greenMachine®

HDR enhanced video image engine Evie+ ©

HDR Evie+ for greenMachine titan

Revision 1.1 – NOV 2020

LYNXTechnik AG®

Broadcast Television Equipment

THIS MANUAL SUPPORTS:	
titan from Revision	862
greenGUI from Revision	2.11.0

Contents

1. Overview

The greenMachine HDR EVIE+ Constellation is a segmented frame-by-frame broadcast-quality HDR-to-SDR converter, with frame sync and metadata processing providing one 12G processing channel supporting formats up to 4K/UHD. EVIE+ stands for Enhanced Video Image Engine (Plus) and is based on a real-time sectional dynamic tone mapping algorithm, which analyzes different sections of an HDR image and applies optimal contrast and color corrections frame-by-frame to produce vibrant and realistic images for the viewer. The HDR EVIE+ Constellation is part of a suite of constellations that can be deployed on the greenMachine titan 4-channel hardware platform.

With High Dynamic Range (HDR), there are entirely new possibilities for broadcast and AV productions to provide an increased dynamic range for the viewer, including brighter highlights and more details in dark areas resulting in more brilliant and realistic images. This is because modern image sensors offer significantly wider dynamic color ranges. But classic Standard Dynamic Range (SDR) TV devices are only able to reproduce the older dynamic range of SDTV and HDTV standards but not the extended dynamic range of HDR. One of the significant challenges when introducing HDR with its tremendous image enhancements is to maintain good backward compatibility with existing SDR displays and receivers.

The greenMachine HDR EVIE+ Constellation is a powerful tool for handling dynamic ranges and color gamuts, offering viewers more vibrant images than previously seen, even without an up-to-date HDR display. It provides conversion functionality, simultaneously combining it with a real-time sectional dynamic tone mapping, which is capable of transferring the maximum amount of image information to the new target format. Depending on the image content, the best compromise is chosen between obtaining as much information as possible and a steep gradation.

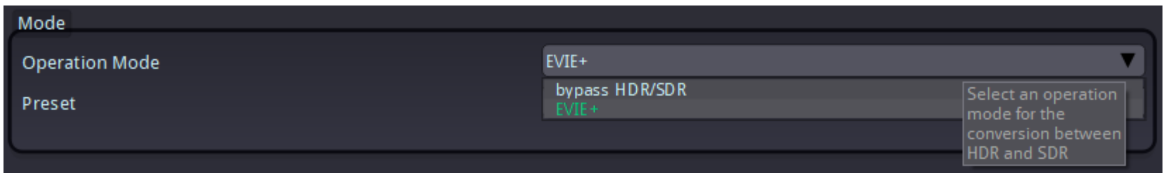
This application allows the user to carry out down-conversions between common HDR transfer characteristics (including PQ, HLG, SLog3, and other proprietary camera capture curves of common camera manufacturers) and the Gamma BT.709 characteristic using the appropriate dynamic tone mapping. The HDR EVIE+ Constellation is also capable of performing conversions between color spaces, including Rec. 601, Rec. 709, Rec. 2020, DCI-P3, ACES, and the respective proprietary color spaces as well as conversions between full and narrow range signals. This allows HDR content to be displayed on non-HDR-capable TV-monitors by using contrast compression, producing a high level of HDR-enhanced image quality for any type of SDR display device.

This greenMachine HDR EVIE+ Constellation also includes audio & video test patterns, video adjustments, embedding and de-embedding, audio processing and shuffling, color matching, timing adjustment, metadata processing, and the Nova controller which enables the greenMachine to be remotely controlled and monitored via third party master control software. CustomControl is also included providing simplified customized screen panels offering direct access to user-selected parameters.

This document describes the HDR processing part of the HDR-EVIE+ Constellation.

2. Operation Modes

The HDR processor provides two selectable modes: “bypass HDR/SDR” and “EVIE+.”



Selecting an Operation Mode

2.1. Operation Mode “bypass HDR/SDR”

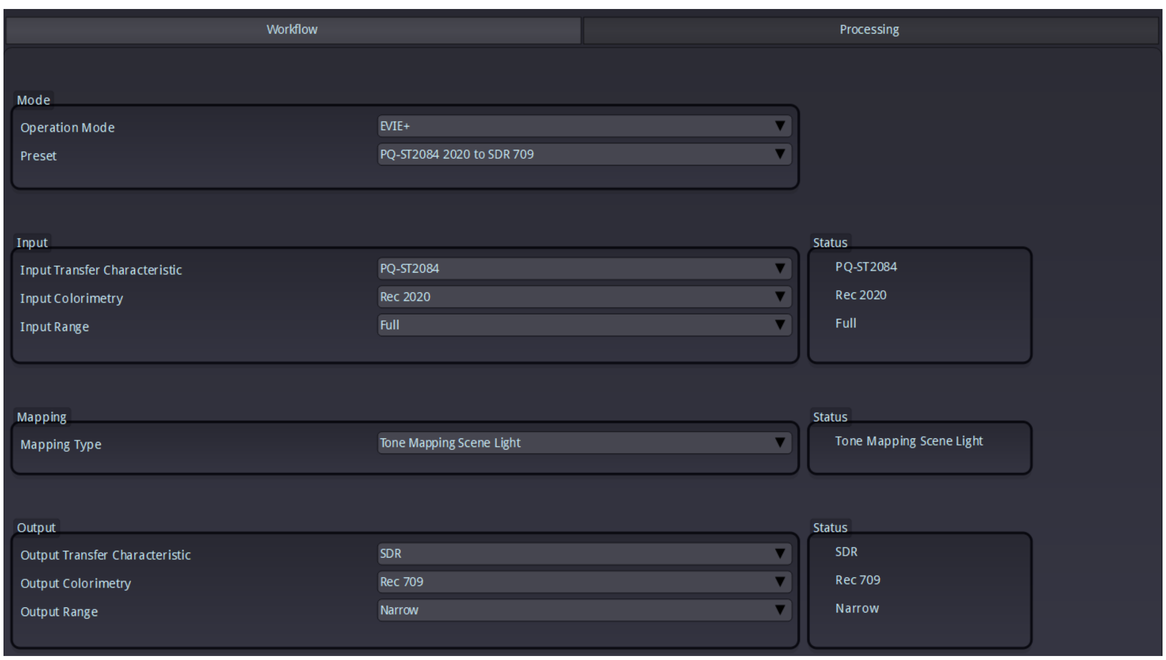
The “bypass HDR/SDR” mode bypasses the HDR conversion functionality of “Transfer Characteristics,” “Colorimetry” (color spaces), and “Ranges” (between narrow and full range) in connection with HDR transfer characteristics, i.e., no HDR-to-SDR down-conversion will be performed. The incoming transfer characteristic of the signal is transparently passed through the system. Conversions of “Colorimetry” and “Ranges” in connection with HDR characteristics will not be performed either. In this mode, only “Colorimetry” and “Range” conversions of SDR (Gamma BT.709) signals are performed correctly, because the conversion functionality for “Colorimetry” and “Range” conversions of SDR signals is also available independently of the HDR EVIE+ Constellation in the greenMachine and thus remains untouched upon activation of “bypass HDR/SDR.” Therefore, these types of conversions continue to be performed, so attention should be paid to the selected input/output “Colorimetry” and “Range” as these conversions are only performed correctly in connection with SDR (Gamma BT.709) signals. When it comes to performing these conversions in connection with HDR signals, the Operation Mode “EVIE+” must be selected. Besides the ability of bypassing input signals, the Operation Mode “bypass HDR/SDR” can also be used to check on input signals and to illustrate the effect of converting or mapping the present transfer characteristic of the input signal.

2.2. Operation Mode "EVIE+"

The Operation Mode "EVIE+" activates the actual operation mode of the HDR EVIE+ Constellation, in which SDR *and* HDR signals can be processed, and conversions in connection with these HDR signals can be performed. The actual operations of this Operation Mode are described in more detail in the following chapters.

2.2.1. HDR Conversions

The Operation Mode "EVIE+" allows the user to perform HDR-to-SDR down-conversions between different HDR transfer characteristics and the SDR gamma (BT.709) characteristic. (e.g. from "PQ-ST2084" to "SDR" [Gamma BT.709] as shown in the figure below). The transfer characteristics available for such conversions are described in more detail in their respective chapters. The available conversions can be performed in different ways by using different Mapping Types, which are described in the following chapter.



Available Conversions

Note: In the HDR EVIE+ Constellation, it is also possible to perform conversions of Colorimetry (color spaces) and signal ranges (between narrow and full). However, the conversion functionality for Colorimetry and Range conversions of SDR signals is also available in the greenMachine independently of the HDR EVIE+ Constellation (see. 2.1. "Operation Mode "bypass HDR/SDR"").
Note: In the HDR EVIE+ Constellation, an HDR cross-conversion between an HDR transfer characteristic and another HDR characteristic as well as SDR-to-HDR up-conversions are not yet available.

2.2.2.Mapping

Especially when it comes to down-conversions, a mapping of the luminance values is required in order to convert an image from HDR into SDR format "correctly," and thus preserving the relative luminance of a scene according to human visual perception. There are several methods existing to perform such a conversion. The HDR EVIE+ Constellation provides a method called "sectional dynamic Tone Mapping." Furthermore, the HDR EVIE+ Constellation allows to combine this type of tone mapping with a global dynamic Tone Mapping of the HDR EVIE Constellation and a static tone mapping similar to the operation of the HDR STATIC Constellation (see "Processing Parameters" – Homogenization and Dynamic Ratio). In the following, the available Mapping Types available in the HDR EVIE+ Constellation are introduced in more detail.

Tone Mapping

Since a simple conversion without adjustment of the luminance is usually not sufficient, the Operation Mode "EVIE+" provides a sectional (and/or global) dynamic Tone Mapping that automatically analyses an incoming HDR signal and adjusts it to the new SDR target format in real-time. This tone mapping operation is called 'sectional dynamic' because it is applied to several spatial areas (sectors) in the image. Depending on the image content within these sectors, the algorithm reacts dynamically, which allows lights and shadows to be treated independently. Therefore, dark areas can be brightened, and bright areas can be darkened without getting a flat gradation of the image. This leads to a homogenization of the image impression as well as an increased local contrast. As a result, lights can be preserved from burning out, and shadow details can be revealed. The viewer can thus follow the events across all areas of the image.

The homogenization of the image impression is particularly suitable for scenes with a very high dynamic range or scenes which are illuminated inhomogeneously. The proportion of this homogenization, i.e., the sectional dynamic component of the algorithm, can be adjusted by using the "Homogenization" parameter (see 2.2.3. "Processing Parameters" – Homogenization). If no such strong homogenization is required, the global dynamic component of the algorithm can be applied to a greater extend by reducing the value of the Homogenization parameter. This global dynamic operation is well suited for indoor scenes (e.g. studio productions) when the contrast range of the scene is lower and more predictable, but also in case of outdoor scenes with low to medium contrast ratios.

The global dynamic Tone Mapping, which corresponds to the operation from the HDR EVIE Constellation, analyses and adjusts the signal over the entire image, basically using one large global "sector" instead of many small image sectors. This type of mapping is well suited for adaptively selecting a steeper gradation for incoming image material with a low contrast range, thus enabling a subjectively higher impression of contrast. In addition, the global dynamic operation is very well suited for automatic exposure of HDR images for an SDR broadcast to counteract changing lighting conditions without working too much with the aperture. Since the dynamic adjustment depends on the incoming signal, over- or underexposures can be compensated (if the input signal is not already clipped).

Technically, the Tone Mapping operation of the HDR EVIE+ Constellation adjusts the signal by using several dynamic curves, one per image sector, combined with a global dynamic curve based on the entire image. While the dynamic curves of the different sectors are perfectly adapted to the respective image content of their sectors, the global curve is perfectly adapted to the content of the entire image. All curves applied in this Operation Mode are based on correction values determined during image analyses. This process, which is performed and applied to each incoming frame, takes place in real-time.

By using this sectional and/or global dynamic Tone Mapping operation, the relative luminance of a scene captured by an HDR camera can be perfectly preserved according to human visual perception. Without such a Tone Mapping operation, an HDR-to-SDR down-conversion would lead to severe clipping of the (high-)lights, i.e. the resulting picture would be burnt out severely. Therefore, the brightness and color information outside the target format is changed in a way that it perfectly fits into the new target format. The brightness component is adjusted during down-conversion preserving (high-)lights and preventing them from being clipped. The color impression is treated accordingly, which means that the chrominance matches the adjusted luminance, and unwanted changes in hue and/or saturation are prevented.

Although a dynamic tone mapping operation, compared to a static one, can save much more image information into the new target format allowing an even greater benefit to be derived from material captured in HDR, there is also a static tone mapping component provided in the HDR processor. In contrast to the dynamic operation, the static tone mapping algorithm* applies the same static curve to each frame. Therefore, the static curve always behaves the same way making the result continuous and best predictable.

**Note: The static Tone Mapping algorithm, which is part of the HDR STATIC Constellation, applies a static curve similar to a knee function, which is sometimes used within conventional video cameras in order to exploit their full dynamic range thus extending the dynamic range of the signal.*

To take advantage of both worlds, the HDR EVIE+ Constellation allows the sectional and/or global dynamic Tone Mapping operation to be combined with a static Tone Mapping similar to the operation of the HDR STATIC Constellation (see chapter 2.2.3. “Processing Parameters” – Dynamic Ratio).

The ITU Report BT.2408 points out that a dynamic HDR-to-SDR conversion may be required to provide a satisfactory SDR output, as the exposure latitude of HDR images is far greater than SDR. Therefore, such a down-conversion for downstream mixing HDR cameras with SDR cameras or converting the complete HDR program output can be preferred to allow the SDR signal to benefit the most from an HDR production workflow. But attention should be paid to graphics, which may need to be inserted after dynamic down-conversion to ensure a constant signal level.

Note: If an HDR signal is present at the input side of the processor and the Output Transfer Characteristic is set to "Auto," e.g. by selecting the Preset "Auto to Auto," no Tone Mapping will be performed since the HDR transfer characteristic is basically bypassed when choosing "Auto" as Output Transfer characteristic (see chapter 3.3. "Auto" and 5. "Presets").

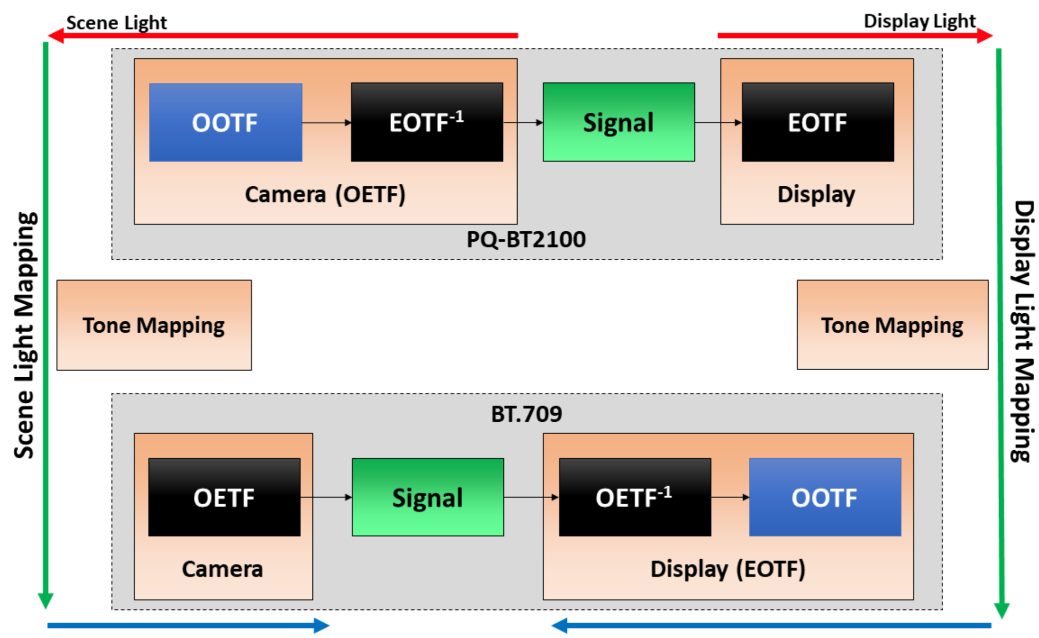
Scene Light or Display Light Mapping

The Tone Mapping operation can be executed with two possible approaches depending on two different use cases. Either with the scene-referred Mapping Type (Scene Light Mapping) or with the display-referred Mapping Type (Display Light Mapping). By using the display-related mapping, the Tone Mapping operation will be performed based on the light reproduced by a reference display, while using the scene-related mapping will result in the Tone Mapping being performed based on the light falling on the camera sensor (but including camera characteristics, white balance, and any artistic camera adjustments).

Therefore, Display Light Mapping should preferably be used when the goal is to preserve the colors and relative tones seen on a reference display, whereas Scene Light Mapping should preferably be used when the goal is to match the colors and relative tones of HDR and SDR cameras.

In other words, by using Scene Light Mapping, the incoming signal is first used to reconstruct the brightness levels of the scene before the Tone Mapping operation is performed. This process is explained in more detail using the example of a down-conversion from PQ-BT2100 to SDR (Gamma BT.709), as shown in the following figure.

In this case, the incoming signal at the input of the HDR processor, e.g. directly derived from the output of a camera operating in PQ-BT2100, corresponds to the upper green "Signal" block in the figure. As shown by the upper red arrows and by order of the camera and display blocks, the left side of the figure represents scene light, while the right side of the figure represents the light output of the display (display light). In order to reconstruct the original linear scene light, the non-linear process that took place within the camera during image capture with PQ-BT2100 (OOTF + $EOTF^{-1}$) must be undone (see the red arrow at the top left). Therefore, the EOTF of PQ-BT2100 is applied first in order to undo the inverse EOTF ($EOTF^{-1}$), whereupon the inverse OOTF ($OOTF^{-1}$) of PQ-BT2100 will be



Scene Light vs Display Light Mapping using the example of down-conversion from PQ-BT2100 to SDR (Gamma BT.709)

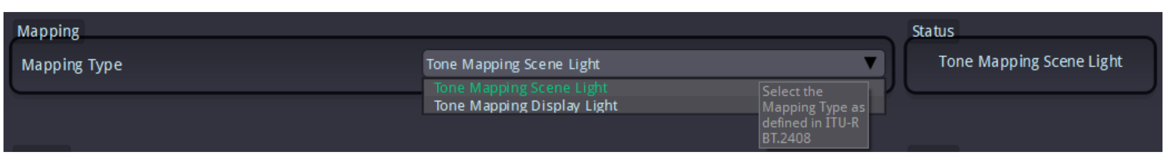
applied in order to undo the OOTF. Once the original scene light has been reconstructed, the actual Tone Mapping operation will be performed in order to carry out the HDR-to-SDR down-conversion (see left green arrow). Since the down-converted scene light is still linear, the non-linear processing of an SDR camera, according to the OETF specified in BT.709, has to be simulated in the last step (see blue arrow bottom left) to get the final SDR signal (bottom green "Signal" block). After applying the reference BT.709 OETF, the final SDR signal is available for display on an SDR display.

By using Display Light Mapping, it is not the brightness values of the scene that are used as a reference for the mapping, but the brightness levels which the input signal would cause on a reference monitor. This process can be explained in detail by taking a closer look at the right side of the example of down-conversion from PQ-BT2100 to SDR (Gamma BT.709) shown in the figure. As in the previous case of Scene Light Mapping, the incoming signal at the input of the HDR processor also corresponds to the upper green "Signal" block in the figure. In order to derive the display light, which is caused by this signal on a PQ reference monitor, the EOTF of PQ is applied to the signal (see the red arrow at top right), according to the reproduction of such a monitor. Once the display light has been derived, the actual Tone Mapping operation will be performed in order to carry out the HDR-to-SDR down-conversion (see right green arrow). Now the down-converted SDR display light must be transferred into a signal that can be displayed on an SDR monitor using the BT.1886 EOTF (BT.709 OETF^{-1} + OOTF). For this purpose, exactly the inverse of this EOTF is applied to the signal (see blue arrow bottom right), i.e. the signal is first passed through the inverse BT.709/BT.1886 OOTF (OOTF^{-1}) before the BT.709 OETF will be applied. Once these steps are done, the final SDR signal (bottom green “Signal” block) is available and can be displayed on an SDR monitor. Therefore, Display Light Mapping should be performed in order to view HDR content on displays with a lower dynamic range.

It is particularly important that Scene Light Mapping is used for matching SDR and HDR camera signals since both signals represent light from the scene captured by the camera. If Display Light Mapping would be used, SDR and HDR cameras (especially HLG camera signals) would not match, because the displayed look of SDR and HDR images is different due to the difference in the opto-optical transfer functions (OOTFs). Therefore, the difference between scene light and display light is the OOTF, which is described in more detail in chapter 3. “Transfer Characteristics” together with subjects like OETF and EOTF. While Display Light Mapping rather tends to preserve the look created by the transfer characteristic used by the display (plus artistic intent), Scene Light Mapping rather tends to represent the look of the signal being converted to. In this case of HDR-to-SDR down-conversion from PQ-BT2100 to SDR (Gamma BT.709), Display Light Mapping would, therefore rather lead to a PQ look, while Scene Light Mapping would rather result in a “traditional” BT.709 look. However, in the latter case, the resulting look depends on which system the shading takes place (HDR or SDR) and whether artistic intents have already been included during the capturing process.

According to BT.2408, e.g. the primary HDR output of a production switcher, which for distribution must be converted into SDR, should be derived via Display Light Mapping to ensure that both the SDR and HDR signals have the same look. For more information on scene-referred and display-referred mapping and its use within production workflows, see ITU Report BT.2408. For more detailed technical descriptions on how scene-referred and display-referred mapping being processed, see ITU Report BT.2390.

The following illustration shows the Mapping Types available in the HDR EVIE+ Constellation.

