APPLICATION NOTE

Adaptive and LUT-based HDR conversion in VIA Xsquare

Contents

Introduction

High Dynamic Range (HDR) is a real game-changer. It provides a transformative immersive experience, but one which requires minimum effort from the viewer and it's in easy reach of the mass market. More and more broadcasters are launching HDR services, and it is in live sports that HDR and Wide Color Gammut (WCG) truly come into their own, delivering vivid life-like pictures with wider contrast and greater depth – banishing shadows that often plague viewers' enjoyment of the action.

When you are working in HDR productions, you will run into the challenge of having to convert SDR to HDR, HDR to SDR or converting from one HDR curve to another.

To address this issue, two types of conversion can be used, based on static Look Up Tables (LUTs) or based on adaptive/dynamic algorithms. Using LUTs has the advantage that you can choose between various LUTs with different outcomes. You can even fine-tune the resulting colors and luminance with the right color grading expertise. You can use various LUTS for various events, or create certain effects. The conversion is static though, so fast changes in brightness are not compensated.

Using Dynamic conversion is much easier compared to LUT based conversions. There are less settings to configure and you don't need a color grading expert to choose or create a LUT for you. Dynamic conversion compensates the color and luminance output when the brightness between scenes changes. On top of that, it ensures the perfect round-trip conversion. This immediately highlights the down-side of this type of conversion: you do not have any control of the output. What you see is what you get, without the possibility to make adjustments.

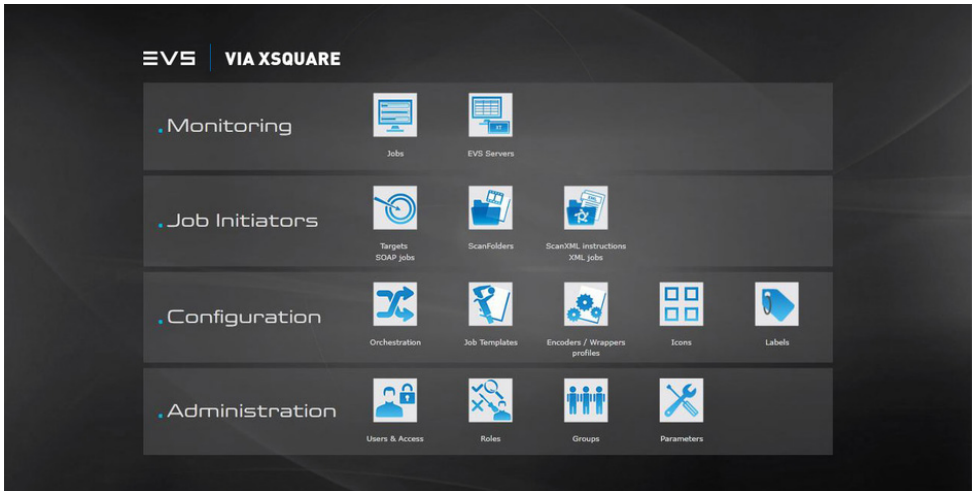
The choice of which conversion method is best, differs per use case. In **VIA Xsquare** and **XTAccess**, you can chose between both methods. This application note will show you exactly where you can configure your HDR conversion and how you can set it up.

VIA Xsquare and XTAccess

VIA Xsquare provides a single entry point for production teams to transform, orchestrate and monitor media files as they move through the live workflow all the way from ingest to shared storage and distribution.

