEquations>CodingEquations\_ITU2100\_ICtCp</CodingEquations>

<VideoRange>st2136\_full\_range\_sdi</VideolRange>

</OutputCharateristics>

<Keywords>Test LUT, Scene Referred</Keywords>

</Info>

<LUT1D name="Linear LUT 1D" interpolation="linear" inBitDepth="32f" outBitDepth="32f" id="urn:uuid:781115c9-7c6c-4fed-8950-84bf2bdfdcb5">  
 <Description>1d-LUT with extended range values</Description>  
 <Array dim=" 5 1">  
 0.000000  
 0.250000  
 0.500000  
 0.750000  
 1.000000  
 </Array>  
 </LUT1D>  
 <Matrix name="identity" inBitDepth="32f" outBitDepth="32f" id="urn:uuid:781115c9-7c6c-4fed-8950-84bf2bdfdcb6">  
 <Description>Identity Matrix 3x3</Description>  
 <Array dim="3 3">  
 1.000000 0.000000 0.000000  
 0.000000 1.000000 0.000000  
 0.000000 0.000000 1.000000  
 </Array>  
 </Matrix>  
  
 <LUT1D name="Linear LUT 1D" interpolation="linear" inBitDepth="32f" outBitDepth="32f" id="urn:uuid:781115c9-7c6c-4fed-8950-84bf2bdfdcb5">  
 <Description>1d-LUT with extended range values</Description>  
 <Array dim=" 5 1">  
 0.000000  
 0.250000  
 0.500000  
 0.750000  
 1.000000  
 </Array>  
 </LUT1D>  
   
 <LUT3D name="Linear LUT 3D" interpolation="tetrahedral" inBitDepth="32f" outBitDepth="32f" id="urn:uuid:781115c9-7c6c-4fed-8950-84bf2bdfdcb4">   
 <Description>3d-LUT with extended range values</Description>   
 <Array dim="65 65 65s 3">  
 0.000000 0.000000 0.000000  
 0.000000 0.000000 0.015625  
 0.000000 0.000000 0.031250  
 0.000000 0.000000 0.046875  
 ... ... ... <!-- Multiple rows removed for brevity in example -->  
 1.000000 1.000000 0.953125  
 1.000000 1.000000 0.968750  
 1.000000 1.000000 0.984375  
 1.000000 1.000000 1.000000  
 </Array>  
 </LUT3D>  
   
 <LUT1D name="Linear LUT 1D" interpolation="linear" inBitDepth="32f" outBitDepth="32f" id="urn:uuid:781115c9-7c6c-4fed-8950-84bf2bdfdcb5">  
 <Description>1d-LUT with extended range values</Description>  
 <Array dim=" 5 1">  
 0.000000  
 0.250000  
 0.500000  
 0.750000  
 1.000000  
 </Array>  
 </LUT1D>  
  
 <Matrix name="identity" inBitDepth="32f" outBitDepth="32f" id="urn:uuid:781115c9-7c6c-4fed-8950-84bf2bdfdcb6">  
 <Description>Identity Matrix 3x3</Description>  
 <Array dim="3 3">  
 1.000000 0.000000 0.000000  
 0.000000 1.000000 0.000000  
 0.000000 0.000000 1.000000  
 </Array>  
 </Matrix>  
 <LUT1D name="Linear LUT 1D" interpolation="linear" inBitDepth="32f" outBitDepth="32f" id="urn:uuid:781115c9-7c6c-4fed-8950-84bf2bdfdcb5">  
 <Description>1d-LUT with extended range values</Description>  
 <Array dim=" 5 1">  
 0.000000  
 0.250000  
 0.500000  
 0.750000  
 1.000000  
 </Array>  
 </LUT1D>  
</ProcessList>