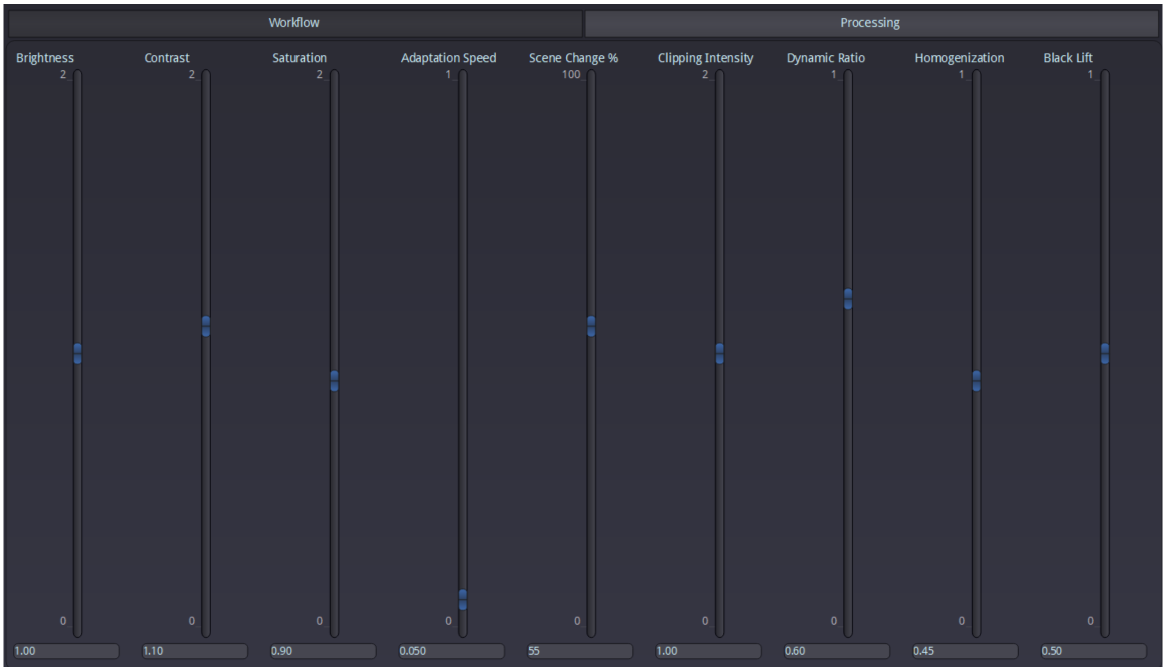


Selecting a Mapping Type

Note: *Conversions including PQ-ST2084 and proprietary transfer characteristics such as SLog3 by Sony, Panasonic V-Log, Arri LogC, RED Log3G10, Canon C-Log2, and BMD Film only support Scene Light Mapping. If Tone Mapping Display Light is selected in case of conversion with these characteristics, the Mapping Type will be forced to Tone Mapping Scene Light.*
Note: *An overview of the existing limitations regarding Mapping Types and Transfer Characteristics is given in the tables of the appendix at the end of the document. The chapter also contains all the other restrictions that apply to the HDR EVIE+ Constellation.*

2.2.3.Processing Parameters

The following processing parameters can be adjusted manually in the Operation Mode "EVIE+."



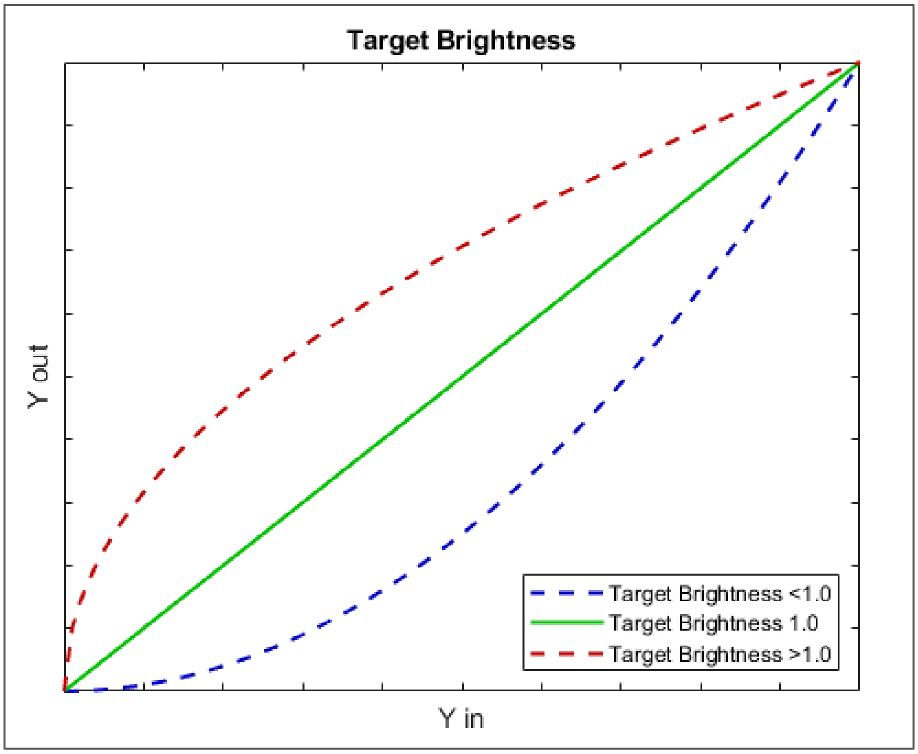
Available Processing Parameters

Brightness

This parameter can be used to adjust the target brightness of the overall image. This target brightness is determined by the value of the mean gray. The default value is set to 1.0 and thus corresponds to the average 18% gray.

2.0: gray = 36%
1.0: gray = 18%
0.5: gray = 9%

The following graphic illustrates the effect of the parameter on the input brightness of the image. As shown in the figure, the Brightness parameter behaves similar to a typical power or gamma function. High values can lead to a flattening of the image impression. In this case, it may be useful to increase the contrast value (see "Contrast"). Vice versa, if a high contrast value is selected, the range of contrast reproduced in the scene is limited, which makes the shadows become darker (see "Contrast"). In this case, an increased Brightness may be useful to prevent the image from appearing too dark. For more recommendations on how to set the Brightness, see chapter 2.2.4. “Setup Guide.”



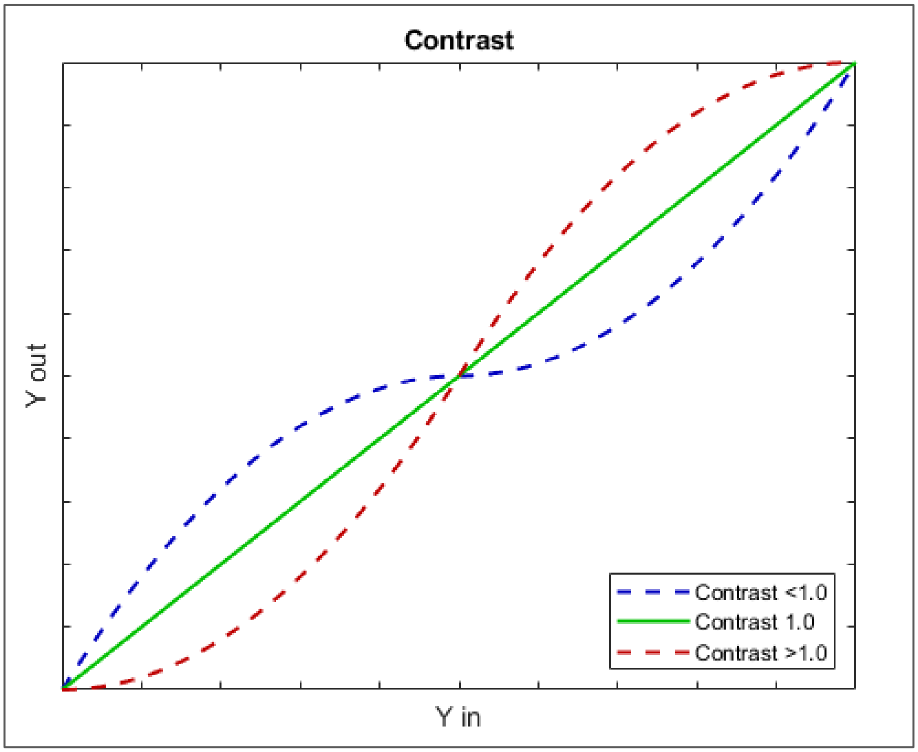
The behavior of the Brightness parameter

Contrast

The "Contrast" parameter determines the slope of the s-curve applied to the image. The default value for Contrast is set to 1.1 and does slightly increase the contrast, as shown in the following figure.

2.0: extremely high contrast
1.0: contrast unchanged
0.0: extremely low contrast

If a high value and thus a high subjective contrast is selected, the range of contrast reproduced in the scene is limited, and the shadows become darker, as shown by the red dashed curve of the following illustration. In this case, the image may appear relatively dark. A readjustment of the brightness (see "Brightness") may be useful in this case. Vice versa, if a high brightness is selected, which can result in a flattening of the image impression, it may be useful to increase the Contrast value. If a low value and thus a low subjective contrast is selected, dark areas will be brightened, and bright areas will be darkened (see blue dashed curve). For more recommendations on how to adjust the Contrast, see chapter 2.2.4. “Setup Guide.”



The behavior of the Contrast parameter

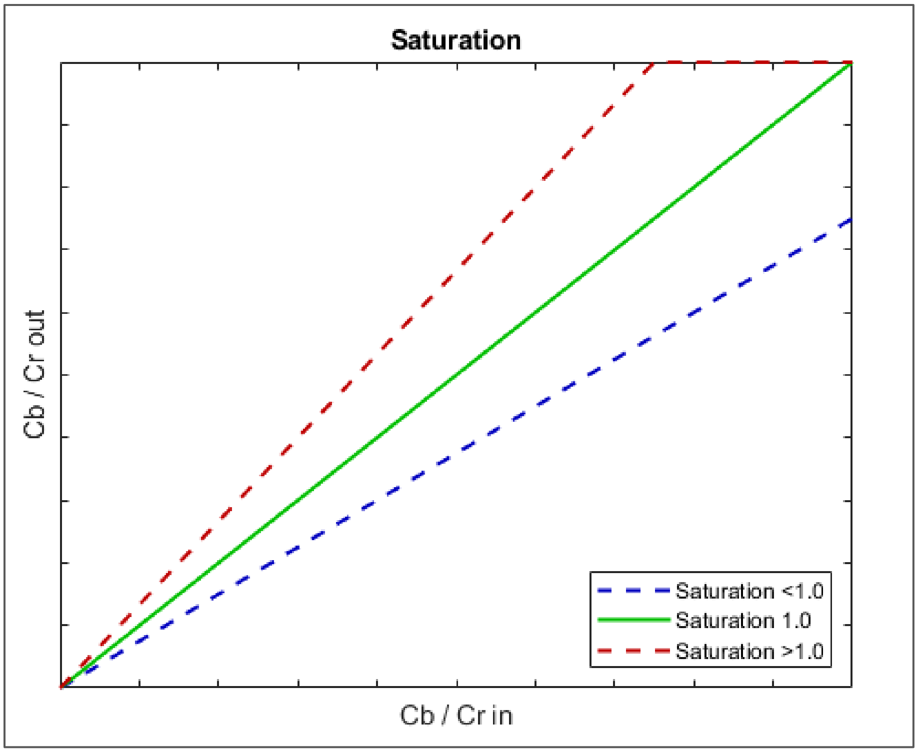
Saturation

Due to the contrast compression performed by the Tone Mapping operation as well as a possible adjustment of the two previously mentioned parameters "Brightness" and "Contrast," which also influence the performed contrast compression, an adjustment of the brightness component is performed, which in turn affects the color impression such as the saturation. Due to these changes, the chrominance is generally treated accordingly. However, if the saturation impression still does not match the expectations, the "Saturation" parameter offers the possibility to adjust it. For more recommendations on how to adjust the Saturation, see chapter 2.2.4. “Setup Guide.”

Basically, this parameter changes the slope or lift of the color saturation. The default value is set to 0.9 and slightly reduces the saturation, whilst a value higher than 1.0 would increase the saturation (see figure on the next page).

2.0: extremely increased saturation
1.0: saturation unchanged
0.0: extremely reduced saturation

However, an increase in saturation can lead to color clipping for already highly saturated colors at the input, as shown in the red dashed curve of the following figure.



The behavior of the Saturation parameter

Adaption Speed

As the calculation of the Tone Mapping takes place on a single image, the values are temporally smoothed to get a consistent viewing impression. The duration of this interpolation can be selected with this slider. The default value is set to 0.05 and is considered as a recommendation for this parameter.

1.00: no smoothing at all (caution!)
0.05: normal adaption speed (recommended)
0.00: extremely slow adaption speed

Depending on the scene or use case (scenic production, live production, sports production, etc.), a slight adjustment of the parameter can be beneficial to the result.

CAUTION: A faster adjustment (higher adaption speed) can also lead to unwanted effects such as "pumping." This adjustment option should, therefore, only be used by experienced users. Strong dependence on scenes, material, and type of production should be considered.

Scene Change (%)

If the HDR processor is operated behind a program output, this output contains cuts between cameras. Therefore, the processing of the Operation Mode "EVIE+" includes a so-called scene change detection, which automatically detects these scene cuts. If such a scene change is detected, the temporal interpolation described in the previous section of this chapter (“Adaption Speed”) is suspended at this point to ensure the algorithm adapts accordingly fast to the new image situation. The adjustment of the image brightness level can thus be carried out faster and more specifically, after a scene change.

Basically, the Scene Change parameter can be used to set the percentage by which the brightness level within an image must change in order to be classified as a scene change. If the change in brightness between two frames exceeds this percentage, that frame is classified as a scene change. The lower the percentage, the more likely a change between two frames is classified as a scene change; the higher the percentage, the greater the difference in brightness between two frames must be in order to be classified as a scene change. The default value is set to 55%, which basically means that the brightness must change significantly across 55% of the image to be classified as a scene change.

100%: basically no Scene Change detectable
55%: normal Scene Change detection (recommended – but depending on material)
0%: extremely fast (reckless*) Scene Change detection

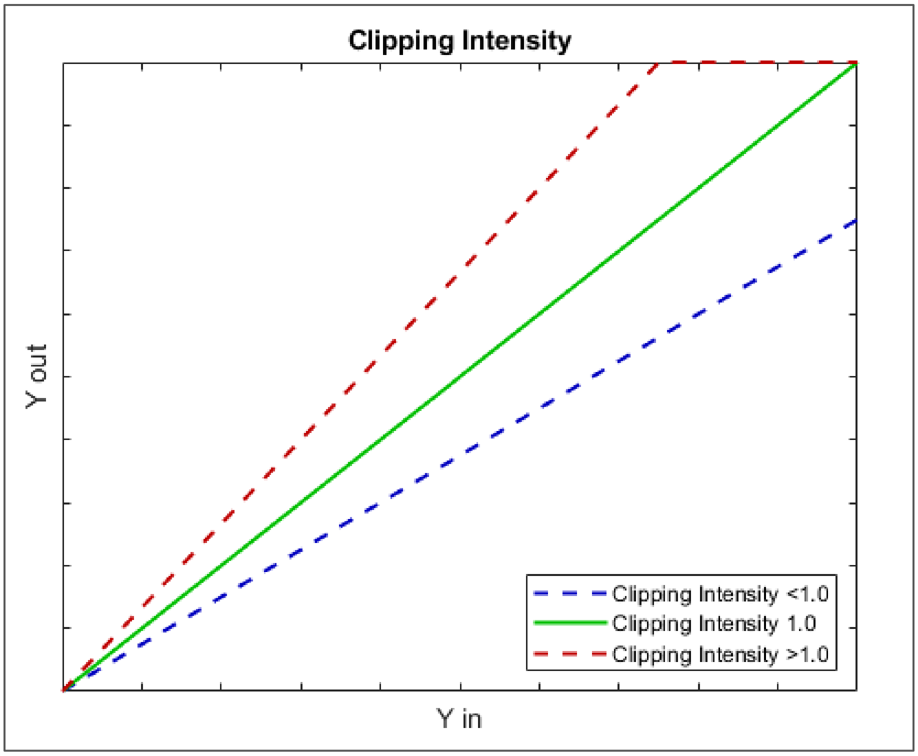
Note: If EVIE+ is not operated behind a program output but directly behind a camera, the “Scene Change” (%) can principally be deactivated by setting it to 100%. However, if large (and rapid) jumps in brightness are to be expected, it may be beneficial to use the “Scene Change” to counteract these (unless this behavior is not desired).
***CAUTION:** *If the “Scene Change” (%) is set too low, scene changes may be detected by mistake, so that unwanted effects such as "light/dark flickering" may occur. If the percentage is set too high, existing scene changes may not be detected, and brightness adaptation may happen too slowly.*

Clipping Intensity

The “Clipping Intensity” parameter can be used to influence the automatic result of the image analysis by controlling the strength of the clipping. The default value is set to 1.0.

2.0: extremely strong clipping
1.0: normal clipping
0.0: almost no clipping

Increasing the value leads to stronger clipping, which causes the image to burn out earlier and stronger, as illustrated in the red dashed curve in the figure below. See chapter 2.2.4. “Setup Guide” for recommendations on how to set the Clipping Intensity.



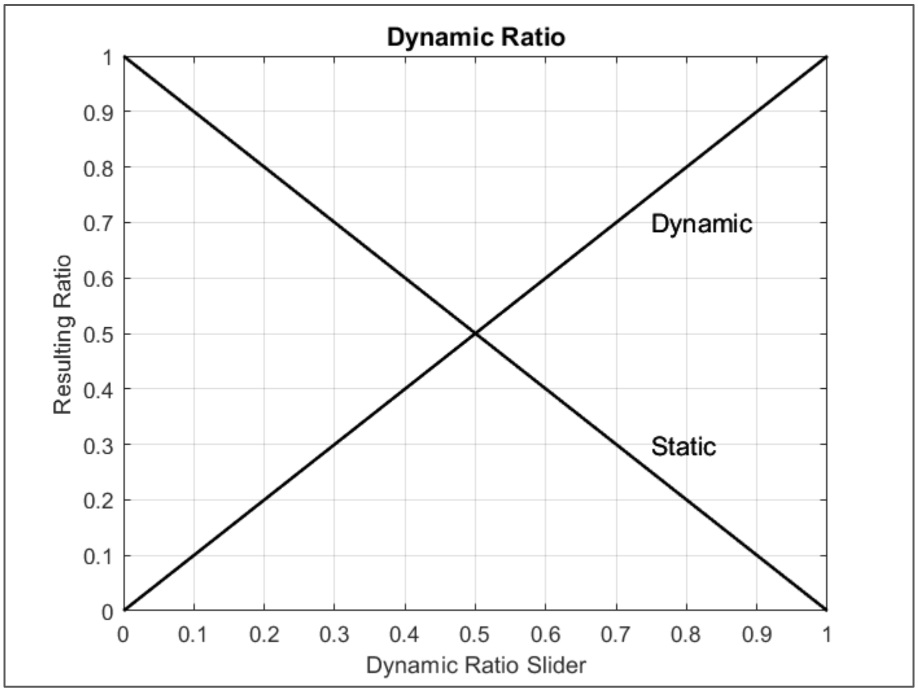
The behavior of the Clipping Intensity parameter

Dynamic Ratio

As already mentioned in chapter 2.2.2. “Mapping,” the HDR EVIE+ Constellation allows the sectional (and/or global) dynamic Tone Mapping operation to be combined with a static Tone Mapping operation similar to the operation of the HDR STATIC Constellation. While a static curve always behaves the same way making the result continuous and best predictable, the dynamic method can usually save even more image information in the SDR target format (see chapter 2.2.2. “Mapping”). Therefore, the advantages of both worlds can be combined.

By using the "Dynamic Ratio" parameter, both the dynamic and the static operation can be mixed proportionally. The default value is set to 0.6 using 60% of the dynamic processing and 40% of the static processing. If the "Dynamic Ratio" is set to 1.00, the dynamic operation is used only; if the value is set to 0.00, the static Tone Mapping operation is used only. By selecting the value 0.50, both operations are included with the same proportion (see figure on the following page).

1.0: dynamic Tone Mapping only
0.6: Default (60% dynamic Tone mapping, 40% static Tone Mapping)
0.5: 50% dynamic Tone Mapping, 50% static Tone Mapping
0.0: static Tone Mapping only



The behavior of the Dynamic Ratio parameter

Depending on the requirements and conditions of production, a high dynamic behavior of the processor may be undesired. If the scene offers a limited contrast range like it is often the case in studio environments and indoor productions, a high dynamic ratio may tend to produce a slightly dark and flat image impression. Furthermore, it is more difficult to have certain image regions (e.g. the face of a host) automatically adjusted by the dynamic processing according to the preferences. Therefore, the Dynamic Ratio can be used to reduce the dynamic and increase the static component. Although the contrast range that can be saved in the SDR format is reduced and the ability to automatically adjust the image is diminished, the image impression becomes brighter and steeper in most cases. In addition, the aperture of the camera can be adjusted without the algorithm counteracting too much (see 2.2.2. “Mapping”).

If the scene offers a higher contrast range and/or more image information is to be saved into the SDR target format, a higher Dynamic Ratio can be used in order to obtain an image that better matches the relative luminance of the scene (see 2.2.2. “Mapping”). Whether the dynamic operation is applied more globally or more locally can be defined by the Homogenization parameter (see 2.2.3. “Processing Parameters” – Homogenization).

For more recommendations on how to adjust the Dynamic Ratio, see chapter 2.2.4. “Setup Guide”.

Homogenization

As already mentioned in chapter 2.2.2. “Mapping,” the HDR EVIE+ Constellation allows the sectional dynamic Tone Mapping operation to be combined with a global dynamic Tone Mapping corresponding to the operation of the HDR EVIE Constellation.

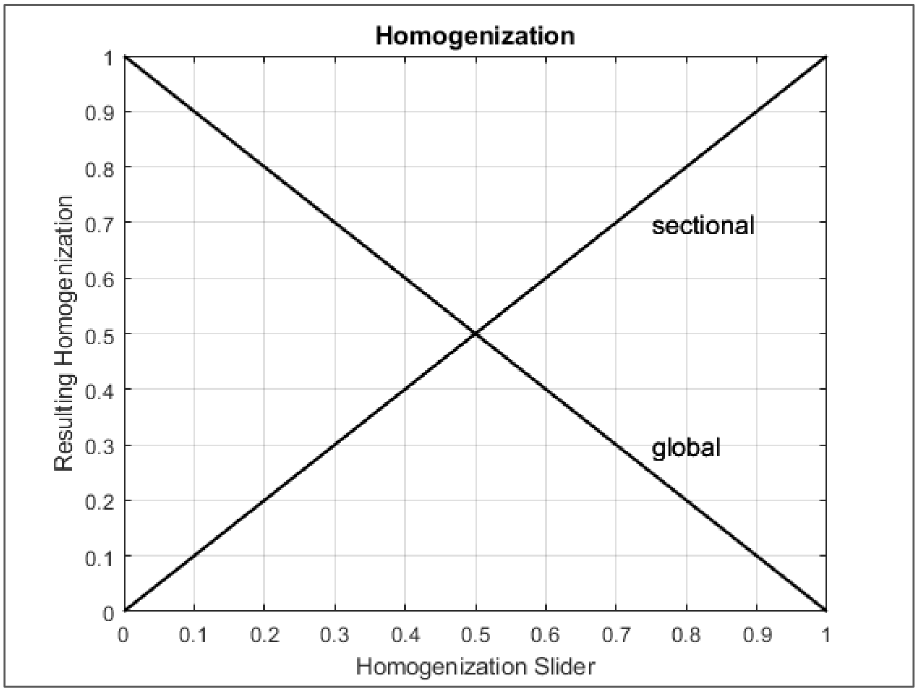
While the sectional dynamic operation applies the Tone Mapping to several spatial areas (sectors) in the image, the global dynamic operation applies the Tone Mapping globally to the entire image, basically using one large global “sector” instead of many small image sectors. Therefore, the global dynamic Tone Mapping adjusts the brightness information of the image depending on the entire image content, while the adjustment of the sectional dynamic Tone Mapping depends on the image content within the several image sectors (see chapter 2.2.2. “Mapping”).