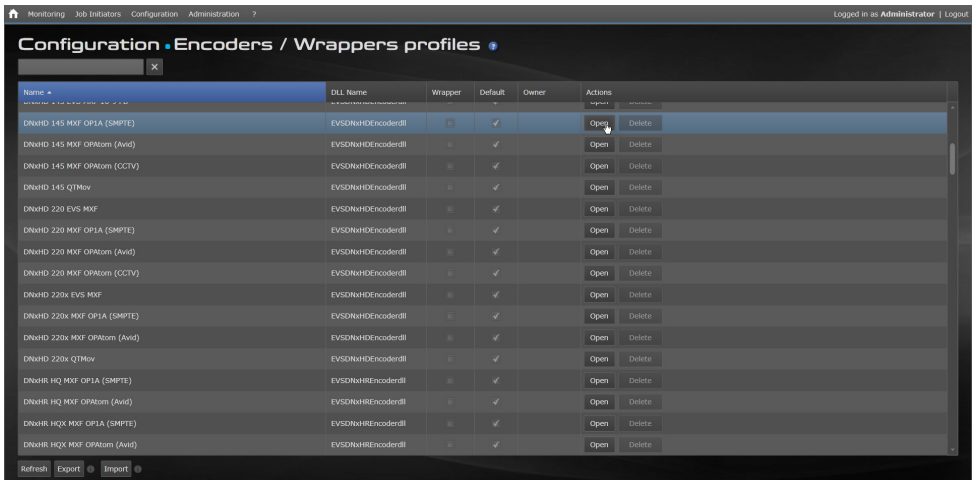
By centralizing all media processing job requests in a single web interface, reducing transcoding needs, and enabling SDR/HDR conversion on the fly, VIA Xsquare maximizes productivity and offers higher visibility of all workflow processes. Its high-availability design and flexible architecture provide users with a scalable system to manage workflows between EVS systems, third-party storage, and non-linear editing (NLE) systems.

XTAccess is the engine which runs the transcoding, wrapping and file transfer processes. If you need more processing power to run more simultanious transcoding jobs at the same time, you simply add more XTAccesses. VIA Xsquare is the software in which the various jobs are monitored and configured by the end-user, and which manages the orchestration of the XTAccess processing devices.



Accessing the HDR conversion settings in VIA Xsquare

To access the HDR conversion settings, you have to go to “Encoders/Wrappers Profiles” under Configuration. You simply select a profile and click “Open”. In the pop-up window you can edit the Adaptive Conversion or LUT-based conversion settings of the selected profile.



LUT-based conversion

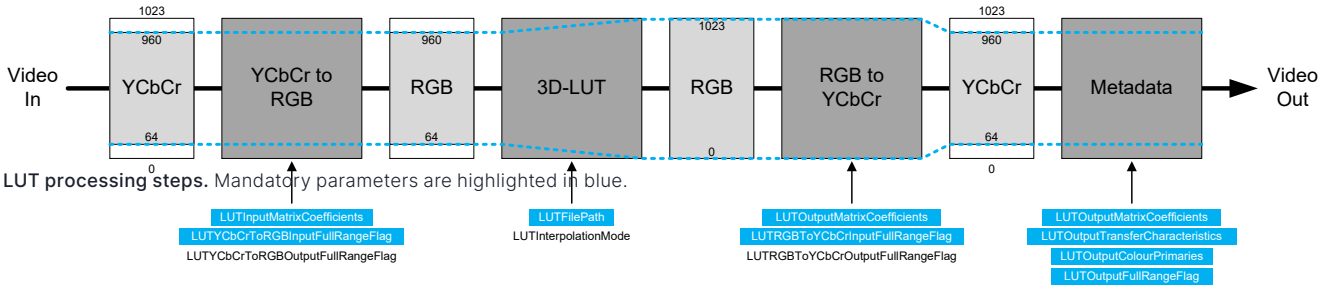
HDR/SDR cross-conversions can be performed using a 3D LUT through a user-provided LUT file. This feature has been introduced with VIA Xsquare 4.0. The 3D LUT conversion feature supports the ".cube" format up to 64-cube LUT and 3 different interpolation modes.

In addition to the custom LUT file, a certain number of associated parameters must be provided to define the intent of the custom LUT file in terms of input and output signal characteristics. Some of these parameters are mandatory.

