# Broadcast Profiles Definition

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.

## 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 signalling via, for example, SMPTE SDI VPIDs.

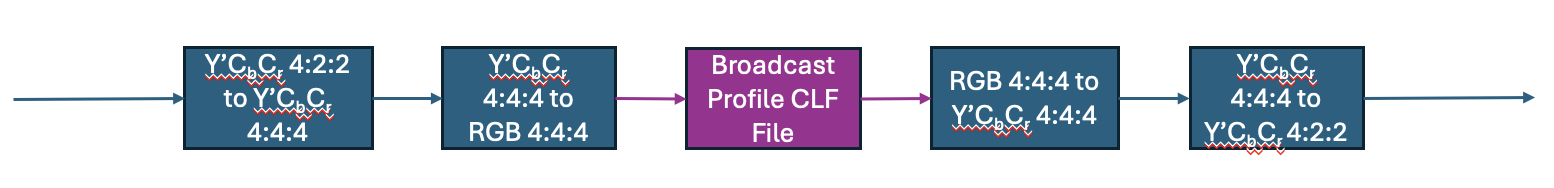


Figure 1: Block diagram showing required hardware modules required before and after CLF processing module. These modules’ parameters are set based on metadata stored in the <info> tags of the CLF file.

## 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 signalling.

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

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.

When ColorPrimaries, CodingEquations, TransferCharacteristic and VideoFullRangeFlag 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 signalling 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 VideoFullRangeFlag 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 signalling 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 quantisation noise can cause visible artefacts, especially in shadow regions.

## Sub-profiles

### 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:**

<?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>  
 <InputFullRangeVideoBool>false</InputFullRangeVideoBool>  
 <InputColorPrimariesSMPTESymbol>ColorPrimaries\_ITU709</InputColorPrimariesSMPTESymbol>  
 <InputCodingEquationsSMPTESymbol>CodingEquations\_ITU709</InputCodingEquationsSMPTESymbol>   
 <InputTransferCharacteristicSMPTESymbol>

TransferCharacteristic\_ITU709

</InputTransferCharacteristicSMPTESymbol>  
 <OutputFullRangeVideoBool>false</OutputFullRangeVideoBool>  
 <OutputColorPrimariesSMPTESymbol>ColorPrimaries\_ITU2020</OutputColorPrimariesSMPTESymbol>  
 <OutputCodingEquationsSMPTESymbol>CodingEquations\_ITU2100\_ICtCp</OutputCodingEquationsSMPTESymbol>  
 <OutputTransferCharacteristicSMPTESymbol>

TransferCharacteristic\_SMPTEST2084

</OutputTransferCharacteristicSMPTESymbol>  
 <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>

### Live\_Broadcast\_LUT65\_10-bit

**URI:** <http://www.smpte-ra.org/ns/2136/2023#Live_Broadcast_LUT65_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:**

<?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-773d95cfba9c">   
  
 <Profile>http://www.smpte-ra.org/ns/2136/2023#Live\_Broadcast\_LUT65\_10-bit</Profile>  
  
 <Description>Demo 65 cubed LUT with dummy values</Description>  
  
 <Info>  
 <AppRelease>SMPTE\_10E\_Example</AppRelease>  
 <Copyright>SMPTE MMXXIV</Copyright>  
 <Revision>1.0</Revision>  
 <InputFullRangeVideoBool>false</InputFullRangeVideoBool>  
 <InputColorPrimariesSMPTESymbol>ColorPrimaries\_ITU709</InputColorPrimariesSMPTESymbol>  
 <InputCodingEquationsSMPTESymbol>CodingEquations\_ITU709</InputCodingEquationsSMPTESymbol>   
 <InputTransferCharacteristicSMPTESymbol>

TransferCharacteristic\_ITU709

</InputTransferCharacteristicSMPTESymbol>  
 <OutputFullRangeVideoBool>false</OutputFullRangeVideoBool>  
 <OutputColorPrimariesSMPTESymbol>ColorPrimaries\_ITU2020</OutputColorPrimariesSMPTESymbol>  
 <OutputCodingEquationsSMPTESymbol>CodingEquations\_ITU2100\_ICtCp</OutputCodingEquationsSMPTESymbol>  
 <OutputTransferCharacteristicSMPTESymbol>

TransferCharacteristic\_SMPTEST2084

</OutputTransferCharacteristicSMPTESymbol>  
 <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 0.015625  
 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>  
</ProcessList>

### 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:**

<?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>  
 <InputFullRangeVideoBool>false</InputFullRangeVideoBool>  
 <InputColorPrimariesSMPTESymbol>ColorPrimaries\_ITU709</InputColorPrimariesSMPTESymbol>  
 <InputCodingEquationsSMPTESymbol>CodingEquations\_ITU709</InputCodingEquationsSMPTESymbol>   
 <InputTransferCharacteristicSMPTESymbol>

TransferCharacteristic\_ITU709

</InputTransferCharacteristicSMPTESymbol>  
 <OutputFullRangeVideoBool>false</OutputFullRangeVideoBool>  
 <OutputColorPrimariesSMPTESymbol>ColorPrimaries\_ITU2020</OutputColorPrimariesSMPTESymbol>  
 <OutputCodingEquationsSMPTESymbol>CodingEquations\_ITU2100\_ICtCp</OutputCodingEquationsSMPTESymbol>  
 <OutputTransferCharacteristicSMPTESymbol>

TransferCharacteristic\_SMPTEST2084

</OutputTransferCharacteristicSMPTESymbol>  
 <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">  
 <!-- Where/How do we generate the id -->  
 <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>