By using the sectional dynamic Tone Mapping, the algorithm reacts dynamically depending on the several image sectors, which allows lights and shadows to be treated independently. Therefore, dark areas can be brightened, and bright areas can be darkened, leading to a homogenization of the image impression. The proportion of this homogenization, i.e. the sectional dynamic component of the algorithm, can be adjusted by using the “Homogenization” parameter.

This parameter allows the sectional dynamic operation to be proportionally mixed with the global dynamic operation. Moreover, the selected value limits the impact of the sectional dynamic component. Therefore, a higher value allows a stronger adjustment of shadows (see 2.2.3. “Processing Parameters” – Black Lift) and highlights. The higher the value, the more the algorithm darkens bright areas and brightens dark areas of the image.

The default value is set to 0.45 using 45% of the sectional dynamic processing and 55% of the global dynamic processing. If the "Homogenization" is set to 1.00, the sectional dynamic operation is used only; if the value is set to 0.00, the global dynamic Tone Mapping operation is used only. By selecting the value 0.50, both operations are included with the same proportion (see figure on the following page).

1.00: sectional dynamic Tone Mapping only
0.50: 50% sectional dynamic Tone Mapping, 50% global dynamic Tone Mapping
0.45: Default (45% sectional dynamic Tone mapping, 55% global dynamic Tone Mapping)
0.00: global dynamic Tone Mapping only



The behavior of the Homogenization parameter

Depending on the requirements and conditions of production, strong homogenization may or may not desirable. The homogenization of the image impression is particularly suitable for scenes with a very high dynamic range or scenes which are illuminated inhomogeneously. If no such strong homogenization is required, the global dynamic component of the algorithm can be applied to a greater extend by reducing the value of the Homogenization parameter.

The global dynamic operation is well suited for indoor scenes (e.g. studio productions) when the contrast range of the scene is lower and more predictable, but also in case of outdoor scenes with low to medium contrast ratios. Furthermore, this type of mapping is well suited for adaptively selecting a steeper gradation for incoming image material with a low contrast range, thus enabling a subjectively higher impression of contrast. In addition, the global dynamic operation is very well suited for automatic exposure of HDR images for an SDR broadcast to counteract changing lighting conditions without working too much with the aperture. Since the dynamic adjustment depends on the incoming signal, over- or underexposures can be compensated (if the input signal is not already clipped).

CAUTION: If the "Homogenization" parameter is set too high and therefore high sectional dynamic processing is active, unwanted effects or artifacts such as unwanted brightening and darkening or halo artifacts may occur.

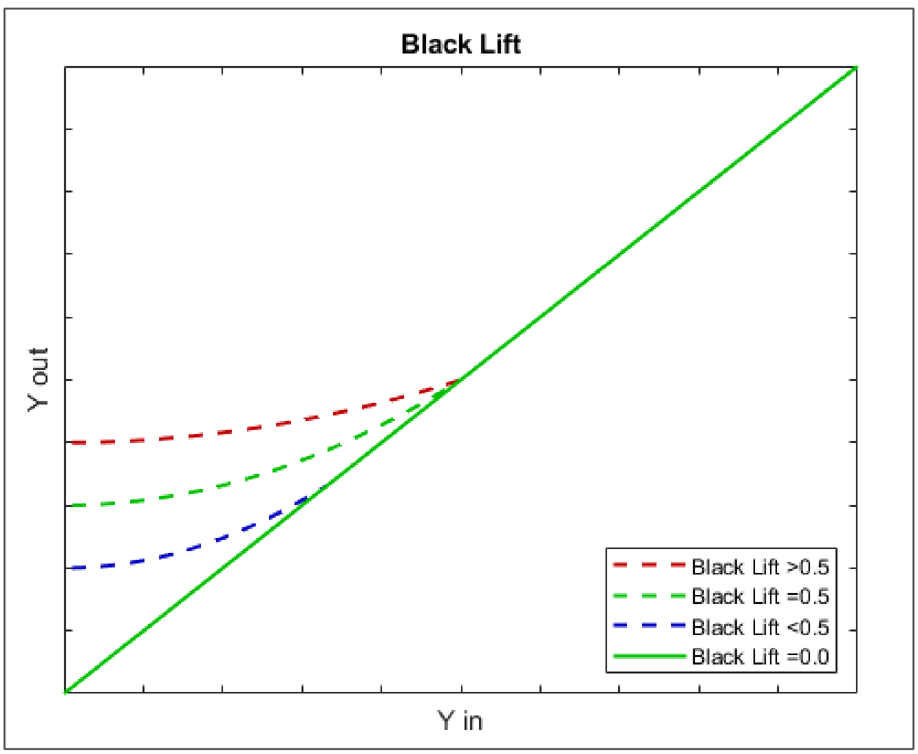
Black Lift

The “Black Lift” parameter can be used to treat dark areas of the image separately.

If a high value is selected for homogenization (see 2.2.3. “Processing Parameters” – Homogenization), the shadows may be increased to an undesirable degree. The Black Lift parameter can be used to counteract this effect by limiting this increase. While a higher value leads to a higher brightening of the shadows, a lower value results in the shadows being less brightened (see figure below). The default value is set to 0.5.

1.0: no limitation (shadows are brightened to the maximum)
0.5: slight limitation (shadows are slightly brightened)
0.0: extreme limitation (shadows are not brightened)

However, it should be noted that the Black Lift parameter has no effect on the image impression if the Homogenization parameter is set to 0.00, i.e. if no sectional dynamic processing is enabled (see 2.2.3. “Processing Parameters” – Homogenization). In this case, the parameter is, therefore, not available.



The behavior of the Black Lift parameter

Overview

The following table shows which settings of the individual processing parameters are considered meaningful and which are critical. The default value is marked with a cross. Extreme areas that carry an increased risk of undesired behavior are marked in red.

	0,0	0,2	0,4	0,6	0,8	1,0	1,2	1,4	1,6	1,8	2,0
Brightness						X					
Contrast							X				
Saturation					X						
Clipping Intensity						X					
	0,0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1,0
Adaption Speed		X									
Dynamic Ratio							X				
Homogenization						X					
Black Lift						X					
	0	10	20	30	40	50	60	70	80	90	100
Scene Change (%)							X				

Overview of meaningful (green) and critical (red) settings of the processing parameters

However, it should be noted that the selected setup strongly depends on the requirements and conditions of production. The following chapter provides a recommendation on how to set up the converter and in which order the Processing Parameters can be set to achieve the desired image impression.

2.2.4.Setup Guide

This setup guide provides a recommendation on how to set up the converter and in which order the Processing Parameters can be set to achieve the desired image impression. In addition, recommendations are given for usual settings considering common requirements and conditions in production. However, it should be noted that the selected setup strongly depends on the requirements and conditions of production. Further, it should be noted that this guide is based on an HDR focused production in which (according to ITU Report BT.2408) the shading takes place in HDR. Therefore, this guide only provides a general tendency. Depending on the production, appropriate settings may differ from the recommendations given below. The following gives a recommendation on how and in which order to proceed in order to obtain the desired image impression:

1. First of all, the "Dynamic Ratio" should be used to determine how dynamic the converter shall behave.

	1. Dynamic Ratio										
sports production (much movement)	0,0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1,0
studio production with regulated lighting conditions	0,0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1,0
compensating backlight and HDR beauty shots (little movement)	0,0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1,0
"shading" via EVIE+*	0,0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1,0

**Note:* *As already described in chapter 2.2.2. "Mapping", the dynamic operation makes it possible to automatically expose an HDR image for an SDR broadcast without working too much with the aperture. Since the dynamic curve depends on the incoming signal, over- and underexposures are compensated (if the input signal is not already clipped). The recommended settings for "shading" via EVIE+ are shown in the respective tables.*

2. Second of all, the Homogenization parameter should be used to decide to what extend the lights and shadows are adjusted (homogenized) by the processor.

	2.1. Homogenization										
sports production (much movement)	0,0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1,0
studio production with regulated lighting conditions	0,0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1,0
compensating backlight and HDR beauty shots (little movement)	0,0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1,0
"shading" via EVIE+*	0,0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1,0

In addition, the Black Lift can be used to separately adjust the effect the processor has on the shadows. If a high Homogenization is selected, shadows might be increased to an undesirable degree. In this case, it may be useful to further reduce the Black Lift.

	2.2. Black Lift										
sports production (much movement)	0,0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1,0
studio production with regulated lighting conditions	0,0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1,0
compensating backlight and HDR beauty shots (little movement)	0,0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1,0
“shading” via EVIE+*	0,0	0,1	0,2	0,3	0,4	0,5	0,6	0,7	0,8	0,9	1,0

3. Subsequently, the “Clipping Intensity” should be set to select the desired clipping point, especially if the lights are too gray or too much clipped. For example, if the image appears too dark and more clipping is acceptable, the Clipping Intensity can be further increased.

	3. Clipping Intensity										
sports production (much movement)	0,0	0,2	0,4	0,6	0,8	1,0	1,2	1,4	1,6	1,8	2,0
studio production with regulated lighting conditions	0,0	0,2	0,4	0,6	0,8	1,0	1,2	1,4	1,6	1,8	2,0
compensating backlight and HDR beauty shots (little movement)	0,0	0,2	0,4	0,6	0,8	1,0	1,2	1,4	1,6	1,8	2,0
very bright HDR	0,0	0,2	0,4	0,6	0,8	1,0	1,2	1,4	1,6	1,8	2,0

4. After Clipping Intensity is adjusted, the “Brightness” parameter should be used to adjust the overall brightness of the image if the overall image appears too dark or too bright.

	4. Brightness										
sports production (much movement)	0,0	0,2	0,4	0,6	0,8	1,0	1,2	1,4	1,6	1,8	2,0
studio production with regulated lighting conditions	0,0	0,2	0,4	0,6	0,8	1,0	1,2	1,4	1,6	1,8	2,0
compensating backlight and HDR beauty shots (little movement)	0,0	0,2	0,4	0,6	0,8	1,0	1,2	1,4	1,6	1,8	2,0
very bright HDR	0,0	0,2	0,4	0,6	0,8	1,0	1,2	1,4	1,6	1,8	2,0

5. The next step is to adjust the contrast of the image by using the “Contrast” parameter if the image appears too steep or too flat. However, it should be noted that a higher contrast can reduce the shadows and darken the image. For this reason, it may be necessary to readjust one of the previous parameters.

	5. Contrast										
sports production (much movement)	0,0	0,2	0,4	0,6	0,8	1,0	1,2	1,4	1,6	1,8	2,0
studio production with regulated lighting conditions	0,0	0,2	0,4	0,6	0,8	1,0	1,2	1,4	1,6	1,8	2,0
compensating backlight and HDR beauty shots (little movement)	0,0	0,2	0,4	0,6	0,8	1,0	1,2	1,4	1,6	1,8	2,0
very bright HDR	0,0	0,2	0,4	0,6	0,8	1,0	1,2	1,4	1,6	1,8	2,0

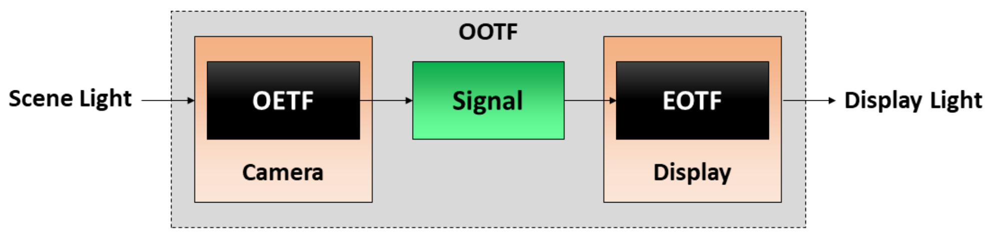
6. Finally, the “Saturation” parameter should be used to adjust the color if the image appears over- or under-saturated.

	6. Saturation										
sports production (much movement)	0,0	0,2	0,4	0,6	0,8	1,0	1,2	1,4	1,6	1,8	2,0
studio production with regulated lighting conditions	0,0	0,2	0,4	0,6	0,8	1,0	1,2	1,4	1,6	1,8	2,0
compensating backlight and HDR beauty shots (little movement)	0,0	0,2	0,4	0,6	0,8	1,0	1,2	1,4	1,6	1,8	2,0

3. Transfer Characteristics

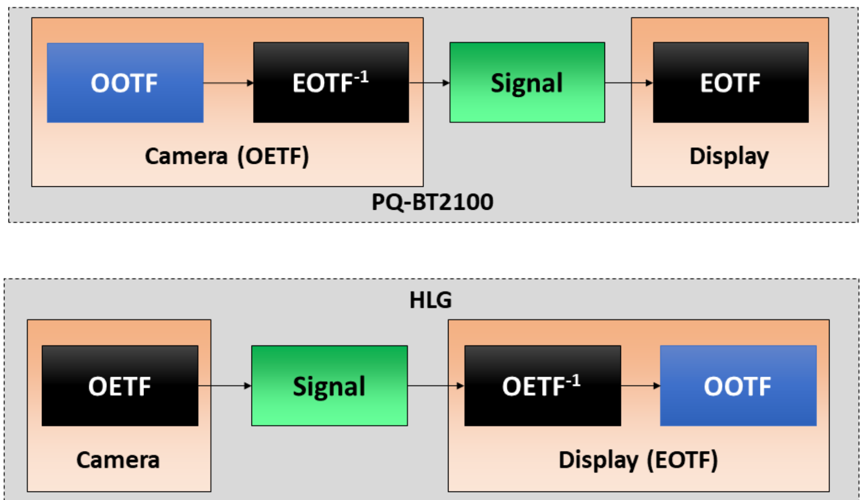
The conversion between different transfer characteristics is considered the main function of the HDR processor since the actual HDR-to-SDR down-conversion takes place at this point. The real-time dynamic Tone Mapping operation is carried out at this point, as well. In order to use this feature, the Operation Mode "EVIE+" must be selected (see chapter 2. "Operation Modes").

Basically, a transfer characteristic can be described as follows: On the recording side, typically within a camera, an opto-electronic transfer function (OETF) is responsible for the transfer of optical brightness information (scene light) into the electrical (digital) video signal (see figure below). Thus, the transfer characteristic of the resulting video signal corresponds to the OETF in use. On the display side, the electro-optical transfer function (EOTF) ensures the transfer of the electrical (digital) video signal back into optical brightness information (display light), as shown in the following figure.



Relationship between OETF, EOTF, and OOTF

So, the OETF maps the light coming from the scene to the video signal, and the EOTF maps the signal representing the scene to the light emitted from the display. The OETF and EOTF in combination result in the opto-optical transfer function (OOTF), which indicates the ratio between the optical brightness information on the recording side (scene light) and the optical brightness information on the display side (display light). If the inverse of the OETF is used as EOTF, the result is a linear OOTF. However, in television systems, the displayed light out of a television display is not linearly related or proportional to the light captured by the camera. A linear reproduction of the scene light on a display would lead to a low contrast washed out image. In addition, the perception of brightness usually differs between camera and display environments, leading to wrong image impressions during reproduction on a monitor. For this reason, an overall non-linearity is applied by imposing the rendering intent using a "reference" OOTF, which compensates for the issue of linearity between scene light and display light as well as the difference in tonal perception between these two environments. Specifying and using such a reference OOTF allows consistent end-to-end image reproduction, which is important in television production. In addition, adjustments of artistic kind can be made to further improve the image impression. These artistic adjustments, e.g. those that are made by using the processing parameters of the HDR EVIE+ Constellation, also affect the OOTF, which then can be called "artistic OOTF." In general, artistic adjustments to the OOTF may be applied either before the reference OOTF on the recording side or after the reference OOTF on the display side, but significantly depend on the OETF and EOTF in use. Basically, the OOTF aims to apply the "rendering intent" and is generally considered to be a concatenation of the OETF, artistic adjustments, and the EOTF. So, the OOTF maps relative scene linear light to display linear light and may also be applied either in the camera on the recording side (PQ) or in the display on reproduction side (HLG), as shown in the following figure and described in chapter 3.2.1. “PQ” and 3.2.2. “HLG.” In general, this topic is specified in more detail in the ITU-Standard ITU-R BT.2100 as well as in ITU Report BT.2390.

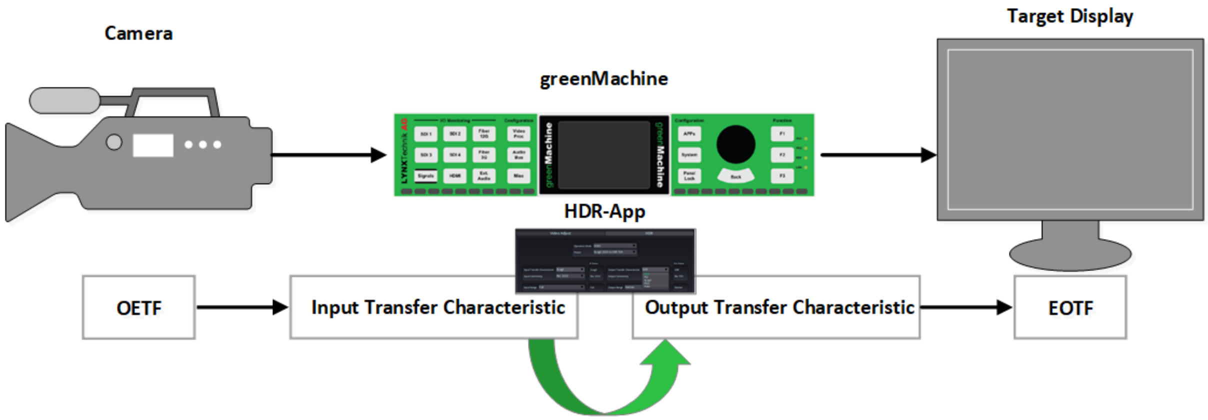


Relationship between OETF, EOTF, and OOTF for PQ and HLG according to ITU-R BT.2100 and ITU Report BT.2390

In the end, the goal is to divide the existing brightness information into a video signal having available certain binary values (bits) according to the given requirements and then convert these signal values back again into suitable brightness information.

Depending on the image material, the camera and/or the target display in use, various adjustments of the transfer characteristic must be made during production process in order to reproduce a signal as it looked like in the original scene or in order to reveal a certain image impression to the viewer. For this reason, the transfer characteristic of a video signal often requires a transformation into another transfer characteristic, e.g. to integrate the signal into another workflow or to enable the signal to be displayed on a certain monitor. Therefore, many possible conversions between capturing and displaying a signal may be required, especially to adapt a captured signal for different target displays, e.g. to display an HDR signal correctly on an SDR display.

At this point, the conversion functionality of transfer characteristics in the HDR processor comes into play. A simple application example, which is shown in the figure below, should clarify the principle of converting transfer characteristics and how the HDR EVIE+ Constellation works.



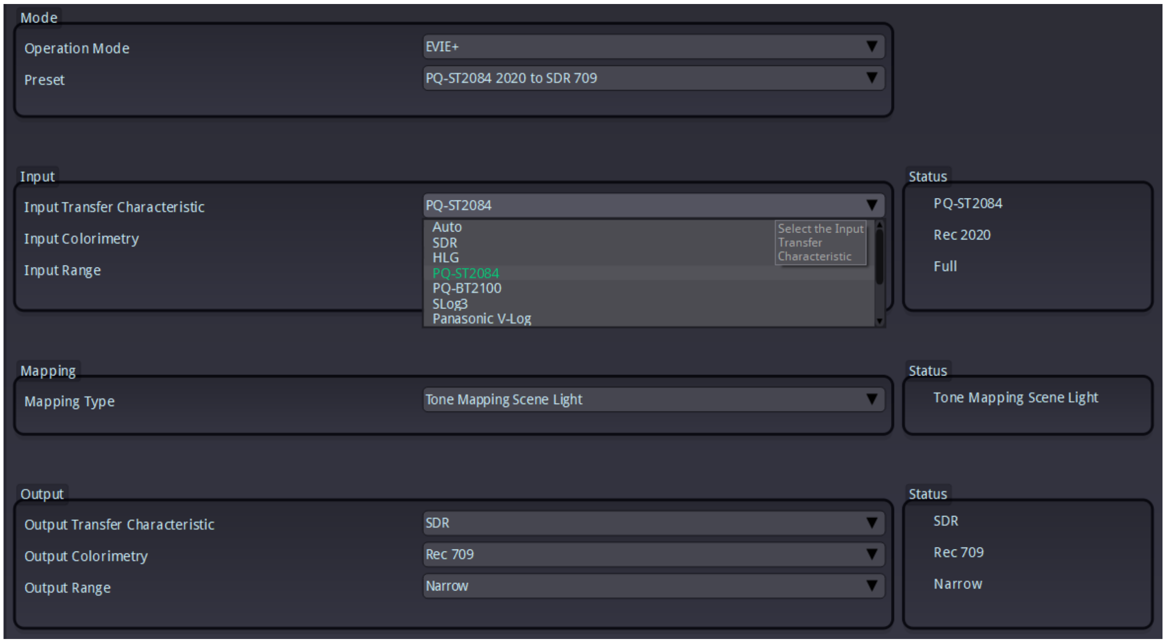
An operation example of transfer characteristics using the HDR processor

If the greenMachine is operated behind a camera like it is shown in the figure above, the “Input Transfer Characteristic” will correspond to the OETF of the camera. Therefore, the “Input Transfer Characteristic” must be selected according to the OETF of the camera. If older, already captured material is present at the input of the greenMachine, the “Input Transfer Characteristic” must be selected according to the characteristic of the material used.

If we stick to our camera example assuming it is an HDR camera capturing with a PQ-ST2084 characteristic curve, a conversion to SDR has to be made in order to reproduce the signal correctly on an SDR display and to display an image impression according to the captured scene. Therefore, the “Input Transfer Characteristic” should be set to “PQ-ST2084”, while the “Output Transfer Characteristic” should be set to “SDR” like it is shown in the figure on the following page.

As described in chapter 2.2.2. “Mapping,” the HDR EVIE+ Constellation, not only provides a simple conversion from PQ-ST2084 (HDR) to SDR (Gamma BT.709) but also applies a sectional (and/or global) dynamic Tone Mapping operation in real-time. As a result, even the resulting SDR image reproduced on today’s SDR devices already benefits greatly from the HDR material captured by the HDR camera using PQ-ST2084.

However, it should be noted that the Mapping Type Scene Light must be used in this case since Display Light Mapping, in combination with PQ-ST2084, is not supported by the HDR EVIE+ Constellation (see chapter 2.2.2. “Mapping”).