A 3D LUT works by mapping input RGB values to output RGB values, thus a conversion from YCbCr to RGB is necessary prior to the LUT, as well as a conversion from RGB back to YCbCr in the output of the LUT. To perform these conversions, the user needs to provide the matrix coefficients that will be used, along with the expected input and output signal ranges.

These parameters as well as the LUT processing and its different steps are illustrated in the figure below.

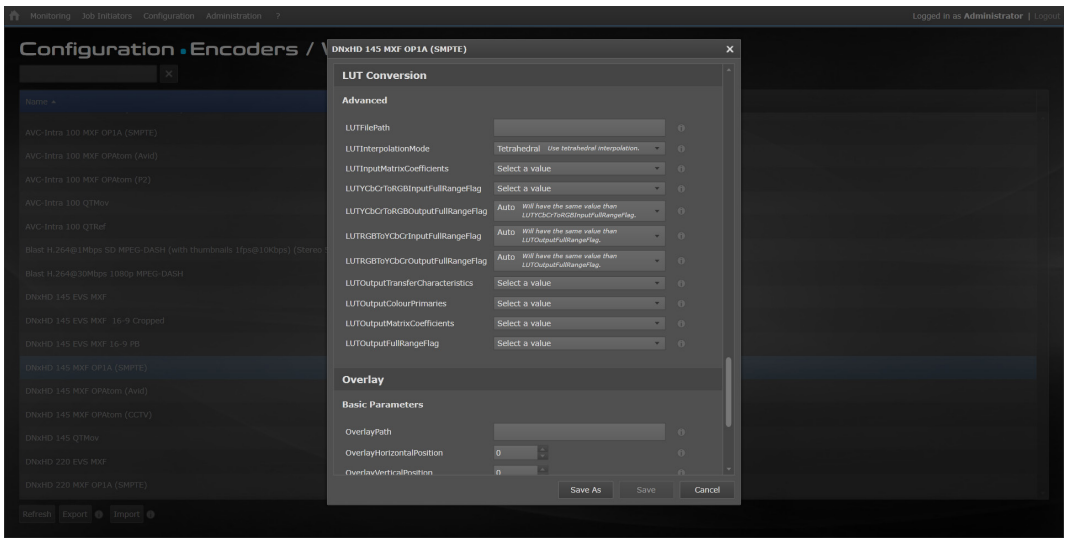
Every individual VIA Xsquare destination (file, XT/XS clip, etc...) which requires a static SDR/HDR conversion will consume 2 XTAccess SW licenses: one XTAccess Destination SW license (**XTA-DEST**) together with one XTAccess Advanced Option SW license (**XTA-ADV-OPT**)



LUT processing steps. Mandatory parameters are highlighted in blue.

LUT parameters in VIA Xsquare

When editing a profile, scroll down untill you see the "LUT conversion" settings.



The following table provides a description of all the parameters related to LUT-based conversion.