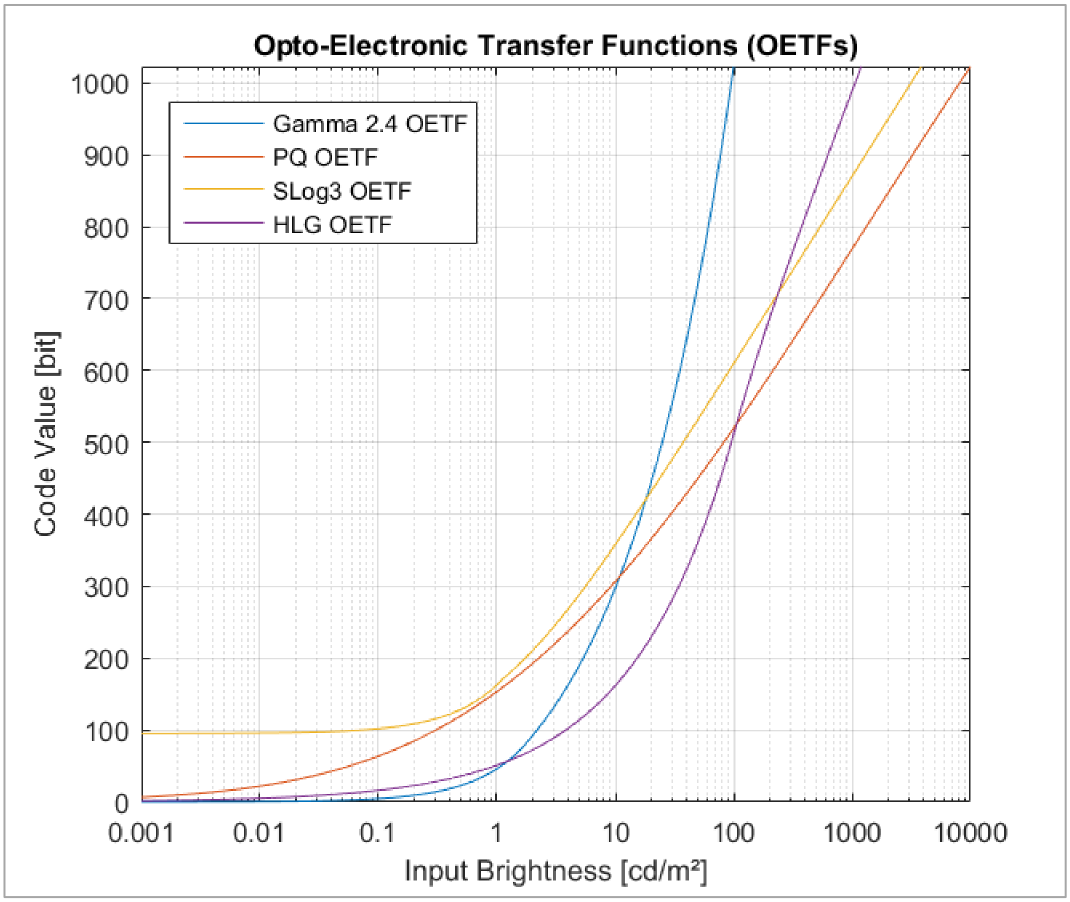


Selecting an Input and Output Transfer Characteristic

However, this example only describes a single case out of many. Particularly for HDR, there are various transfer characteristics that offer various possibilities for scene light being encoded in video signals and video signals being decoded in display light.

The HDR EVIE+ Constellation is able to perform HDR-to-SDR down-conversions between all relevant, standardized transfer characteristics. These include – in addition to the standard Gamma BT.709 characteristic for SDR – the characteristic curves PQ* and HLG generally or “officially” standardized for HDR by the ITU as well as common proprietary HDR characteristics like Sony’s SLog3. These curves are shown in the figure below as opto-electronic transfer functions (OETFs)**, which illustrate how the incoming brightness values are mapped to the respective code values (in the camera).

**Note:* *PQ is available as a transfer characteristic from both the SMPTE ST-2084 standard, which defines PQ as EOTF and OETF as exactly inverse to each other without a reference OOTF or rather with a linear OOTF and the ITU-R BT.2100 standard, which takes the reference OOTF into consideration (see chapter 3.2.1. “PQ”). For more details, see ITU standard BT.2100 or ITU Report BT.2390.*
***Note:* *The OETF of PQ is illustrated as simple OETF, i.e., as exactly inverse to the EOTF (as EOTF-1) without consideration of the OOTF (see the second figure in this chapter).*



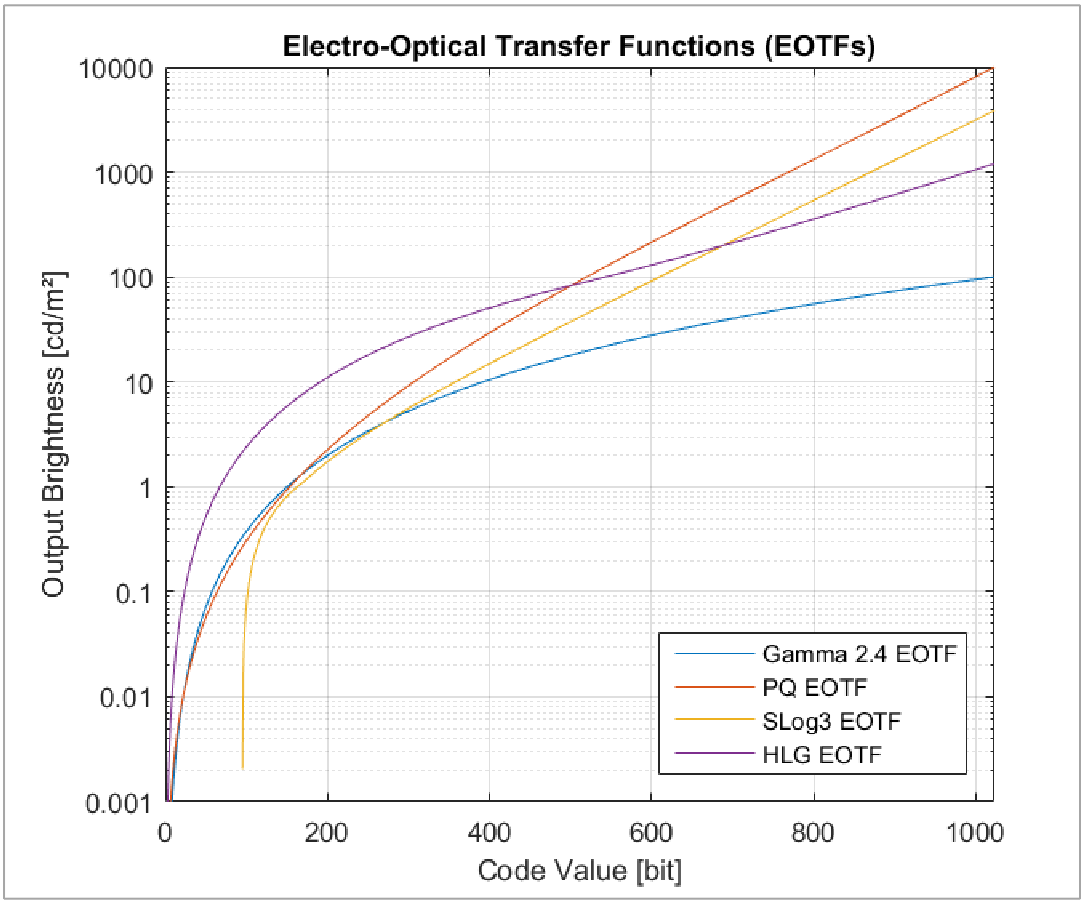
Transfer Characteristics shown as opto-electronic transfer functions (OETFs)

The figure on the following page shows these characteristics as electro-optical transfer functions (EOTFs)*, which illustrate how the encoded values are mapped back to optical brightness information by the respective transfer characteristic (in the display). In these illustrations, the incoming brightness values were normalized between 0 and 1. These curves are already used widely as industry standards for both cameras and displays.

**Note:* *The EOTF of HLG is illustrated as simple EOTF, i.e. as exactly inverse to the OETF (as OETF-1) without consideration of the OOTF (see the second figure in this chapter).*

In addition, the HDR processor is also capable of processing other common proprietary HDR OETFs of camera manufacturers like Panasonic V-Log, Arri LogC, RED Log3G10, Canon C-Log2 and BMD Film.

Since the HDR EVIE+ Constellation is a pure HDR-to-SDR down-converter, the HDR characteristics provided in the processor are only available as “Input Transfer Characteristics.” In the following chapters, the available characteristic curves are considered in more detail.



Transfer Characteristics shown as electro-optical transfer functions (EOTFs)

3.1. SDR (Gamma BT.709)

Standard Dynamic Range (SDR) describes the well-known contrast range, which has been known by television and broadcast for decades. Historically, this range was given by the maximum displayable luminance of 100 cd/m² at this time. This limitation, as well as the transfer characteristic (EOTF) used at that time, was due to the properties of the cathode ray tube (CRT). The transfer curve of the CRT, the so-called gamma characteristic, was a physical property and thus an integral part of the former imaging technique by CRTs.

On the recording side, this characteristic has been compensated by a so-called gamma correction, which has found its place as OETF in the cameras. This OETF has been standardized in HDTV standard ITU-R BT.709 and is shown as the blue curve in the OETF figure in the previous chapter.

Due to its non-linearity, the gamma characteristic previously led to a visually improved signal-to-noise ratio in analog systems of that time. Now the same non-linearity helps to prevent quantization artefacts in today's digital systems. Besides the efficient use of the available range given by SDR, the gamma characteristic is also quite similar to the human visual system. These are the main reasons why this characteristic is still in use for today's SDR-displays.

However, what the CRT has been able to apply by itself, is what today's modern displays such as LCDs and OLEDs must imitate technically. This is the main reason why the gamma characteristic of the CRT has been standardized as EOTF in ITU standard ITU-R BT.1886. As already noted, the gamma characteristic does not go unmentioned in HDTV standard ITU-R BT.709. There it is described as a power function with the exponent 2.4 and quantization of 8-bit (=256 code values) or 10-bit (=1024 code values). BT.709 also contains a reference to the BT.1886 standard. This EOTF gamma characteristic specified by these standards is shown as the blue curve in the EOTF illustration in the previous chapter.

According to ITU Report BT.2390, a reference OOTF corresponding to the gamma characteristic is not explicitly specified. "The reference OOTF is the cascade of the OETF and the EOTF, and the actual OOTF is the cascade of those plus the artistic and display adjustments." Thus, there is also no clearly defined location for a reference OOTF in this system.

Even in today's UHDTV standard ITU-R BT.2020, the gamma characteristic has been standardized but with quantization of 10-bit (=1024 code values) or 12-bit* (=4096 code values). Therefore, the gamma characteristic in the HDR processor is fully available for all video formats and resolutions (SD, 720p, HD, and 4K/UHD).

But when does the use of "SDR" as transfer characteristic become necessary?

**Note: Since 12-bit quantization is not yet relevant today and is not yet supported by the greenMachine, this is not further covered in this manual.*

3.1.1. Use cases for "SDR"

As there are still plenty of SDR devices existing today, the Gamma BT.709 standard is not obsolete at all. In order to ensure the compatibility between these devices and the new HDR formats, an HDR-to-SDR down-conversion is very important.

As described in more detail in chapter 2.2.2. "Mapping," the HDR EVIE+ Constellation, not only provides a simple conversion between transfer characteristics but also applies a sectional (and/or global) dynamic Tone Mapping operation in real-time. As a result, image quality and viewing experience on common SDR devices already benefit greatly from converting an HDR signal to the SDR format. Another, more accurate example of down-converting a signal has already been described in chapter 3. "Transfer Characteristics."

The “SDR” setting should be selected as “Input Transfer Characteristic” whenever an SDR (Gamma BT.709) signal is present on the input side, or as “Output Transfer Characteristic” whenever an HDR-to-SDR down-conversion is required. If SDR is selected at both “Input Transfer Characteristic” and “Output Transfer Characteristic,” the system will basically bypass.

The operation behind the down-conversion, as well as the resulting looks in the context of the available Mapping Types, have already been discussed in more detail in chapter 2.2.2. “Mapping.” The operations and resulting looks in the context of Scene Light and Display Light Mapping between PQ, HLG and SDR (Gamma BT.709), will be discussed in the following chapters (see chapter 3.2.1. “PQ” and 3.2.2. “HLG”).

For more information on HDR-to-SDR down-conversion and its use within production workflows, see ITU Report BT.2408, where the suggested format conversions and the resulting looks (for PQ and HLG production) are described in detail. For more detailed technical descriptions on how Scene Light and Display Light Mapping is being processed in the context of SDR (Gamma BT.709), see ITU Report BT.2390.

As already mentioned, the HDR EVIE+ Constellation provides the SDR format for all video formats and resolutions like SD, 720p, HD, and 4K/UHD.

An overview of the existing use cases of transfer characteristics is also given in chapter 3.4. “Use cases.”

3.2. HDR

The dynamic range of modern HDR video cameras is considerably greater than can be conveyed by a video signal using a conventional OETF gamma curve. This is one of the main reasons why the specification of new HDR transfer characteristics was required.

HDR has technically been specified in ITU-R BT.2100 containing the transfer characteristics PQ and HLG as OETF and EOTF (respectively with reference OOTF) and providing a quantization of 10-bit (see chapters 3.2.1. “PQ” and 3.2.2. “HLG”). However, BT.2100 also specifies 12-bit coding, which is not further mentioned in this manual, as 12-bit is not yet relevant today and is not yet supported by the greenMachine. In the case of today’s 10-bit, this results in a total of 1024 code values, which are theoretically available for encoding brightness and color information. In fact, there is a limitation of this range given by the UHDTV standard ITU-R BT.2020, whereas BT.2100 allows the entire range to be used as well. We will go into more detail on this issue in chapter 6. “Signal Range. “

In contrast to the usual 8-bit quantization (256 code values) of the gamma characteristic in SDR reproduction, the new HDR standard enables four times the amount of code values now.* As a result, four times the number of brightness information can be encoded, providing more values for brighter image information and more intermediate values for finer gradations in bright and dark image areas. How these gradations in these areas exactly occur and, therefore, how the brightness information is divided (coded) into the 1024 code values, depends on the transfer characteristic used.

**Note:* This statement refers in particular to the playback of SDR and HDR material. In the context of production, SDR is usually processed in 10-bit, too (in accordance with BT.601 and BT.709).*

Furthermore, the BT.2100 standard only specifies HD and 4K/UHD formats for the use of HDR transfer characteristics. There is no specification for lower image resolutions existing, which is why the HDR EVIE+ Constellation provides the HDR transfer characteristics (PQ-ST2084, PQ-BT2100, HLG and the proprietary characteristics of the camera manufacturers such as SLog3 by Sony, Panasonic V-Log, Arri LogC, RED Log3G10, Canon C-Log2, and BMD Film) for HD and 4K/UHD footage only. The use of HDR characteristics for SD or 720p material is not supported by the HDR processor, so these transfer characteristics are not available for these cases. An overview of all invalid cases is contained in the tables of the appendix.

For HDR, unlike SDR, there are significantly more approaches to transfer characteristics existing. As a result, more transfer curves and more options are available compared to classic SDR. The characteristics of HDR and, therefore, the resulting image impression strongly depend on these transfer curves.

In order to ensure compatibility between SDR devices and the new HDR formats, HDR-to-SDR down-conversion has become very important. As described in more detail in chapter 2.2.2. “Mapping,” the HDR EVIE+ Constellation not only provides a simple conversion between transfer characteristics but also applies a sectional (and/or global) dynamic Tone Mapping operation in real-time. As a result, image quality and viewing experience on common SDR devices already benefit greatly from converting an HDR signal to the SDR format. Another, more accurate example of down-converting a signal has already been described in chapter 3. “Transfer Characteristics.”

With PQ and HLG as “officially” standardized HDR characteristics by the ITU and the common proprietary HDR characteristics of camera manufacturers like Sony’s SLog3, Panasonic V-Log, Arri LogC, RED Log3G10, Canon C-Log2, and BMD Film, the HDR

EVIE+ Constellation includes all relevant representatives in today's HDR format. Since EVIE+ is a pure HDR-to-SDR down-converter, these HDR characteristics provided in the processor are only available as "Input Transfer Characteristics."

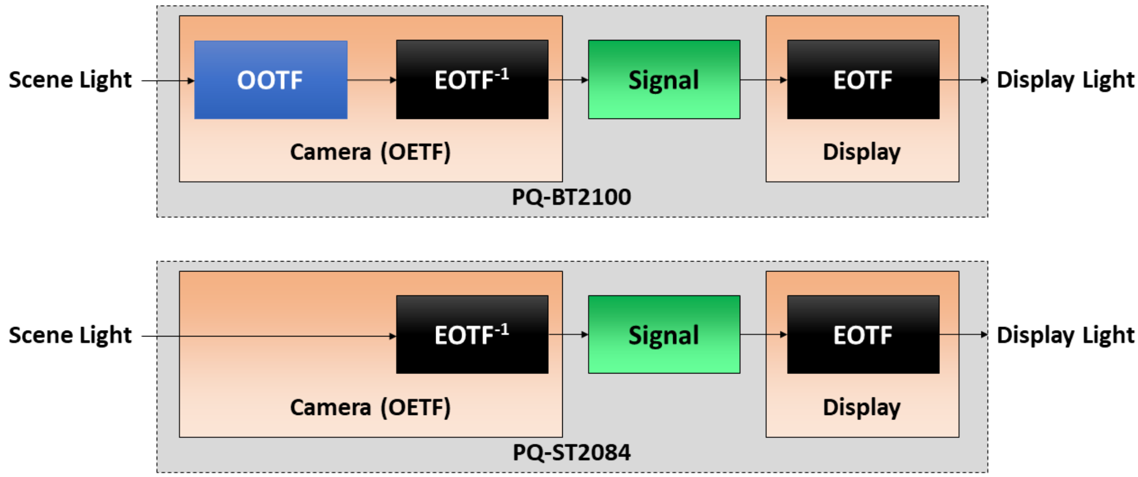
If one of the HDR characteristics PQ, HLG or SLog3 is to be bypassed, but a color space and/or range conversion needs to be performed nevertheless, "Auto" must be selected as "Output Transfer Characteristic" (see. chapter 3.3. "Auto"), e.g. by selecting the "Auto to Auto" Preset (see chapter 5. "Presets"). However, it should be noted that the Operation Mode "EVIE+" must be selected in order to perform these conversions in connection with HDR characteristics (see chapter 2. "Operation Modes"). Since the HDR characteristics of the camera manufacturers are only used as OETFs in the cameras on recording side and not as EOTFs for reproduction on the display side, this feature is not available for these characteristics. If "Auto" is selected as Output Transfer Characteristic and one of these manufacturers' characteristics is present at the input, the system will automatically perform a down-conversion to SDR (Gamma BT.709) if the Operation Mode "EVIE+" is active (s. chapter 3.3. "Auto").

In the following chapters, the available HDR characteristics are described in more detail.

3.2.1.PQ

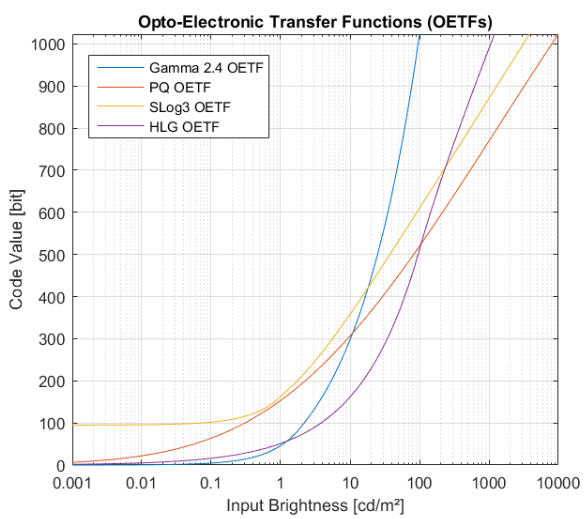
Dolby's perceptual quantizer (PQ) has been standardized by the SMPTE as SMPTE ST-2084 as EOTF and OETF. In this standardization, the OETF is considered to be the exact inverse of the EOTF, resulting in a linear OOTF, i.e. no reference OOTF is applied (see chapter 3. "Transfer Characteristics") as shown in the following figure. The standard is based on the Barten characteristic, which depicts the functioning of human brightness perception in a complex and modern model. In addition, PQ is based on a SMPTE and Dolby subject study to determine audience preference over the required dynamic range. Since the study showed that viewers prefer a luminance range between 0.001 cd/m^2 and 10,000 cd/m^2, the standard covers exactly this dynamic range.

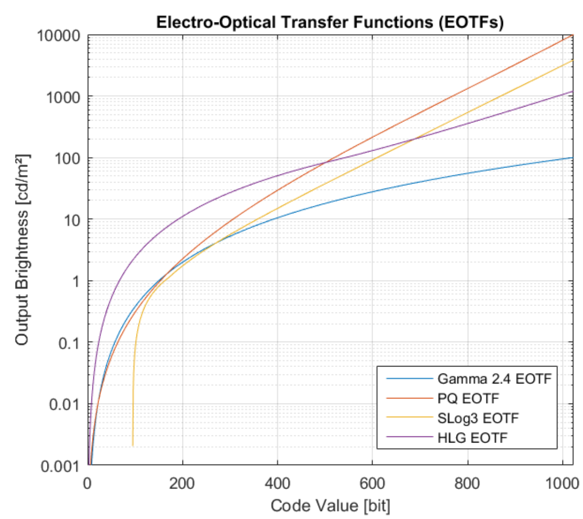
Furthermore, the ITU's HDR standard, ITU-R BT.2100, specifies PQ as a 10-bit EOTF and OETF as well, but in combination with a reference OOTF as described in chapter 3. "Transfer Characteristics" and shown in the following figure. The OOTF being considered in the camera (or being imposed in the production process), makes PQ a display-related system that is initially designed to provide an intended image impression in a BT.2100 defined reference environment (5 nits or cd/m^2 around the monitor while avoiding scattered light on the display). This means that the image should, therefore, be adapted according to these reference conditions on the recording side using the reference OOTF, so viewing under these conditions during reproduction leads to an optimized image impression on the



Difference between PQ-BT2100 and PQ-ST2084

reproduction side. Vice versa, this also means that if this reference condition is not fulfilled, the viewer will get a wrong impression of the image. Therefore, PQ as an absolute brightness metric basically ensures that an image is reproduced on all systems with the same absolute luminance, which ensures good comparability. For more details, see ITU standard BT.2100 and ITU Report BT.2390.





The 10-bit PQ characteristic is shown as simple OETF, i.e. as exactly inverse to the EOTF without consideration of the OOTF (as EOTF^{-1}) in the OETF figure and as EOTF in the EOTF figure above as well as in chapter 3. “Transfer Characteristics.” With PQ-ST2084 and PQ-BT2100, the HDR EVIE+ Constellation offers both the transfer characteristic according to SMPTE ST-2084, which defines PQ as EOTF and OETF as exactly inverse to each other with a linear OOTF or rather without a reference OOTF and the transfer characteristic according to ITU-R BT.2100, which is considered to be EOTF, and OETF in combination with the reference OOTF. Basically, PQ-ST2084* or PQ-BT2100 should always be used as “Input

Transfer Characteristic" whenever a PQ-ST2084 or PQ-BT2100 signal being present at the input of the processor. Since the HDR EVIE+ Constellation is a pure HDR-to-SDR down-converter, both characteristics PQ-ST2084 and PQ-BT2100 are only available as "Input Transfer Characteristics." Therefore, selecting one of these PQ characteristics will lead to an HDR-to-SDR down-conversion if "SDR" is selected as "Output Transfer Characteristic." If a PQ characteristic is to be bypassed, but a color space and/or range conversion needs to be performed; nevertheless, the "Output Transfer Characteristic" "Auto" must be selected (see. chapter 3.3. "Auto"). However, it should be noted that the Operation Mode "EVIE+" must be selected in order to perform these conversions in connection with one of the PQ characteristics (see chapter 2. "Operation Modes").

*Note: *PQ-ST2084 as the most common PQ characteristic, especially on the recording side, should be used as transfer characteristic whenever material is being or has been captured in ST-2084 unless the signal shall be interpreted as PQ-BT2100 to achieve a certain look. Please note the following explanations and notes on this topic.*

Furthermore, a more detailed example of down-converting PQ signals has already been given in chapter 2.2.2. "Mapping" as well as in chapter 3. "Transfer Characteristics." The example is shown in chapter 2.2.2. "Mapping" describes the process of Scene Light and Display Light Mapping in more detail by using a PQ-BT2100 signal. As described, scene-referred mappings are based on the light falling on the camera sensor. Therefore, the brightness levels of the scene must be reconstructed first before the Tone Mapping operation can be performed. According to the descriptions in chapter 2.2.2. "Mapping," the non-linear process that took place within the camera during image capture, must be undone in order to reconstruct the original linear scene light. Since this scene-referred operation differs between PQ-BT2100 and PQ-ST2084 due to the missing OOTF in the recording process of PQ-ST2084 (as shown in the first figure of this chapter), this missing OOTF must be considered in case of a scene-referred down-conversion from PQ-ST2084 to SDR (Gamma BT.709). While PQ-BT2100 requires both the EOTF and inverse OOTF ($OOTF^{-1}$) to be applied, PQ-ST2084 requires only the EOTF to be applied in order to reconstruct the original linear scene light (see diagram in chapter 2.2.2. "Mapping").

As already described in chapter 2.2.2. "Mapping," PQ-ST2084 only supports Scene Light Mapping and no Display Light Mapping. If Tone Mapping Display Light is selected in case of down-converting a PQ-ST2084 signal, the Mapping Type will be forced to Tone Mapping Scene Light. However, according to the first figure in this chapter, Display Light Mapping would be the same operation in both cases anyway, since only the EOTF must be applied in both cases in order to derive the required display light a monitor would reproduce.

While Display Light Mapping tends to preserve the look created by the transfer characteristic used by the display (plus artistic intent), Scene Light Mapping tends to represent the look of the signal being converted to. In the case of HDR-to-SDR down conversion from PQ to SDR (Gamma BT.709), Display Light Mapping would, therefore, lead to an PQ look, while Scene Light Mapping would result in a "traditional" BT.709 look. However, in the latter case, the resulting look depends on which system the shading takes place (HDR or SDR) and whether artistic intents have already been included during the capturing process. The looks resulting from PQ-BT2100 workflows, i.e. caused by conversions of all kinds from or to PQ-BT2100, are summarized and described in detail in ITU Report BT.2408. However, since this report does not refer to SMPTE ST-2084, the looks resulting from PQ-ST2084 in relation to PQ-BT2100 are described in the following.

In general, an image captured by PQ-ST2084 is brighter than an image captured by PQ-BT2100. The reason why the image resulting from PQ-BT2100 is darker is because of the decrease in brightness due to the reference OOTF of PQ-BT2100. If a signal captured with PQ-ST2084 is interpreted as a PQ-BT2100 signal during playback on display, no further difference will occur. The same applies to the interpretation of a PQ-BT2100 signal as PQ-ST2084 in the display. This is due to the fact that the EOTF applied by the display is exactly the same in both cases, PQ-ST2084 and PQ-BT2100, as shown in the first figure of this chapter. The PQ-BT2100 signal will, therefore, look as much darker than the PQ-ST2084 signal regardless of which EOTF standard will be used within the display.

However, in the case of HDR-to-SDR down-conversion from PQ to SDR, it strongly depends on how the signal is interpreted and especially which Mapping Type, Scene Light, or Display Light is selected. Thus, the selection of the Mapping Type influences the look of the resulting image. If a PQ-ST2084 signal is present at the input of the HDR processor, it should be interpreted as PQ-ST2084 in order to maintain the displayed brightness level in respect of a displayed SDR signal according to BT.709/BT.1886.*

***Note:** *When PQ-BT2100 is selected instead, the displayed signal will appear brighter after down-conversion. This is related to the reference OOTF, which is considered by ITU-R BT.2100 in contrast to SMPTE-ST2084.*

Due to the ability in the HDR EVIE+ Constellation to interpret a PQ-ST2084 signal as PQ-BT2100, the following table provides information on how the respective interpretations and Mapping Types affect the image in relation to each other.

PQ-ST2084/BT2100 → SDR			to SDR
from	PQ-ST2084	Scene Light Mapping	• lowest image brightness • high contrast • highest saturation level
	PQ-BT2100	Display Light Mapping	• medium image brightness • low contrast • medium saturation level
		Scene Light Mapping	• highest image brightness • low contrast • lowest saturation level

Resulting looks after HDR-to-SDR down-conversion regarding PQ-ST2084 and PQ-BT2100 with the corresponding Mapping Types Scene Light and Display Light

The reason why the result of Scene Light Mapping appears darkest with PQ-ST2084 and brightest with PQ-BT2100 is due to the fact that no inverse reference OOTF is applied when reconstructing the scene light with PQ-ST2084, whereas the reference OOTF is taken into account using PQ-BT2100.

However, the HDR EVIE+ Constellation offers the ability to interpret PQ-BT2100 signals as PQ-ST2084 as well.* Therefore, the relationships provided in the previous table are also valid in case of a PQ-BT2100 signal being present at the input of the HDR processor except for the results being equally darker overall compared to a PQ-ST2084 signal being present at the input. As already mentioned, this is because the image resulting from PQ-BT2100 is generally darker due to the reference OOTF included. However, if a PQ-BT2100 signal is present at the input of the HDR processor, it should be interpreted as PQ-BT2100 in order to maintain the displayed brightness level in respect of a displayed SDR signal according to BT.709/BT.1886.

**Note:* In this case, the displayed signal will appear darker after down-conversion, as shown in the table on the previous page. This is related to the reference OOTF, which is considered by ITU-R BT.2100 in contrast to SMPTE-ST2084.*

According to ITU Report BT.2408, using PQ as a full range signal is beneficial, providing an incremental advantage against the visibility of banding/contouring and in terms of processing. Since the range of PQ signals is as large as it is, it is rare for content to contain pixel values close to the extreme values of the range. Therefore, over- and under-shoots are unlikely to be clipped. More information about this topic can be found in chapter 6. "Signal Range" and 6.2. "Full Range."

For more information on suggested format conversions and resulting looks in PQ production, see ITU Report BT.2408. For more detailed technical descriptions on how conversions concerning PQ are being processed, see ITU Report BT.2390.

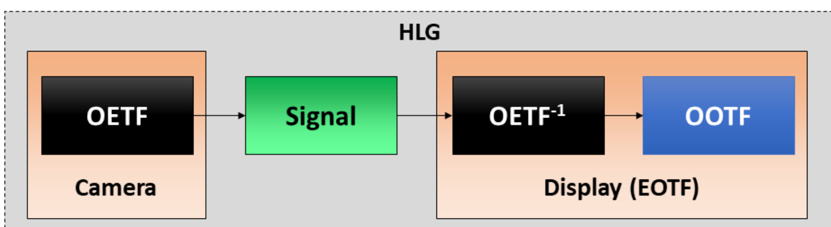
3.2.2.HLG

Hybrid Log Gamma (HLG) is an evolutionary approach developed jointly by the BBC and the NHK. As the name implies, HLG is a combination of gamma manipulation in the dark and logarithmic coding in the bright areas of the curve. This guarantees, on the one hand, certain compatibility with existing systems and workflows, and on the other hand, the logarithmic encoding "in the lights" and a pure square root OETF "in the blacks" allows an extended dynamic range in contrast to the SDR gamma characteristic*.

***Note:** *In contrast, the SDR OETF uses a linear portion near black to avoid excessive noise amplification.*

According to BT.2390, the signal characteristic of HLG is similar to that of a traditional standard dynamic range camera with a 'knee'" and is "therefore compatible with conventional standard dynamic range production equipment, tools, and infrastructure." Furthermore, HLG has been designed to provide a certain level of compatibility with BT.2020 SDR displays.

HLG is considered a scene-related system, which is based on the characteristics of the original scene. In simple terms, the signal represents the camera and is adapted by the consumer display to the display's representable luminance range. Therefore, the system was designed in a way that the adaptation of the image impression takes place on the reproduction side, i.e., by the OOTF being considered in the display, as shown in the following figure.

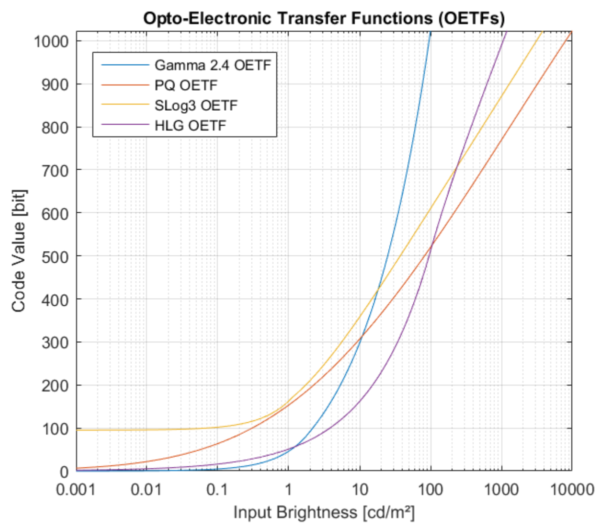


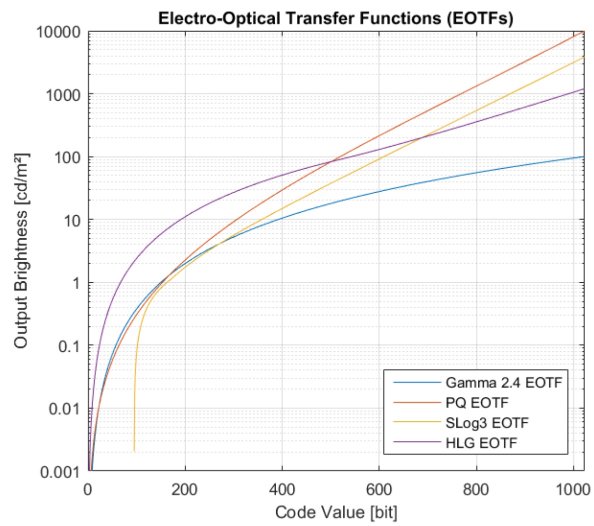
HLG according to ITU-R BT.2100

The image should, therefore, be adjusted in the consumer display based on its representable luminance range using the reference OOTF. This means the mapping of the luminance to the display also includes an adjustment of the OOTF, in which the gamma value is adjusted according to the brightness range of the display. Brighter displays should use an increased gamma, darker displays a lower one. However, the absolute representation of luminance can vary greatly due to the wide variety of conditions appearing on the display side. Therefore, HLG is only considered a relative brightness metric in contrast to PQ as an absolute brightness metric. For more information on the HLG system, see ITU Report BT.2390 and BT.2408.

Just like PQ, this characteristic has also been described as 10-bit OETF and EOTF in the HDR standard ITU-R BT.2100. The 10-bit HLG characteristic is illustrated as OETF and as simple EOTF, i.e. as exactly inverse to the OETF without consideration of the OOTF (as $OETF^{-1}$) in the following figures as well as in chapter 3. "Transfer Characteristics."

Basically, HLG should always be used as "Input Transfer Characteristic" whenever an HLG signal is present at the input of the processor. Since the HDR EVIE+ Constellation is a pure HDR-to-SDR down-converter, HLG is only available as "Input Transfer Characteristics." Therefore, selecting HLG will lead to an HDR-to-SDR down-conversion if "SDR" is selected as "Output Transfer Characteristic."

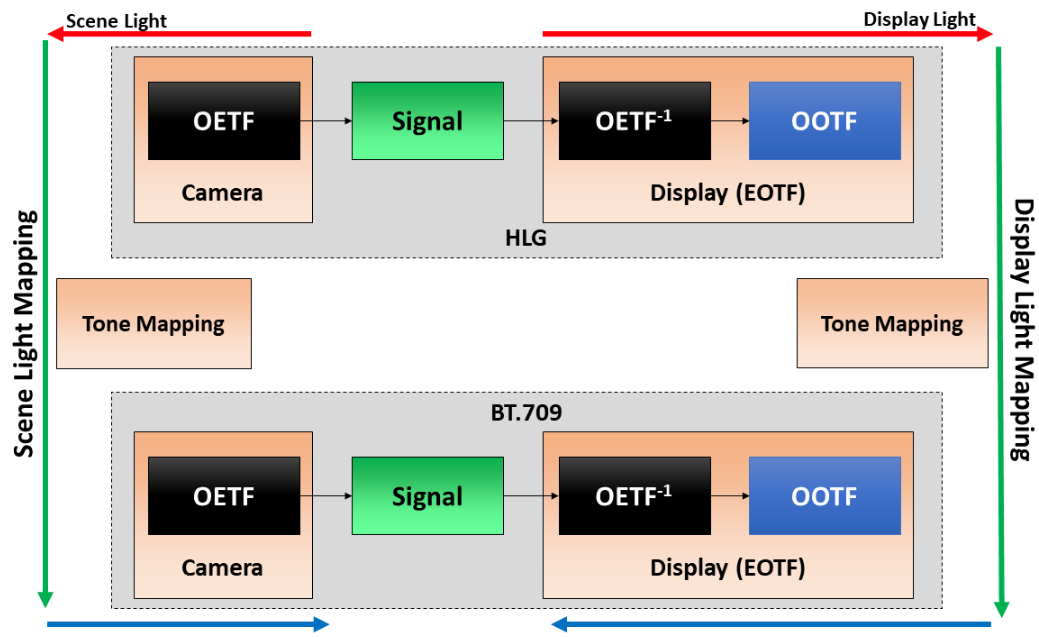




If an HLG characteristic is to be bypassed, but a color space and/or range conversion needs to be performed nevertheless, the "Output Transfer Characteristic" "Auto" must be selected (see. chapter 3.3. "Auto"). However, it should be noted that the Operation Mode "EVIE+" must be selected in order to perform these conversions in connection with the HLG characteristic (see chapter 2. "Operation Modes").

Furthermore, a more detailed example of down-converting an HDR signal has already been given in chapter 2.2.2. "Mapping" as well as in chapter 3. "Transfer Characteristics." The example is shown in chapter 2.2.2. "Mapping" describes the process of Scene Light and Display Light Mapping in more detail by using a PQ-BT2100 signal. The HDR-to-SDR down-conversion from HLG to SDR (Gamma BT.709) can be retraced likewise.

As described in chapter 2.2.2. "Mapping," scene-referred mappings are based on the light falling on the camera sensor. Therefore, the brightness levels of the scene must be reconstructed first before the Tone Mapping operation can be performed. According to the descriptions in chapter 2.2.2. "Mapping," the non-linear process that took place within the camera during image capture, must be undone in order to reconstruct the original linear scene light. Thus, in case of down-conversion from HLG to SDR (Gamma BT.709), the inverse HLG OETF ($OETF^{-1}$) is applied first in order to reconstruct the original linear scene light (see the red arrow at the top left of the following figure). After performing the Tone Mapping operation (see left green arrow), the gamma BT.709 OETF will be applied (see blue arrow bottom left) in order to simulate or rather generate a signal captured by an SDR camera capture curve.



Down-conversion from HLG to SDR (Gamma BT.709)

By using Display Light Mapping, the brightness levels which the input signal would cause on a reference monitor are used as a reference for the display-referred mapping. According to the explanations in chapter 2.2.2. “Mapping”, the HLG EOTF, i.e. the inverse OETF ($OETF^{-1}$) and the OOTF is applied to the signal first (see the red arrow at top right) in order to derive the display light a monitor would reproduce. After performing the Tone Mapping operation (see right green arrow), the BT.1886 inverse EOTF ($EOTF^{-1}$), i.e. the inverse BT.709/BT.1886 OOTF ($OOTF^{-1}$) and the BT.709 OETF will be applied to obtain the SDR (Gamma BT.709) signal (see the blue arrow at the bottom right).

According to ITU-Report BT.2408 and BT.2390, if no further artistic adjustments are made, HLG signals preserve the chromaticity of the scene as captured by the camera compared to the “traditional” look of SDR cameras. While Display Light Mapping tends to preserve the look created by the transfer characteristic used by the display (plus artistic intent), Scene Light Mapping tends to represent the look of the signal being converted to. In the case of HDR-to-SDR down conversion from HLG to SDR (Gamma BT.709), Display Light Mapping would, therefore, lead to an HLG look, while Scene Light Mapping would result in a “traditional” BT.709 look. However, in the latter case, the resulting look depends on which system the shading takes place (HDR or SDR) and whether artistic intents have already been included during the capturing process.

The looks resulting from HLG workflows, i.e. caused by conversions of all kinds from HLG, are summarized and described in detail in ITU Report BT.2408.

According to ITU Report BT.2408 and specified in ITU Report BT.2390, using narrow range signals is strongly preferred for HLG to maintain signal fidelity and to reduce the risk of confusing full range with narrow range signals (and vice versa) in production. More information about this topic can be found in chapter 6. "Signal Range" and 6.1. "Narrow Range."

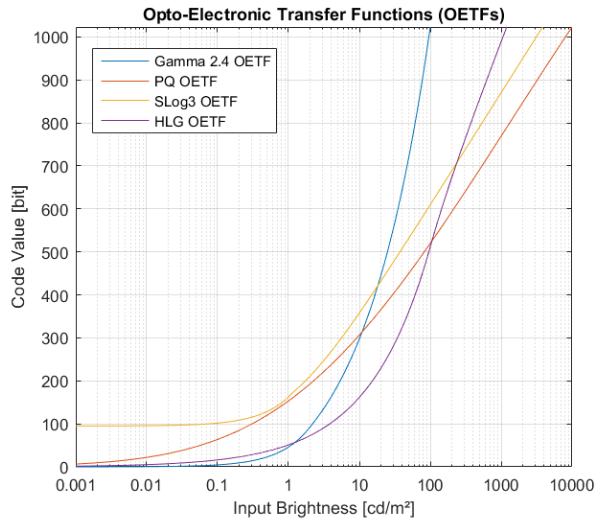
For more information on suggested format conversions and resulting looks in HLG production, see ITU Report BT.2408. For more detailed technical descriptions on how conversions concerning HLG are being processed, see ITU Report BT.2390.

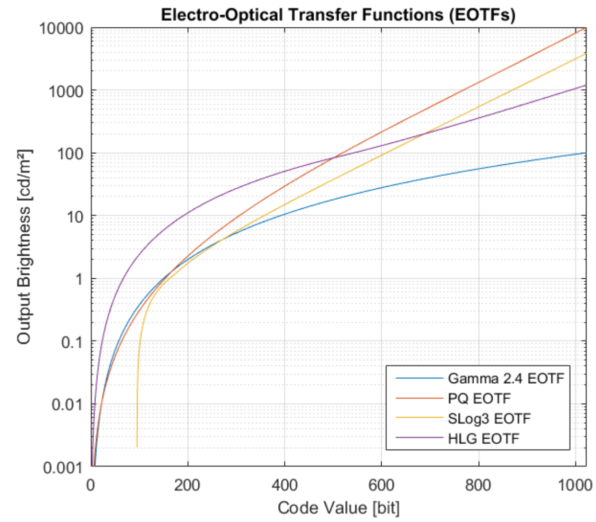
3.2.3. SLog3

SLog3 is a consistently logarithmic transfer characteristic developed by Sony, which is often used in the field of film and scenic productions. On the recording side, the logarithmic characteristic enables the capturing of a very large dynamic range or contrast range and receives a particularly large number of gradations in dark areas. Therefore, SLog3 provides a high contrast, especially in dark areas of the image. The characteristics of the SLog3 curve are comparable to those of scanned film, and in consequence, the adaptation of captured SLog3 material is usually done in the context of a more elaborate postproduction.

For capturing with SLog3 the Sony standard provides a 10-bit quantization and only allows the full range, i.e. the use of the entire 10-bit code value range. More on this subject in chapter 6. "Signal Range." The 10-bit SLog3 characteristic is represented as OETF in the following OETF figure and as an inverse function as EOTF in the EOTF figure as well as in chapter 3. “Transfer Characteristics.”

Basically, SLog3 should always be used as “Input Transfer Characteristic” whenever a SLog3 signal is present at the input of the processor. Since the HDR EVIE+ Constellation is a pure HDR-to-SDR down-converter, SLog3 is only available as “Input Transfer Characteristic.” Therefore, selecting SLog3 will lead to an HDR-to-SDR down-conversion if “SDR” is selected as “Output Transfer Characteristic.”





If a SLog3 characteristic is to be bypassed, but a color space and/or range conversion needs to be performed, nevertheless, the “Output Transfer Characteristic” “Auto” must be selected (see. chapter 3.3. “Auto”). However, it should be noted that the Operation Mode “EVIE+” must be selected in order to perform these conversions in connection with the SLog3 characteristic (see chapter 2. “Operation Modes”).

As already described in chapter 2.2.2. "Mapping," SLog3 only supports Scene Light Mapping and no Display Light Mapping. If Tone Mapping Display Light is selected in case of down-converting a SLog3 signal, the Mapping Type will be forced to Tone Mapping Scene Light.

3.2.4. Other manufacturers’ characteristics

Besides SLog3, the HDR processor does support other common proprietary HDR camera capture curves (OETFs) of camera manufacturers such as Panasonic V-Log, Arri LogC, RED Log3G10, Canon C-Log2 and BMD (Blackmagic Design) Film. These proprietary transfer characteristics are also intended for wider dynamic ranges such as the “officially” by the ITU standardized characteristics PQ and HLG. However, since these camera capture curves are consistently logarithmic and are mainly used for film and scenic productions, they show the most similarity to SLog3 and work more or less the same way (see chapter 3.2.3. “SLog3”).