Parameter	Mandatory or default value	Description
LUTFilePath	Mandatory	Specifies the path to the Look Up Table (LUT) file
LUTInterpolationMode	Tetrahedral	Specifies the interpolation mode • Nearest: Use nearest interpolation • Trilinear: Use trilinear interpolation • Tetrahedral: Use tetrahedral interpolation
LUTInputMatrixCoefficients	Mandatory	Specifies the input matrix coefficients. Those matrix coefficients will be used when converting from YCbCr to RGB prior to the LUT. It is mandatory to specify this parameter when a LUT file is used. • sRGB: Matrix coefficients are sRGB • BT601: Matrix coefficients are BT-601 • BT709: Matrix coefficients are SDR BT-709 • BT2020: Matrix coefficients are BT-2020
LUTYCbCrToRGBInputFullRangeFlag	Mandatory	Specifies the range of the input YCbCr signal prior to the conversion to RGB prior to the LUT. The colour matrix equations used for the conversion YCbCr to RGB prior to the LUT will be different whether the signal is full or narrow range. It is mandatory to specify this parameter when a LUT file is used. • True: Full range flag is true • False: Full range flag is false (= legal/narrow/tv range)
LUTYCbCrToRGBOutputFullRangeFlag	Auto	Specifies whether the LUT expects full range RGB or narrow range RGB in input. The color matrix equations used for the conversion YCbCr to RGB prior to the LUT will be different whether the expected RGB range is full or narrow. • Auto: Will have the same value as LUTYCbCrToRGBInputFullRangeFlag • True: Full range flag is true • False: Full range flag is false (= legal/narrow/tv range)
LUTRGBToYCbCrInputFullRangeFlag	Auto	Specifies the range of the output RGB signal subsequent to the LUT. The colour matrix equations used for the conversion from RGB to YCbCr subsequent to the LUT will be different whether the RGB signal in output of the LUT is full or narrow range. • Auto: Will have the same value than LUTOutputFullRangeFlag • True: Full range flag is true • False: Full range flag is false (= legal/narrow/tv range)
LUTRGBToYCbCrOutputFullRangeFlag	Auto	Specifies the expected range of the YCbCr signal subsequent to the conversion from RGB to YCbCr subsequent to the LUT. The colour matrix equations used for the conversion from RGB to YCbCr subsequent to the LUT will be different whether the YCbCr signal expected range is full or narrow. • Auto: Will have the same value than LUTOutputFullRangeFlag • True: Full range flag is true • False: Full range flag is false (= legal/narrow/tv range)
LUTOutputTransferCharacteristics	Mandatory	Specifies the output color transfer characteristics. This parameter simply overrides the metadata in output of the LUT, it has no effect on the LUT processing and the RGB<->YCbCr conversions. This value will be included in the video data bistream and in the container after encoding. It is mandatory to specify this parameter when a LUT file is used. • BT601: Transfer characteristics are BT-601 • BT709: Transfer characteristics are BT-709 • PQ: Transfer characteristics are PQ • HLG: Transfer characteristics are HLG • SLog3: Transfer characteristics are SLog3 • VLog: Transfer characteristics are VLog

Parameter	Mandatory or default value	Description
LUTOutputColourPrimaries	Mandatory	Specifies the output colour primaries metadata. This parameter simply overrides the metadata in output of the LUT, it has no effect on the LUT processing and the RGB<->YCbCr conversions. This value will be included in the video data bistream and in the container after encoding. It is mandatory to specify this parameter when a LUT file is used. • BT601: Color primaries are BT-601 • BT709: Color primaries are SDR BT-709 • BT2020: Color primaries are BT-2020
LUTOutputMatrixCoefficients	Mandatory	Specifies the output matrix coefficients. As well as overriding the metadata in output of the LUT, this parameter defines the colour matrix equations used for the conversion from RGB to YCbCr subsequent to the LUT. This value will be included in the video data bitstream and in the container after encoding. It is mandatory to specify this parameter when a LUT file is used. • sRGB: Matrix coefficients are sRGB • BT601: Matrix coefficients are BT-601 • BT709: Matrix coefficients are BT-709 • BT2020: Matrix coefficients are BT-2020
LUTOutputFullRangeFlag	Mandatory	Specifies the output full range flag. This value will be included in the video data bitstream and in the container after encoding. It is mandatory to specify this parameter when a LUT file is used. • True: Full range flag is true • False: Full range flag is false (= legal/narrow/tv range)

Common LUT-based conversion scenarios

To help you configure the 3D LUT, we have summarized, in the table below, the values of the parameters for the most common HDR/SDR conversion scenarios.