These characteristic curves should always be used as “Input Transfer Characteristic,” respectively, if one of these characteristics is present on the input side, e.g., by directly connecting a camera capturing with one of these characteristics. Since the HDR EVIE+ Constellation is a pure HDR-to-SDR down-converter, these characteristics are only available as “Input Transfer Characteristics.” Therefore, selecting one of these characteristics will lead to an HDR-to-SDR down-conversion if “SDR” is selected as “Output Transfer Characteristic.”

Furthermore, these transfer characteristics are only used by the respective cameras as capture curves (OETFs) and not as EOTFs on the display side at all.

This is also the reason why the HDR processor does only support these characteristics in combination with Scene Light Mapping and not with Display Light Mapping, as already described in chapter 2.2.2. “Mapping.” If Tone Mapping Display Light is selected in case of down-converting one of these characteristics, the Mapping Type will be forced to Tone Mapping Scene Light.

Furthermore, the system will not bypass such a characteristic if one of these characteristics is present at the input of the processor, and the Output Transfer Characteristic “Auto” is selected. Instead, the system will automatically perform a down-conversion to SDR (Gamma BT.709) if the Operation Mode “EVIE+” is active (see chapter 3.3. “Auto”).

Further information about these proprietary transfer characteristics and their properties should be taken from the documentation of the respective manufacturers.

3.3. Auto

By selecting "Auto" as “Input Transfer Characteristic” and/or “Output Transfer Characteristic”, it is possible to use the auto feature of the HDR EVIE+ Constellation for setting the input and/or output characteristic automatically. With activating “Auto” as “Input Transfer Characteristic”, the HDR processor automatically selects the transfer characteristic of the signal being present at the input.

However, the presence of this information as ancillary data in the video stream, i.e. in the vertical blanking region as VANC (vertical ancillary data) of an SDI signal, is necessary for using this feature.* If the information regarding the transfer characteristic of the signal is not contained in the data stream of the signal, this feature should not be used.

**Note:* *Markings in the VANC are read and inserted by the processor according to ITU-R BT.1120-9 for HD and SMPTE - ST2082-10:2018 for 4K/UHD. These standards allow the markings of SDR BT.709, HLG, PQ and “unspecified”. "Unspecified" is regarded as SLog3 in the HDR processor.*

Using this setting as "Input Transfer Characteristic" has the advantage that regardless of which signal is present at the input, it is always ensured that the correct down-conversion is carried out if SDR is selected as "Output Transfer Characteristic." If an SDR (Gamma BT.709) signal is present at the input, the system will basically bypass.
By selecting "Auto" as “Output Transfer Characteristic,” the transfer characteristic at the output is set according to the “Input Transfer Characteristic,” assuming this output format corresponds to one of the standards supported by the HDR EVIE+ Constellation.* An

overview of all permissible and impermissible combinations can be found in the tables of the appendix. Therefore, by selecting “Auto” as Output Transfer Characteristic, the transfer characteristic of the input signal is basically bypassed (unless it is one of the manufacturers’ characteristics*), which means that no Tone Mapping and thus no HDR-to-SDR down-conversion will be performed. In addition, this feature can be used to bypass HDR characteristics like PQ, HLG, and SLog3 and still allows color space and/or range conversions of these HDR signals to be performed. However, it should be noted that the Operation Mode “EVIE+” must be selected in order to perform these conversions in connection with HDR characteristics (see chapter 2. “Operation Modes”).

By using “Auto” as both “Input Transfer Characteristic” and “Output Transfer Characteristic” simultaneously, the system will also basically bypass the present input characteristic unless it is one of the manufacturers’ characteristics.*

**Note:* *Since the HDR characteristics of the camera manufacturers are only used as OETFs in the cameras on the recording side and not as EOTFs for reproduction on the display side, this feature is not available for these characteristics. If “Auto” is selected as Output Transfer Characteristic and one of these manufacturers’ characteristics is present at the input, the system will automatically perform a down-conversion to SDR (Gamma BT.709) if the Operation Mode “EVIE+” is active.*
Note: *The Operation Mode "bypass HDR/SDR" prevents down-conversions between HDR transfer characteristics and SDR (Gamma BT.709) from being performed. Conversion functionality of Colorimetry (color spaces) and Ranges in connection with HDR characteristics will not be performed either. In this mode, color space and range conversions are only performed correctly in connection with SDR (Gamma BT.709) signals (see chapter 2.1. “Operation Mode “bypass HDR/SDR””). When using Auto, attention should be paid to which signal is present at the input and which Operation Mode and settings are selected to ensure the correct operation will be performed.*

3.4. Use cases

This chapter summarizes the available use cases of the transfer characteristics in the following tables. The existing limitations regarding transfer characteristics are listed in a separate table with all other limitations of the HDR EVIE+ Constellation (regarding colorimetry and range) in the appendix at the end of the document.

Conversions:

Conversions		to
		SDR
from	SDR	none
	PQ	down-conversion
	HLG	down-conversion
	SLog3	down-conversion
	Manufacturers' characteristics	down-conversion

Conversion overview of the available transfer characteristics

Mapping Type:

Tone Mapping		to
		SDR
from	SDR	none
	PQ	(sectional) dynamic Tone Mapping
	HLG	(sectional) dynamic Tone Mapping
	SLog3	(sectional) dynamic Tone Mapping
	Manufacturers' characteristics	(sectional) dynamic Tone Mapping

Mapping overview of the available transfer characteristics regarding Tone Mapping

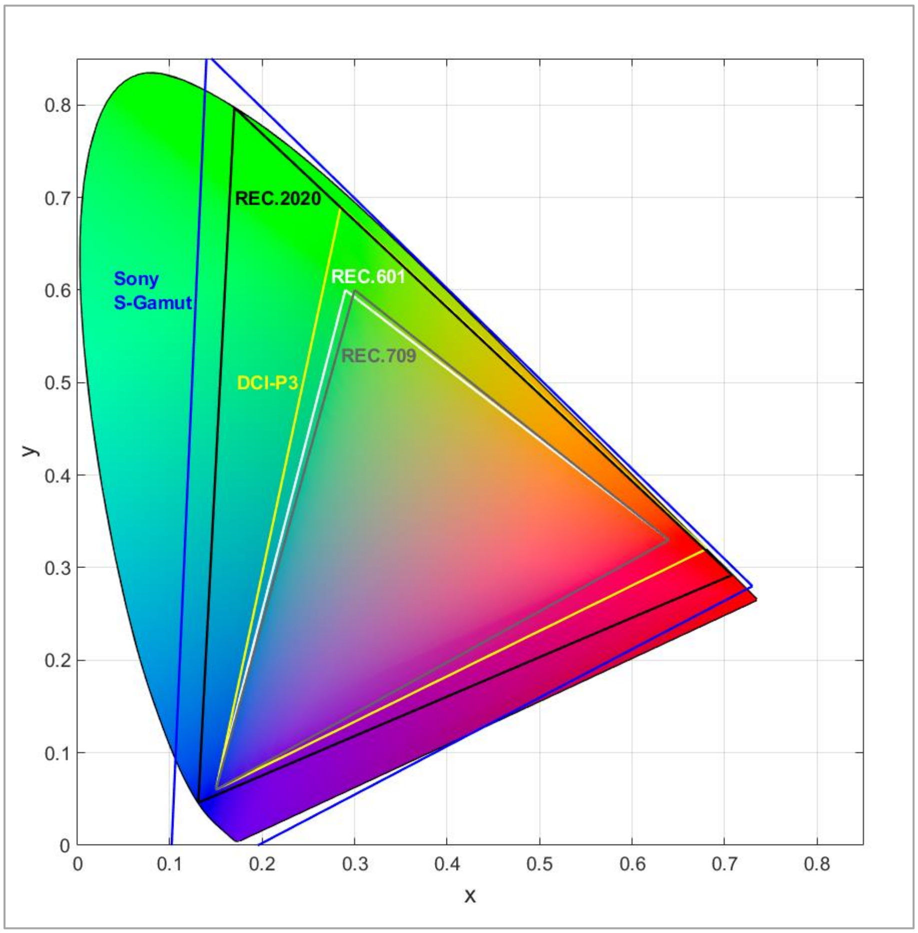
Mapping Type:

Tone Mapping		to
		SDR
from	SDR	none
	PQ-ST2084	Scene Light
	PQ-BT2100	Scene Light / Display Light
	HLG	Scene Light / Display Light
	SLog3	Scene Light
	Manufacturers' characteristics	Scene Light

Mapping overview of the available transfer characteristics regarding Scene Light Mapping and Display Light Mapping

4. Colorimetry / Gamut

As with developments in the brightness range (greater luminance, contrast, and dynamic range), the television and broadcast world is always striving to make progress in the field of colors as well. For example, the ITU's new UHDTV standard BT.2020 has already specified a new and larger color space, commonly known as Rec. 2020. This spans a much larger color triangle in the CIE standard color chart than the former and common Rec. 709 color space of the HDTV standard ITU-R BT.709 (see figure below). In the context of BT.2020, the term "Wide Color Gamut" (WCG) is used quite often as well.



A selection of available color gamuts shown in the CIE chromaticity diagram

The CIE standard color chart shown in the figure above contains all perceptible colors occurring in human color vision. The color triangles within this color chart indicate which and how many of the existing colors can be represented with the respective standard. All colors within a color triangle are specified in the respective standard and theoretically displayable.

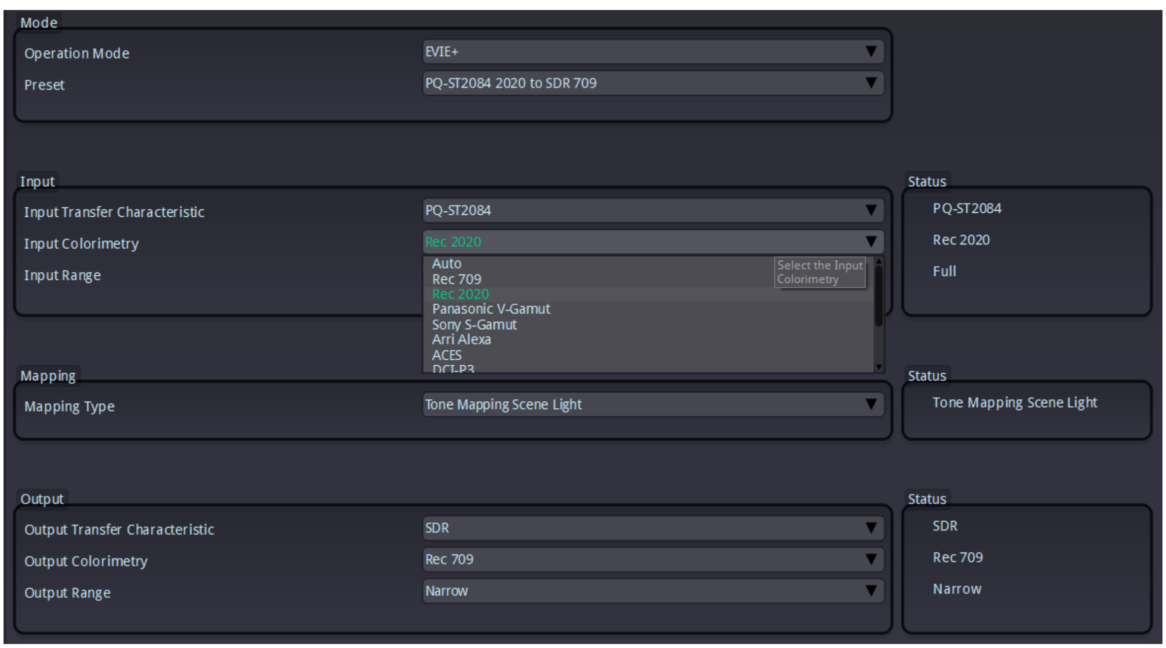
Today's television systems are not 100% capable of displaying all the colors contained in Rec. 2020, but possibly in the future. However, some of the "new" colors can already be viewed today with modern TV sets.

The HDR EVIE+ Constellation contains all common and previously specified television color spaces from the past and present, including Rec. 601, Rec. 709 and Rec. 2020, whereas Rec. 601, unlike Rec. 709 and Rec. 2020, cannot actively be selected as “Input” or “Output Colorimetry” in the HDR processor. However, Rec. 601 is automatically detected, selected and processed by the processor whenever an SD signal, according to BT.601, is present at the input.

In addition to these television gamuts, the standardized cine gamuts ACES and DCI-P3 are also included in the HDR EVIE+ Constellation.

According to the common proprietary transfer characteristics of the camera manufacturers described in chapter 3. “Transfer Characteristics” and 3.2.4. “Other manufacturers’ characteristics,” the HDR EVIE+ Constellation also contains the corresponding color gamuts of these manufacturers, known as Sony S-Gamut, Panasonic V-Gamut, Arri Alexa, RED Wide Gamut, Canon Cinema Gamut and BMD Film.

The HDR EVIE+ Constellation provides extensive conversion functionality between these different color spaces, including all reasonable combinations.

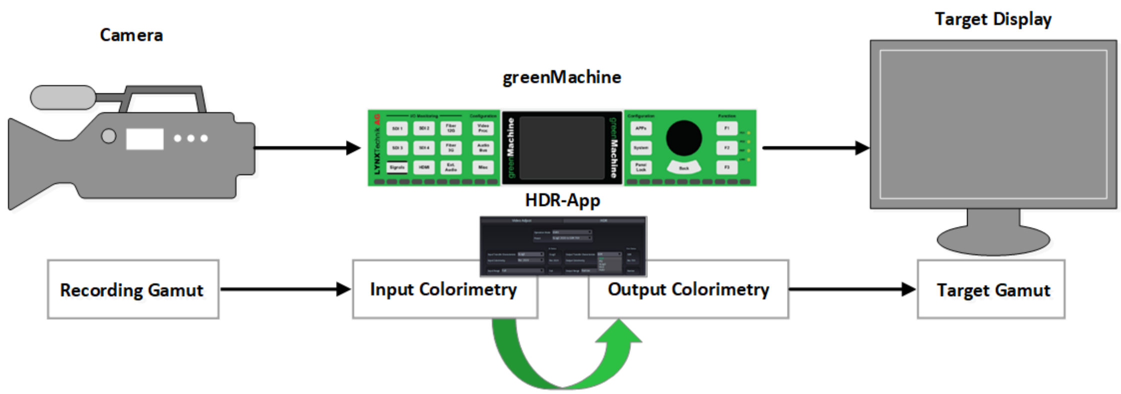


Selecting an Input and Output Colorimetry

The use of the color space conversion should follow a simple principle:
As the selection of the “Input Transfer Characteristic,” the "Input Colorimetry" should also be selected according to the color space of the input signal. If we stick to the example used in

chapter 3. "Transfer Characteristics," operating an HDR camera directly in front of the greenMachine, the "Input Colorimetry" should be selected according to the capture color space used by the camera. Assuming the camera captures in Rec. 2020, “Input Colorimetry” should also be selected as “Rec. 2020”. In order to reproduce colors correctly on a standard SDR display with Rec. 709 color space (or similar), a conversion to Rec. 709 color space must be performed.* Therefore, the "Output Colorimetry" must be set to “Rec. 709”.

**Note: Since the Rec. 2020 color gamut as a wide gamut is significantly larger than the Rec. 709 gamut, a Rec. 2020 input signal may contain color values outside the Rec. 709 gamut. In case of a down-conversion from one of the available wide color gamuts (e.g. Rec. 2020) to Rec. 709, these values outside the Rec. 709 gamut need to be transferred from the wide gamut to the smaller Rec. 709 gamut. This can be done either by a simple “clipping” of the values or by a more elaborate and more appropriate “Gamut Mapping” algorithm (see chapter 4.7. “Gamut Mapping”). Therefore, the “Gamut Mapping” tends to be better suited for “correct” (accurate) color reproduction.*



Operation example for colorimetry using the HDR processor

In general, the “Input Colorimetry” should always correspond to the color space of the incoming video signal, while the “Output Colorimetry” should be selected according to the desired target color space of the target display to be addressed.

Similar to the conversions between transfer characteristics, we also speak of a down-conversion when a Rec. 2020 signal is converted to Rec. 709 color space, or of an up-conversion when a Rec. 709 signal is converted to the Rec. 2020 color space.

The HDR EVIE+ Constellation allows any up-, down- and cross-conversion in combination with these standardized TV color spaces, except for Rec. 601, since this gamut is only permissible in combination with SD material. Rec. 709 and 2020, on the other hand, can be selected as both input and output colorimetry and can, therefore, be used in combination with all characteristics.
The HDR EVIE+ Constellation is also able to perform cross-conversions between cine gamuts (DCI-P3, ACES) or common proprietary color gamuts of camera manufacturers (Sony S-Gamut, Panasonic V-Gamut, Arri Alexa, RED Wide Gamut, Canon Cinema Gamut, BMD Film), which are also intended for wider color gamut, and Rec. 2020 as well as down-

conversion between these cine gamuts or proprietary manufacturers' gamuts and Rec. 709. However, it should be noted that the cine gamuts, as well as the proprietary gamuts of the camera manufacturers, are only available on the input side, i.e. as "Input Colorimetry," since these proprietary camera capture gamuts are only used in the cameras on recording side and not for reproduction on the display side. Thus, even scenic productions that are carried out with cine cameras as well as archive material from scenic productions that has been captured with cine camera gamuts can be transferred to the common color spaces of broadcast standards. However, since these color gamuts are only available at the input side of the processor, the system will not bypass such a color gamut if one of these gamuts is present at the input of the processor and the Output Colorimetry "Auto" is selected. Instead, the system will automatically perform a down-conversion to Rec. 709 (see chapter 4.6. "Auto").

The standardized broadcast gamuts Rec. 601, Rec. 709, and Rec. 2020. as well as the DCI-P3 cine gamut and the proprietary Sony S-Gamut are illustrated exemplarily in the CIE chromaticity diagram at the beginning of the chapter.

Since the HDR EVIE+ Constellation does not allow all format combinations arbitrarily, there are also certain restrictions and conditions regarding color space conversions in the HDR processor. The tables in the appendix provide a good overview of the restrictions and conditions being imposed on the executable conversions in the HDR processor.

As described in chapter 2.1. "Operation Mode "bypass HDR/SDR"," color space conversions of SDR (Gamma BT.709) signals are available in both Operation Modes "EVIE+" and "bypass HDR/SDR" since the conversion functionality for Colorimetry is also available independently of the HDR EVIE+ Constellation in the greenMachine and thus remains untouched upon activation of the Operation Mode "bypass HDR/SDR." If color space conversions are to be performed in connection with HDR characteristics, the Operation Mode "EVIE+" must be selected (see chapter 2. "Operation Modes").

The available color spaces provided by the HDR EVIE+ Constellation are described in more detail below.

4.1. Rec. 601

The Rec. 601 color gamut has been specified in the ITU standard ITU-R BT.601 for SDTV (Standard Definition Television) as the first television color space defined for digital television. The Rec. 601 color space, which is very similar to the HDTV color space Rec. 709, however, has a slightly different color triangle. While the Rec. 601 color gamut specifies a few more

colors in the green-blue area, Rec. 709 defines slightly more colors in the green-red area (see figure at the beginning of chapter 4. “Colorimetry / Gamut”).
Rec. 601 cannot actively be selected as “Input” or “Output Colorimetry” in the HDR EVIE+ Constellation but is automatically detected, selected, and processed by the processor whenever an SD signal according to BT. 601 is present.

4.2. Rec. 709

The Rec. 709 color space has been specified in the ITU standard ITU-R BT.709 and is, therefore, still valid as today’s HDTV color space. Unlike Rec. 601, Rec. 709 specifies slightly more colors in the green-red area, but fewer colors in the green-blue area. Compared to Rec. 2020, both, Rec. 601 and Rec. 709 contain significantly fewer colors (see figure at the beginning of chapter 4. “Colorimetry / Gamut”).

Therefore, conversion from Rec. 709 to Rec. 2020 corresponds to an up-conversion, whereas a conversion from Rec. 2020, DCI-P3, ACES or one of the proprietary camera capture gamuts of the manufacturers (Sony S-Gamut, Panasonic V-Gamut, Arri Alexa, RED Wide Gamut, Canon Cinema Gamut, BMD Film) to Rec. 709 corresponds to a down-conversion.*

**Note: Since these color gamuts are wider than the Rec. 709 color gamut, the input signal may contain color values outside the Rec. 709 gamut. In case of a down-conversion, these values need to be transferred from the wider gamut to the smaller Rec. 709 gamut. This can be done either by a simple “clipping” of the values or by a more elaborate and more appropriate “Gamut Mapping” algorithm (see chapter 4.7. “Gamut Mapping”).*

Basically, Rec. 709 should always be selected as "Input Colorimetry" whenever a Rec. 709 color space signal is present on the input side, or as "Output Colorimetry" when a present signal is to be converted to the Rec. 709 color space. Thus, Rec. 709 can be selected as both input and output colorimetry and can be used in combination with all transfer characteristics provided by the HDR EVIE+ Constellation. If Rec. 709 is selected as both “Input Colorimetry” and “Output Colorimetry” simultaneously, the system will basically bypass the Rec. 709 signal being present at the input.

However, it should be noted that Rec. 709 has been standardized for HD signals only, but not for SD and 4K/UHD resolutions. In the HDR EVIE+ Constellation, the combination of the Rec.709 color gamut with 4K/UHD material is still permissible, since the combination of 4K/UHD and SDR is classified as admissible as described in chapter 3.1. "SDR (Gamma BT.709)". The combination of Rec. 709 with a 720p signal according to the SMPTE standard is also permissible in the processor. Only the combination of Rec. 709 and SD material is considered inadmissible in the HDR EVIE+ Constellation and, therefore, cannot be selected. These and all other functional limitations of the HDR EVIE+ Constellation, as well as all possible combinations have been compiled and illustrated in the respective tables of the appendix.

4.3. Rec. 2020

With the Rec. 2020 color space, the HDR processor provides the most recent and largest television gamut, which has been standardized to date. As the name implies, this has been approved by the ITU standard ITU-R BT.2020 and has also found its place in the HDR standard BT.2100. Thus, HDR and Rec. 2020 are also considered a common combination in television production, which is why the HDR EVIE+ Constellation provides several useful presets covering common combinations. Please read more in chapter 5. "Presets."

Rec. 2020 spans a significantly larger color space than its predecessors Rec. 709 and Rec. 601 (see figure at the beginning of chapter 4. “Colorimetry / Gamut”). The standard allows all colors contained in its color triangle to be encoded, even if they are not yet fully representable on today’s displays.

Basically, Rec. 2020 should be selected as "Input Colorimetry" whenever a Rec. 2020 color space signal is present on the input side, or as "Output Colorimetry" when a present signal is to be transferred to the Rec. 2020 color space. Thus, Rec. 2020 can be selected as both input and output colorimetry and can be used in combination with all transfer characteristics provided by the HDR EVIE+ Constellation. If Rec. 2020 is selected as both “Input Colorimetry” and “Output Colorimetry” simultaneously, the system will basically bypass the Rec. 2020 signal being present at the input.

A conversion from Rec. 2020 to Rec. 709 corresponds to a down-conversion*, whereas a conversion from Rec. 709 to Rec. 2020 corresponds to an up-conversion. Conversions between cine gamuts (ACES, DCI-P3) or one of the proprietary color gamuts of the camera manufacturers (Sony S-Gamut, Panasonic V-Gamut, Arri Alexa, RED Wide Gamut, Canon Cinema Gamut, BMD Film) to Rec. 2020 correspond to a cross-conversion.

**Note*: Since the Rec. 2020 color gamut is significantly larger than Rec. 709, a Rec. 2020 input signal may contain color values outside the Rec. 709 gamut. In case of a down-conversion from Rec. 2020 to Rec. 709, these values need to be transferred from the wider Rec. 2020 gamut to the smaller Rec. 709 gamut. This can be done either by a simple “clipping” of the values or by a more elaborate and more appropriate “Gamut Mapping” algorithm (see chapter 4.7. “Gamut Mapping”).*

However, it should be noted that conversion between these cine gamuts or these proprietary color gamuts of the camera manufacturers and Rec. 2020 is only permissible in the direction from one of these gamuts *to* Rec. 2020, since these cine gamuts as well as the proprietary color gamuts of the camera manufacturers are only available on the input side as “Input

Colorimetry" (see chapters 4. "Colorimetry / Gamut," 4.4. "Cine Gamuts (DCI-P3, ACES)" and 4.5. "Manufacturers' Gamuts").

However, using Rec. 2020 color gamut in the HDR EVIE+ Constellation is allowed for HD and 4K/UHD footage only. Although the Rec. 2020 color space in BT.2020 has only been specified for 4K/UHD resolutions, the additional consideration of the color space in BT.2100 makes it equally valid for both HD and 4K/UHD resolutions. Therefore, using this color space in the HDR processor is allowed for both HD and 4K/UHD footage, but not for SD or 720p resolutions. A summary of these and all other restrictions, as well as all possible combinations, can be found in the tables of the appendix.

4.4. Cine Gamuts (DCI-P3, ACES)

With DCI-P3 and ACES, the HDR processor also provides color space standardizations from the field of digital cinema. The DCI-P3 standard, which refers to the actively used color space in digital cinemas, was defined by the digital-cinema community "Digital Cinema Initiatives" (DCI) and published in SMPTE RP 431-2. Approximating the color gamut of motion picture film, DCI-P3 is deployed in commercial digital cinema projectors. Furthermore, some LCD- and OLED-displays, especially professional "grade 1" reference monitors, also provide DCI-P3 as color gamut. Offering a larger color gamut than Rec. 709 but a smaller one than Rec. 2020, DCI-P3 could be used as an intermediate step in television systems and home cinemas as well. Currently, DCI-P3 content is limited to digital theaters and is not fully available to consumers.

The ACES format, standing for "Academy Color Encoding System," is an exchange format developed by AMPAS (Academy of Motion Pictures Arts & Sciences) or "Oscar Academy" for the reliable and consistent exchange of "film data." The system provides free, open, and device-independent color management and image exchange system for encoding digital film masters. ACES is suitable for acquisition and post-production, as well as for mastering and archiving. It also enables color transformations for consistent reproduction regardless of the display technology in use. The system is mainly published in SMPTE ST-2065-1 and supports both HDR and WCG. The ACES color space AP0 with its defined color primaries for red, green, and blue covers all perceptible colors of the human visual system and thus includes all colors of the CIE chromaticity diagram. For this reason, ACES is in fact a "virtual" color space that cannot be displayed physically. The standard, with its 16-bit half float encoding, provides a total of 30 f-stops with 1024 "code words" per f-stop, creating an enormous headroom with almost unlimited dynamic range. For on-set use and transmission between camera systems, on-set look management systems, and displays via SDI, the standard provides a lightweight integer encoding with ACESproxy (AP1) color space.

However, the ACES color space contained in the HDR processor corresponds to the AP0 color space.

The cine gamuts DCI-P3 and ACES, which are often used for acquisition, post-production, mastering, and archiving of the material of scenic productions, are provided in the HDR EVIE+ Constellation to be able to convert this kind of material into common color spaces of broadcast standards. The HDR EVIE+ Constellation is not meant to output or generate these gamuts, which is why these gamuts are only available on the input side of the processor. This is also the reason why the system will not bypass such a color space if one of these gamuts is present at the input of the processor, and the Output Colorimetry “Auto” is selected. Instead, the system will automatically perform a down-conversion to Rec. 709 (see chapter 4.6. “Auto”).

In principle, DCI-P3 or ACES should be selected as "Input Colorimetry" respectively whenever a signal with one of these color spaces is present on the input side and needs to be converted to one of the broadcast gamuts (Rec. 709, Rec. 2020). A conversion from DCI-P3 or ACES to Rec. 709 corresponds to a down-conversion*, a conversion from DCI-P3 or ACES to Rec. 2020 to a cross-conversion (see chapter 4. “Colorimetry / Gamut”).

**Note: Since the cine gamuts are significantly larger than the Rec. 709 gamut, an input signal of such kind may contain color values outside the Rec. 709 gamut. In case of a down-conversion from one of these gamuts to Rec. 709, these values need to be transferred from the wider cine gamut to the smaller Rec. 709 gamut. This can be done either by a simple “clipping” of the values or by a more elaborate, more appropriate “Gamut Mapping” algorithm (see chapter 4.7. “Gamut Mapping”).*

The cine gamuts DCI-P3 and ACES can be used in combination with all transfer characteristics. However, using DCI-P3 or ACES in the HDR EVIE+ Constellation is allowed for HD and 4K/UHD footage only, not for SD or 720p resolutions. A summary of all restrictions, as well as all valid combinations, can be found in the tables of the appendix.

4.5. Manufacturers’ Gamuts

The HDR EVIE+ Constellation also supports common proprietary camera capture gamuts of camera manufacturers such as Sony S-Gamut, Panasonic V-Gamut, Arri Alexa, RED Wide Gamut, Canon Cinema Gamut, and BMD Film. These proprietary camera capture gamuts are also intended for wider color gamut and even exceed the size of Rec. 2020 containing even more visible colors. Most of these gamuts are quite similar to each other, which is why the Sony S-Gamut is illustrated as an example in the CIE chromaticity diagram in chapter 4. “Colorimetry / Gamut.”
Since these color spaces originate from the respective cameras and are therefore used for capturing only but not for displaying at all, they are only available as “Input Colorimetry.”

Therefore, only cross-conversions from one of these proprietary gamuts to Rec. 2020 or down-conversions to Rec. 709* can be performed, but no cross- or up-conversion to any of these gamuts. This is also the reason why the system will not bypass such a color space if one of these gamuts is present at the input of the processor, and the Output Colorimetry "Auto" is selected. Instead, the system will automatically perform a down-conversion to Rec. 709 (see chapter 4.6. "Auto").

Note: *Since the manufacturers' gamuts are significantly larger than the Rec. 709 gamut, an input signal of such kind may contain color values outside the Rec. 709 gamut. In case of a down-conversion from one of these gamuts to Rec. 709, these values need to be transferred from the wide gamut to the smaller Rec. 709 gamut. This can be done either by a simple "clipping" of the values or by a more elaborate and more appropriate "Gamut Mapping" algorithm (see chapter 4.7. "Gamut Mapping").*

Basically, these gamuts should always be used as "Input Colorimetry," respectively, if one of these gamuts is present at the input of the processor, e.g. by directly connecting a camera capturing with one of these gamuts. However, using one of these proprietary gamuts in the HDR EVIE+ Constellation is allowed for HD and 4K/UHD footage only, not for SD or 720p resolutions. A summary of these and all other restrictions, as well as all possible combinations, can be found in the tables of the appendix. Further information about these proprietary gamuts and their properties should be taken from the documentation of the respective manufacturers.

4.6. Auto

By selecting "Auto" as "Input Colorimetry" and/or "Output Colorimetry," it is possible to use the auto feature for setting the input and/or output color space automatically. By activating "Auto" as "Input Colorimetry", the HDR processor automatically selects the color space of the signal being present at the input of the processor. However, the presence of this information as ancillary data in the video stream, i.e. in the vertical blanking region as VANC (vertical ancillary data) of an SDI signal, is necessary for using this feature.* If the information regarding the used color space is not contained in the data stream of the signal, this feature should not be used.

Note: *Markings in the VANC are read and inserted by the processor according to ITU-R BT.1120-9 for HD and SMPTE - ST2082-10:2018 for 4K/UHD. These standards allow the markings of BT.709 and BT.2020 only!*

Using this setting as "Input Colorimetry" has the advantage that, regardless of which signal is present at the input, it is always ensured that the correct conversion is carried out if the desired output color space has been selected as "Output Colorimetry." Depending on which gamut is present at the input and which target gamut is selected at the output, either a down-conversion*, a cross-conversion (e.g. Sony S-Gamut to Rec. 2020) or no conversion of the gamut (e.g. Rec. 2020 to Rec. 2020) will be performed.

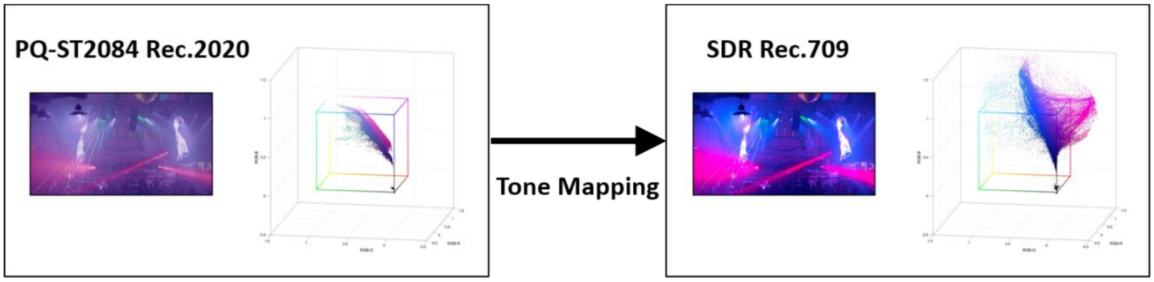
By selecting "Auto" as “Output Colorimetry,” the output color space is set according to the “Input Colorimetry,” assuming this output format corresponds to one of the standards supported by the HDR EVIE+ Constellation.** An overview of all permissible and impermissible combinations can be found in the tables of the appendix. Therefore, by selecting “Auto” as Output Colorimetry, the color space of the input signal is basically bypassed (unless it is one of the cine gamuts or one of the proprietary manufacturers’ gamuts**), which means that no color space conversion will be performed. Depending on which gamut is present and selected at the input, either a down-conversion* or no conversion of the gamut will be performed if “Auto” is selected as Output Colorimetry.

By using “Auto” as both “Input Colorimetry” and “Output Colorimetry” simultaneously, the system will also basically bypass the color gamut of the input signal unless it is one of the cine gamuts or one of the proprietary manufacturers’ gamuts.**

**Note: The information about color space transformations given in chapter 4.7. “Gamut Mapping” and in the respective subchapters of the affected color gamuts must be considered.*
***Note: As the proprietary color gamuts of the camera manufacturers, as well as the cine gamuts, are only available at the input of the processor, this feature is not available for these gamuts. If “Auto” is selected as Output Colorimetry and one of these gamuts is present at the input, the system will automatically perform a down-conversion to Rec. 709.*
Note: The Operation Mode "bypass HDR/SDR" prevents conversions between color spaces in connection with HDR characteristics from being performed. In this mode, color space conversions are only performed correctly in connection with SDR (Gamma BT.709) signals. Moreover, this Operation Mode prevents down-conversions of transfer characteristics from being performed (see chapter 2.1. “Operation Mode “bypass HDR/SDR”,”). When using Auto, attention should be paid to which signal is present at the input and which Operation Mode and settings are selected to ensure the correct operation will be performed.

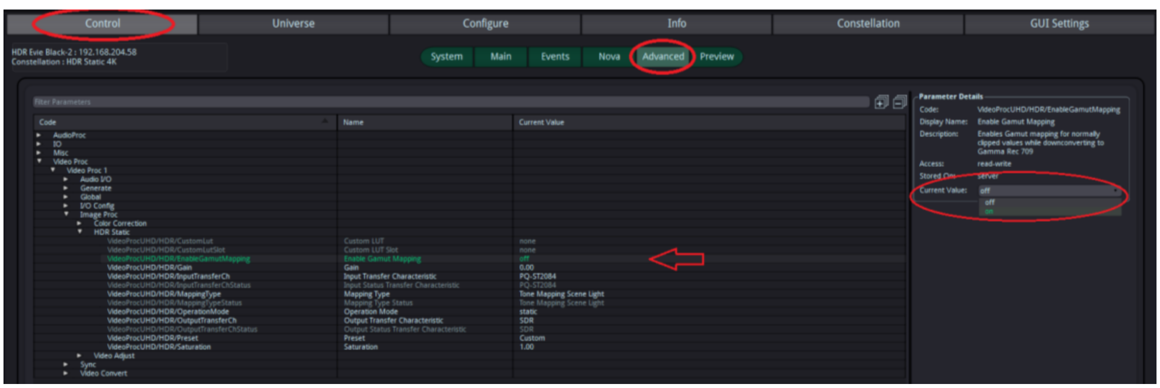
4.7. Gamut Mapping

With the UHDTV gamut Rec. 2020, the cine gamuts DCI-P3 and ACES as well as the proprietary color gamuts of the camera manufacturers (Sony S-Gamut, Panasonic V-Gamut, Arri Alexa, RED Wide Gamut, Canon Cinema Gamut and BMD Film), a total of nine wide color gamuts can be processed by the HDR processor. Since these wide gamuts span a significantly larger color gamut than the HDTV gamut Rec. 709 (see chapter 4. “Colorimetry / Gamut”), material being captured with one of these gamuts may contain color values which may not be covered by Rec. 709. Consequently, a tone mapping will result in color values lying outside Rec. 709 as target gamut. The following figure shows an example of color values in the R’G’B’ cube model before and after a conversion from PQ-ST2084 Rec. 2020 to SDR (Gamma) Rec. 709 using a tone mapping operation.



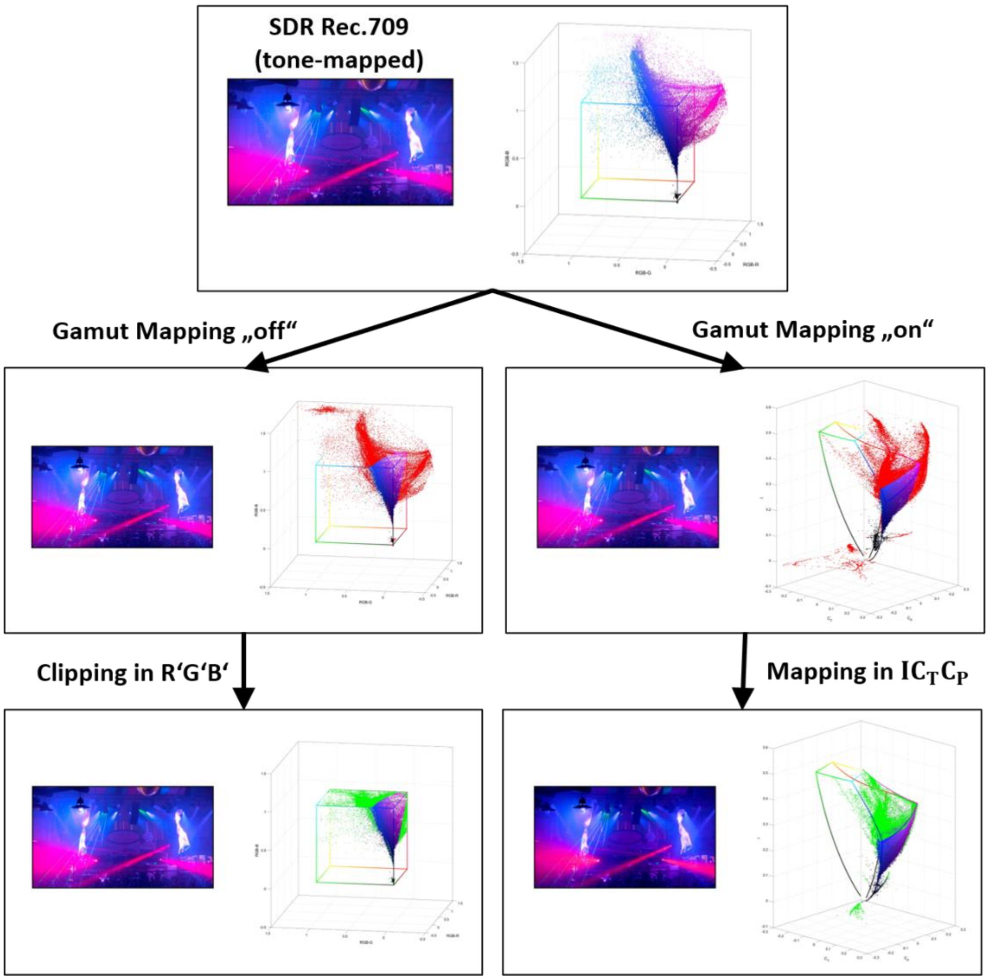
R'G'B' color values before and after conversion from PQ-ST2084 2020 to SDR 709

After the conversion is executed, some of the color values are clearly lying outside the Rec. 709 R’G’B’ cube. To be able to process and display the values outside of the target gamut Rec. 709, these values need to be transferred to the boundary or the inside of the target gamut and thus to the boundary or the inside of the R’G’B’ cube (see figure on the following page). The HDR processor offers two possibilities to perform such a transformation of color values lying outside the target gamut. This can be done either by a simple “clipping” or by a more elaborate and more appropriate mapping of the values by a “Gamut Mapping” algorithm, which technically performs a color volume mapping.



Where and how to enable the “Gamut Mapping” in the greenGUI

The “Gamut Mapping” option can be found on the "Advanced" tab in the "Code" column under "Video Proc>Video Proc x>Image Proc>HDR Static>Enable Gamut Mapping" (see figure above). The mapping can be enabled by setting the “Current Value” to “on”. If the “Current Value” is set to “off”, the “clipping” method is used instead. In this case, color values outside the Rec. 709 target gamut will be simply moved to the edge of the gamut. This can either cause colors to be displayed vividly and highly saturated, or it causes colors to be displayed incorrectly or not to be displayed at all. As a result, hue changes and artefacts such as constant color regions (color block artefacts) may occur (see image samples on the last page of this chapter). The clipping method is performed in the R’G’B’ color representation (see following figure), which is not very well suited for color space transformation due to the missing reference to the human visual system (HVS).



Clipping in R'G'B' vs. mapping in IC_TC_P

For a perceptually accurate reproduction of converted HDR images, the color space transformation should be performed by using the “Gamut Mapping”, which technically performs a color volume mapping. As shown in the figure above, the mapping is performed in the IC_TC_P color representation, which accurately represents the vision capabilities of the HVS. This is because IC_TC_P with its logarithmic scaling of the brightness axis allows the human perception of brightness (which in fact is logarithmic) to be considered. In addition, the decorrelation of the channels in IC_TC_P as color difference representation plays a decisive role for accurate color volume mapping. During mapping process, colors outside the target color space are allocated to colors in the target space in a perceptually accurate manner. This is done using a method called “PAHI” (= “Perception Accurate Hueshift Interpolating”) [1], in which necessary hueshifts are interpolated perceptually accurate. The PAHI method provides a solution for the mapping between color volumes with large size differences. Therefore, the “Gamut Mapping” option can preserve color differentiation in critical color areas. For more information about the entire mapping process, see [1].

[1] P. Kutschbach, “A Color-Volume Mapping System: For a perception-accurate reproduction of HDR Imagery in SDR production workflows”, SMPTE 2020 Game On

Clipping of the color values (left) vs. Mapping of the color values (right)

As can be seen in the image samples above, the “Gamut Mapping” allows more details to be preserved in critical image areas. Clipped areas are no longer clipped or less clipped than before and colors are displayed correctly according to the human color perception. But compared to clipping, the “Gamut Mapping” may produce a more desaturated result, especially in critical image areas. Therefore, clipping may provide a more saturated result, but mapping tends to be better suited for accurate color reproduction.

However, the “Gamut Mapping” operation is not roundtrip capable since there is no inverse operation for the “Gamut Mapping” existing. As a result, the image impression will change after “round-tripping” (e.g. from Rec. 2020 to Rec. 709 and back again to Rec. 2020), which may result in “round-tripped” material showing a difference in hue and saturation compared to the original version of the material.

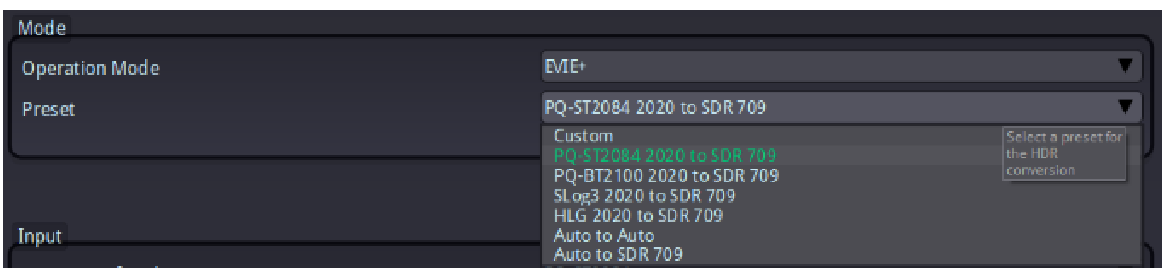
By combining Tone Mapping, which is able to perform a compression of large differences in the brightness range, and “Gamut Mapping”, which is able to perform a compression of large differences in the chromaticity range, the HDR processor is able to handle both, the compression of brightness and chromaticity. This combination of Tone Mapping and “Gamut Mapping” leads to the visual most pleasing results in most cases. However, in order to achieve the image impression that most closely matches the expectations, it is recommended to check from case to case which achieves the best result, clipping or “Gamut Mapping”.

5. Presets

The HDR EVIE+ Constellation provides a number of useful presets that will make it easier and faster using the constellation. All conversions between transfer curves and color spaces can be selected and performed with just a few mouse clicks. The presets include all down-conversions between common combinations of transfer characteristics and color gamuts, which result from the ITU production standards BT.709, BT.2020, and BT.2100.