	BT.2100 HLG to BT.709	BT.709 to BT.2100 HLG	BT.2100 PQ (full) to BT.709	BT.2100 PQ (narrow) to BT.709	BT.709 to BT.2100 PQ (full)	BT.709 to BT.2100 PQ (narrow)	BT.2100 PQ (full) to BT.2100 HLG	BT.2100 PQ (narrow) to BT.2100 HLG	BT.2100 HLG to BT.2100 PQ (full)	BT.2100 HLG to BT.2100 PQ (narrow)
LUTInputMatrixCoefficients	BT2020	BT709	BT2020	BT2020	BT709	BT709	BT2020	BT2020	BT2020	BT2020
LUTYCbCrToRGBInputFullRangeFlag	False	False	True	False	False	False	True	False	False	False
LUTOutputMatrixCoefficients	BT709	BT2020	BT709	BT709	BT2020	BT2020	BT2020	BT2020	BT2020	BT2020
LUTOutputFullRangeFlag	False	False	False	False	True	False	False	False	True	False
LUTOutputTransferCharacteristics	BT709	HLG	BT709	BT709	PQ	PQ	HLG	HLG	PQ	PQ
LUTOutputColourPrimaries	BT709	BT2020	BT709	BT709	BT2020	BT2020	BT2020	BT2020	BT2020	BT2020

BBC HLG 3D LUT Conversions

In addition to being able to use your proprietary LUT conversion files, VIA Xsquare also enables customers to use BBC LUT conversion files, to take advantage of the latest BBC HLG LUT improvements. LUT conversion files are stored in the following folder: C:\Program Files\EVS Broadcast Equipment\Xsquare\. The relevant files can be found in the subfolders whose names begin with: **BBC_HLG_HDR_Format_Conversion_LUTs_v...**, e.g. the **BBC_HLG_HDR_Format_Conversion_LUTs_v1_5_2020-12-08** subfolder.

The following conversions can be enabled by the BBC LUTs:

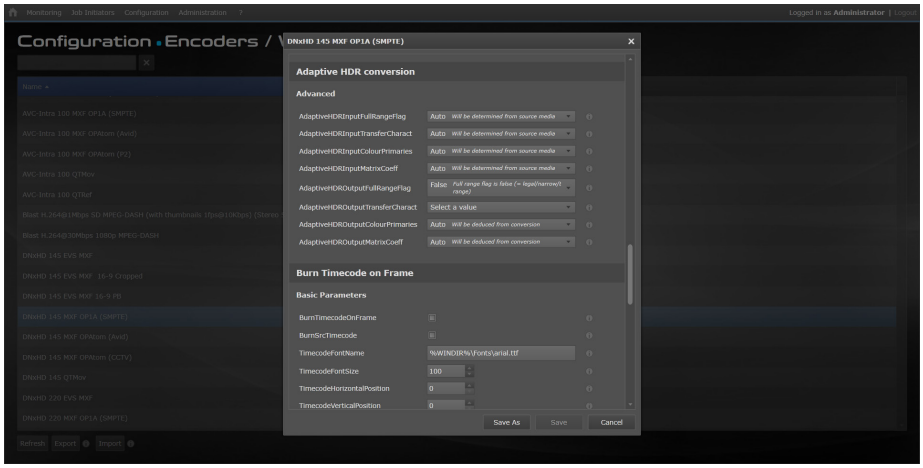
1. from BT.2100 PQ 1000 to BT.2100 HLG
2. from BT.2100 PQ 4000 to BT.2100 HLG
3. from BT.709 to BT.2100 HLG (mapping)
4. from BT.709 to BT.2100 HLG (up – conversion)
5. from BT.709 to BT.2100 HLG (scene light mapping for cameras)
6. from BT.709 to BT.2100 HLG (scene light up conversion for cameras)
7. from BT.2100 HLG to BT.2100 PQ
8. from BT.2100 HLG to BT.709 (display-light- hue preserving colour volume management)
9. from BT.2100 HLG to Dolby PRM4200/4220
10. from S-Log3 to BT.2100 HLG
11. from BT.2100 HLG to BT.709 (scene-light- for matching cameras)
12. from PQ 1000 (P3D65) to BT.2100 HLG
13. from BT.2100 HLG to PQ (P3D65)
14. from BT.2100 HLG to PQ (110 cd/m2) X'Y'Z'

Adaptive conversion

The Adaptive HDR Converter makes it possible to add SDR/HDR conversions in both HD and UHD to any VIA Xsquare workflow. Based on an intelligent algorithm, this converter guarantees an optimal conversion, regardless of the video content. This feature has been introduced with VIA Xsquare 4.1.

Every individual VIA Xsquare destination (file, XT/XS clip, etc...) which requires an adaptive/dynamic SDR/HDR conversion will consume 3 XTAccess SW licenses: one XTAccess Destination SW license (XTA-DEST) together with one XTAccess Advanced Option SW license (called XTA-ADV-OPT) and one XTAccess Premium Option SW Licence (called XTA-PREM-OPT).

When editing a profile, scroll down untill you see the “Adaptive HDR conversion” settings.



Adaptive conversion output parameters

If the mandatory output parameter (AdaptiveHDROutputTransferCharact) is set, the Adaptive HDR/SDR Conversion will be enabled. The following table explains all Adaptive parameters.

Parameter	Mandatory or default value	Description
AdaptiveHDROutputTransferCharact	Mandatory	Specifies the output color transfer characteristics. If not set, Adaptive HDR/SDR conversion is not applied. • BT709: Transfer characteristics are SDR BT-709 • PQ: Transfer characteristics are HDR PQ • HLG: Transfer characteristics are HDR HLG • SLog3: Transfer characteristics are HDR SLog3
AdaptiveHDROutputFullRangeFlag	False	Specifies the output full range flag. • True: Full range flag is true • False: Full range flag is false (= legal/narrow/tv range)
AdaptiveHDROutputColourPrimaries	Auto	Specifies the output color primaries metadata. • Auto: will be determined from the AdaptiveHDROutputTransferCharact • BT601: Color primaries are BT-601 • BT709: Color primaries are SDR BT-709 • BT2020: Color primaries are BT-2020
AdaptiveHDROutputMatrixCoefficients	Auto	Specifies the output matrix coefficients. If not set, it will be the same as input. • Auto: will be determined from the AdaptiveHDROutputTransferCharact • sRGB: Matrix coefficients are sRGB • BT60 : Matrix coefficients are BT-601 • BT709: Matrix coefficients are BT-709 • BT2020: Matrix coefficients are BT-2020

Adaptive conversion input parameters

By default, for all "Input" parameters, values are determined from the video input video media (Auto). It is nevertheless possible to force a different value, if the HDR metadata of the input media is not correct.

Parameter	Mandatory or default value	Description
AdaptiveHDRInputTransferCharact	Auto	Specifies the input color transfer characteristics. • Auto: value will be determined from the input video media • BT709 : Transfer characteristics are BT-709 • PQ : Transfer characteristics are PQ • HLG : Transfer characteristics are HLG • SLog3 : Transfer characteristics are SLog3
AdaptiveHDRInputColourPrimaries	Auto	Specifies the input color primaries metadata. • Auto: value will be determined from the input video media • BT601 : Color primaries are BT-601 • BT709 : Color primaries are SDR BT-709 • BT2020 : Color primaries are BT-2020
AdaptiveHDRInputMatrixCoefficients	Auto	Specifies the input matrix coefficients. • Auto: value will be determined from the input video media • sRGB : Matrix coefficients are sRGB • BT601 : Matrix coefficients are BT-601 • BT709 : Matrix coefficients are BT-709 • BT2020 : Matrix coefficients are BT-2020
AdaptiveHDRInputFullRangeFlag	Auto	Specifies the input full range flag for AdaptiveHDRConversion. • Auto: value will be determined from the input video stream • True : Full range flag is true • False : Full range flag is false (= legal/narrow/tv range)

LEGAL INFO

DISCLAIMER

The information in this document is believed to be correct as of the date of publication. However, our policy is one of continual development so the information in this guide is subject to change without notice, and does not represent a commitment on the part of EVS Broadcast Equipment.

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