As already described in chapter 4.3. "Rec. 2020", the combination of Rec. 2020 with an HDR transfer characteristic according to BT.2100, is a particularly common option since the Rec. 2020 color space is also an integral part of the HDR standard BT.2100. Therefore, PQ* and HLG, in combination with Rec. 2020 color space, are considered in the presets. The combination of the SDR characteristic (Gamma BT.709) and Rec. 709 color gamut, which is also considered to be the usual combination, is included in the presets as well. In addition to these combinations, a down-conversion preset, including SLog3 as a widespread camera characteristic, is also included. Thus, settings that are necessary for certain workflows can be made in no time.

**Note: Both PQ-ST2084 and PQ-BT2100 are considered in the presets in combination with Rec. 2020. When using a preset containing one of these transfer characteristics, the effects and capabilities resulting from these transfer characteristics as described in chapter 3.2.1. "PQ" must be considered.*



Selecting a Preset

All other conversion combinations that are not defined by these standards but still allowed in the HDR EVIE+ Constellation can be set by selecting "Custom"**, which can be found in the "Preset" drop-down list, too. Settings including the proprietary camera

***Note: The setting "Custom" does not necessarily have to be selected in the drop-down list before custom settings can be set. As soon as a setting is made which does not match any of the defined presets, the Custom setting will automatically be activated.*
Note: The Operation Mode "bypass HDR/SDR" prevents down-conversions between HDR transfer characteristics and SDR (Gamma BT.709) from being performed. Conversion functionality of color spaces and signal ranges in connection with HDR characteristics will not be performed either. In this mode, color space and range conversions are only performed correctly in connection with SDR (Gamma BT.709) signals (see chapter 2.1. "Operation Mode "bypass HDR/SDR""). When using an Auto preset, attention should be paid to which signal is present at the input and which Operation Mode and settings are selected to ensure the correct operation will be performed.

characteristics and/or gamuts of the camera manufacturers as well as the cine gamuts DCI-P3 and ACES need to be selected manually by using the Custom setting as well.

The following table summarizes the available presets:

Presets		to
		SDR 709
from	PQ* 2020	down-conversion
	HLG 2020	down-conversion
	SLog3 2020	down-conversion

Overview of the presets available for down-conversions

These down-conversion presets can be selected whenever one of the broadcast HDR signals according to the ITU (PQ*, HLG) or an SLog3 signal in combination with the Rec. 2020 color space is present at the input and needs to be down-converted to SDR (Gamma BT.709) in combination with Rec. 709 color space. Of course, the choice of the correct preset depends on the transfer characteristic being present at the input. The representatives that can occur in this case are therefore: PQ*, HLG or SLog3, and must each occur in combination with the Rec. 2020 color space.

**Note: Both PQ-ST2084 and PQ-BT2100 are considered in the presets in combination with Rec. 2020. When using a preset containing one of these transfer characteristics, the effects and capabilities resulting from these transfer characteristics as described in chapter 3.2.1. "PQ" must be considered.*

This conversion transfers the present HDR characteristic into the gamma characteristic and performs a sectional (and/or global) dynamic Tone Mapping operation in real-time, which prevents (high-)lights from being clipped and reveals shadow details. As a result, image quality and viewing experience on common SDR devices already benefit greatly from converting an HDR signal to the SDR format (see chapter 2.2.2. "Mapping" and 3.1.1. "Use cases of 'SDR'"). "). The transformation of the Rec. 2020 color gamut into the Rec. 709 gamut can be done either by a simple "clipping" of the values or by a more elaborate and more appropriate "Gamut Mapping" algorithm (see chapter 4.7. "Gamut Mapping").

By selecting one of the Auto presets, the HDR EVIE+ Constellation ensures that the desired output signal is always generated, regardless of what signal is present at the input.

***Note:** The Operation Mode "EVIE+" should be selected to properly execute these presets. If the Operation Mode "bypass HDR/SDR" is selected, no conversion of the transfer characteristic and consequently no mapping would be performed. Conversion functionality of Colorimetry (color spaces) and Ranges in connection with HDR characteristics will not be performed either. In "bypass HDR/SDR", color space and range conversions are only performed correctly in connection with SDR (Gamma BT.709) signals (see chapter 2.1. "Operation Mode "bypass HDR/SDR""). Therefore, attention should be paid to which signal is present at the input and which Operation Mode and settings are selected to ensure the correct operation will be performed.*

By using the “Auto to SDR 709” preset, the HDR EVIE+ Constellation ensures that an SDR (Gamma BT.709) signal is generated, regardless of what signal is present at the input. If the “Auto to Auto” preset is selected, the system will basically bypass the input signal being present at the input of the processor, unless one of the proprietary manufacturer’s characteristics or gamuts or one of the cine gamuts are present at the input of the processor. If such a characteristic and/or gamut is present at the input, the system will automatically perform a down-conversion to SDR (Gamma BT.709) and/or Rec. 709 instead (see chapter 3.3. “Auto” and 4.6. “Auto”).* If one of the HDR characteristics PQ, HLG or SLog3 and/or the Rec. 709 or Rec. 2020 color gamut is present at the input, the system will basically bypass. Therefore, no Tone Mapping and thus no HDR-to-SDR down-conversion will be performed (see chapter 2.2.2. “Mapping” and 3.3. “Auto”). In addition, this feature still allows range conversions in combination with these HDR characteristics to be performed if the Operation Mode “EVIE+” is active (see chapter 2. “Operation Modes”).

**Note:* *The information about color space transformations given in chapter 4.7. “Gamut Mapping” and in the respective subchapters of the affected color gamuts must be considered.*

However, to use these presets properly, the information about which signal is in fact present at the input is necessary as ancillary data in the video stream, i.e. in the vertical blanking region as VANC (vertical ancillary data) of an SDI signal.* If this information is not included in the data stream of the input signal used, the auto-preset should not be selected.

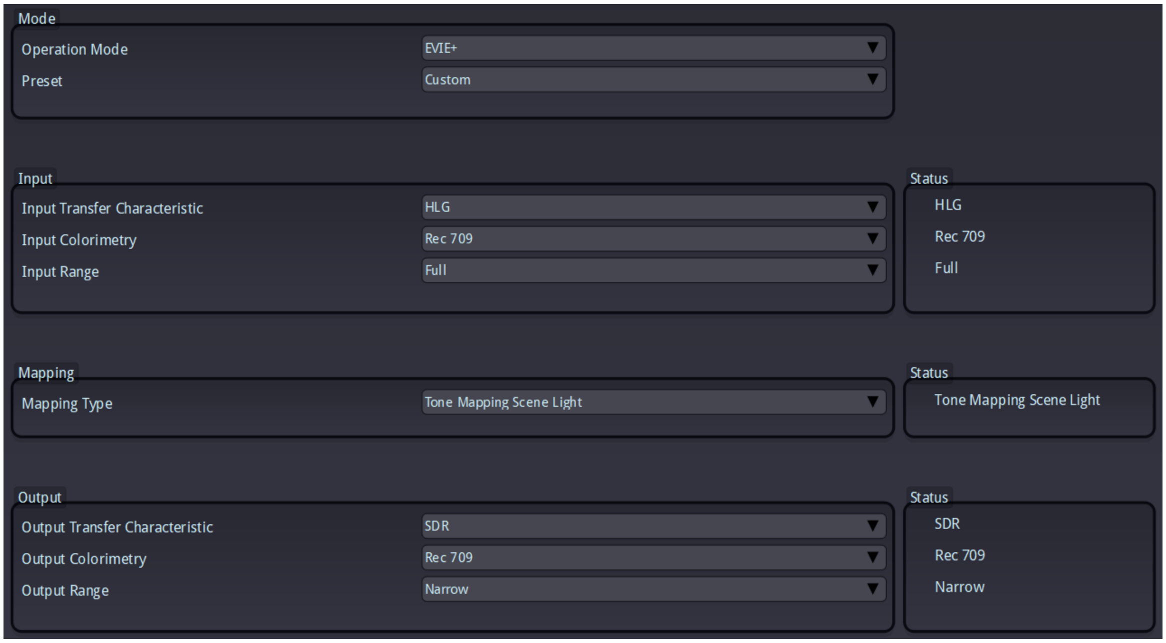
***Note:* *Markings in the VANC are read and inserted by the processor according to ITU-R BT.1120-9 for HD and SMPTE - ST2082-10:2018 for 4K/UHD. These standards allow the markings of BT.709 and BT.2020 in terms of colorimetry and SDR BT.709, HLG, PQ and “unspecified” in terms of transfer characteristics. "Unspecified" is regarded as SLog3 in the HDR processor.*

The “Custom” setting, which can be found in the "Preset" drop-down list as well, allows settings that are beyond the settings of the existing presets. As a result, less common combinations and conversions can also be set, which are not directly defined in the production standards BT.709, BT.2020 and BT.2100, but can theoretically occur.

The user has the option to enforce these less common settings by using the Custom setting, as long as they are considered admissible in the HDR processor.

An overview of all inadmissible combinations and settings can be found in the "limitations" table of the appendix.

By using the Custom setting, the HDR EVIE+ Constellation allows, for example, the combination of an HDR signal (PQ-ST2084, PQ-BT2100, HLG. SLog3, etc.) with Rec. 709 color space, which is illustrated in the figure on the following page.



Selecting Custom as Preset

The combination of an SDR signal (Gamma BT.709) with Rec. 2020 color space is also available by using the Custom setting.

Settings including the proprietary camera characteristics and/or gamuts of the camera manufacturers as well as the cine gamuts DCI-P3 and ACES need to be selected manually by using the Custom* setting as well.

Note: *The setting "Custom" does not necessarily have to be selected in the drop-down list before custom settings can be set. As soon as a setting is made which does not match any of the defined presets, the Custom setting will automatically be activated.*
Note: *The Operation Mode "EVIE+" should be selected in order to perform a down-conversion of the transfer characteristics. If the Operation Mode "bypass HDR/SDR" is selected, no conversion of the transfer characteristic and consequently no mapping would be performed. Conversion functionality of Colorimetry (color spaces) and Ranges in connection with HDR characteristics will not be performed either. In "bypass HDR/SDR", color space and range conversions are only performed correctly in connection with SDR (Gamma BT.709) signals (see chapter 2.1. "Operation Mode "bypass HDR/SDR""). Therefore, attention should be paid to which signal is present at the input and which Operation Mode and settings are selected to ensure the correct operation will be performed.*

6. Signal Range

As already mentioned in chapter 3.1. "SDR (Gamma BT.709)" and 3.2. "HDR", the size of the available signal range depends on the quantization level of a characteristic curve. While an 8-bit range with $2^8 = 256$ code values is usually available for SDR reproduction, HDR with a quantization level of 10-bit even allows $2^{10} = 1024$ code values.* This corresponds to four times the number of available code values.

**Note: This statement refers in particular to the playback of SDR and HDR material. In the context of production, SDR is usually processed in 10-bit, too (in accordance with BT.601 and BT.709).*

However, most standards do not provide the complete range for encoding video signals. As already described in chapter 3. "Transfer Characteristics", the Transfer Characteristic determines how the brightness information is distributed over the available code value range. The "Range" parameter, which also exists in the HDR EVIE+ Constellation, decides how many or which values of the code value range are actually available or used for encoding the wanted signal, i.e. the video data.

In the past, every broadcast standardization provided for a limited code-value range. During the introduction of digital television, the lowest and highest bits (code values) of the digital video signals have been reserved for encoding synchronization information. However, the code values required for this additional information are not available for encoding the actual video signal. Therefore, only a limited range of values remains for the actual video signal, which is why this type of signal range is called "narrow range"**. Narrow range signals are still in widespread use today and are considered the standard or default for encoding television signals.

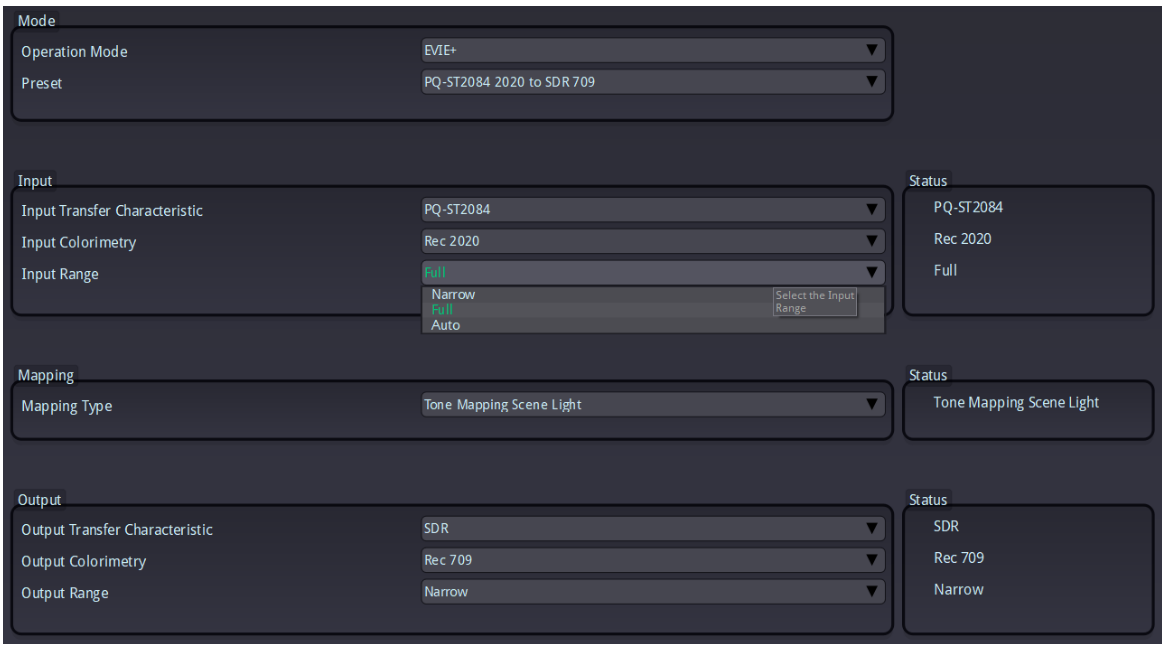
***Note: Over-shoots that extend above the nominal peak luminance into the so called "super-white" region and under-shoots that extend below black into the so called "sub-black" regions of narrow range signals using 109% of nominal full scale are not yet considered by the HDR EVIE+ Constellation and are therefore simply clipped of.*

Furthermore, the HDR standard ITU-R BT.2100 has newly introduced an additional range representation, called "full range", providing a further definition of the signal range with the intention of being used only when all parties in broadcast agree. For the first time, this full range signal allows nearly*** the entire signal range to be used for encoding a video signal. As a result, more intermediate values for a finer gradation of the brightness are available for encoding actual image information.

****Note: 10-bit: 4-1019 (inclusive)*

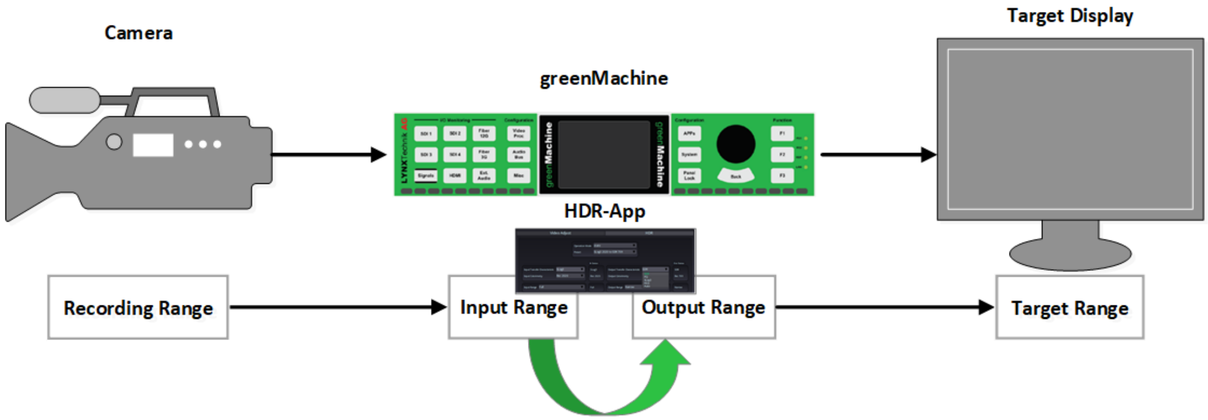
Consequently, the image impression differs between narrow and full range signals, which is why narrow range encoded image material should by no means be combined with full range encoded image material. Therefore, conversions between these ranges are of great importance. Especially by increasing amount of material used in both signal ranges, the range conversion becomes more and more important.

In addition to the conversions between transfer characteristics and color spaces, the HDR EVIE+ Constellation enables conversions between these signal ranges, including narrow-to-full range conversion, which corresponds to an up-conversion and full-to-narrow range conversion, which corresponds to a down-conversion. Whereas a conversion from narrow to full range results in the narrow code value range being "pulled apart" over the entire value range, the inverse conversion from full to narrow range basically results in a kind of compression of the full code value range into the limited range.



Selecting Input Range

The use of the range conversion should follow a simple principle: As the selection of the “Input Transfer Characteristic” or “Input Colorimetry”, the "Input Range" should also be selected according to the range of the input signal, while the "Output Range" should be selected according to the desired target range. If we stick to the camera example of chapter 3. "Transfer Characteristics" and 4. "Colorimetry / Gamut", operating an HDR camera directly in front of the greenMachine, the "Input Range" should be selected according to the used capture range of the camera (see figure below). Assuming the camera captures in full range, "Input Range" should also be selected as "Full". If a narrow range signal is required due to the workflow, a conversion from full to narrow range must be performed. So, the “Output Range” must be set to “Narrow” to do so (see figure above).



Operation example for ranges using the HDR processor

As described in chapter 2.1. "Operation Mode “bypass HDR/SDR””, signal range conversions of SDR (Gamma BT.709) signals are available in both Operation Modes "EVIE+" and "bypass HDR/SDR" since the conversion functionality for ranges is also available independently of the HDR EVIE+ Constellation in the greenMachine and thus remains untouched upon activation of the Operation Mode “bypass HDR/SDR”. If signal range conversions are to be performed in connection with HDR characteristics, the Operation Mode “EVIE+” must be selected (see chapter 2. “Operation Modes”). The available signal ranges are described in more detail below.

6.1. Narrow Range

In the past, every broadcast standardization provided for a limited code-value range. During the introduction of digital television, the lowest and highest bits (code values) of the digital video signals have been reserved for encoding synchronization information. However, the code values required for this additional information are not available for encoding the actual video signal. Therefore, only a limited range of values remains for the actual video signal, which is why this type of signal range is called "narrow range". Narrow range signals are still in widespread use today and are considered the standard or default for encoding television signals. The specification of the signal range “Narrow”, which is also unofficially known under the terms "legal range" or “limited range”, is basically included in all previously adopted broadcast standards, including ITU-R BT.601, BT.709, BT.2020 as well as BT.2100. However, under the term "narrow range" this specification appears for the first time in the HDR standard BT.2100, since this term simply did not exist before the adoption of the HDR standard.

The SDR standards BT.601 and BT.709 each include 8-bit quantization, providing a total of 2^8 = 256 code values or 10-bit quantization, providing a total of 2^{10} = 1024 code values for SD-SDR and HD-SDR signals. For encoding the actual image information, the narrow range specification of these two standards reserves the following code values:

- 16-235 → for 8-bit RGB signals
- 16-240 → for 8-bit color difference signals (Y CB CR)
- 64-940 → for 10-bit RGB signals
- 64-960 → for 10-bit color difference signals (Y CB CR)

The code values below and above are actually reserved for encoding timing reference signals or additional information:

- 0-15 and 236-255 → for 8-bit RGB signals
- 0-15 and 241-255 → for 8-bit color difference signals (Y CB CR)
- 0-63 and 941-1023 → for 10-bit RGB signals
- 0-63 and 961-1023 → for 10-bit color difference signals (Y CB CR)

The BT.2020 UHDTV standard, which does not yet provide a specification for HDR but is part of the HDR standard BT.2100, specifies a quantization of 10-bit, giving a total of 2^{10} = 1024 code values for encoding data. But even this standard only provides the narrow signal range as the default range, which limits the video coding range to the code values:

- 64-940 → for 10-bit RGB signals
- 64-960 → for 10-bit color difference signals (Y CB CR)

The values below and above are actually available for encoding additional data as well.

However, it should be noted that over-shoots that extend above the nominal peak luminance into the so called "super-white" region and under-shoots that extend below black into the so called "sub-black" regions of narrow range signals using 109% of nominal full scale are not yet considered by the HDR EVIE+ Constellation and are therefore simply clipped of.

The HDR standard BT.2100 also contains the narrow range specification from BT.2020, but newly introduced an additional "full range" representation providing a further definition of the signal range with the intention of being used only when all parties in broadcast agree. For the first time, this full range definition allows the entire signal range to be used for encoding the actual video signal, except the code values 0 to 3 and 1020 to 1023.

As a result, more intermediate values for a finer gradation of the brightness are available for encoding actual image information. Consequently, the image impression differs between narrow and full range signals, which is why narrow range encoded image material should by no means be combined with full range encoded image material. Therefore, conversions between these ranges are of great importance.

The HDR EVIE+ Constellation enables conversions between these signal ranges, including narrow-to-full range* conversion, which corresponds to an "up-conversion" and full-to-narrow range conversion, which corresponds to a "down-conversion". Whereas a conversion from narrow to full range results in the narrow code value range being "pulled apart" over the entire value range, the inverse conversion from full to narrow range basically results in a kind of compression of the full code value range into the limited range.

**Note*: Over-shoots that extend above the nominal peak luminance into the so called "super-white" region and under-shoots that extend below black into the so called "sub-black" regions of narrow range signals using 109% of nominal full scale are not yet considered by the HDR EVIE+ Constellation and are therefore simply clipped of.*

The narrow range specification is available in the HDR processor for all formats and standards. Basically the "Input Range" should always be selected as "Narrow" whenever a narrow range signal is present at the input, while the "Output Range" should be selected as "Narrow" whenever a narrow range signal is required as target range.

According to BT.2408, the use of narrow range signals is strongly preferred for HLG to maintain signal fidelity and to reduce the risk of confusing full range with narrow range signals (and vice versa) in production.

6.2. Full Range

The HDR standard ITU-R BT.2100 providing a total of 2^{10} = 1024 code values for 10-bit quantization has newly introduced an additional range representation, called "full range", providing a further definition of the signal range with the intention of being used only when all parties in broadcast agree. For the first time, this full range signal allows nearly the entire signal range (code values) to be used for encoding the actual image information of the video signal, except the code values:

- 0-3 and 1020-1023 → in terms of 10-bit signals

As a result, more intermediate values for a finer gradation of the brightness are available for encoding actual image information. Consequently, the image impression differs between full and narrow range signals, which is why full range encoded image material should by no means be combined with narrow range encoded image material. Therefore, conversions between these ranges are of great importance. Especially by increasing amount of material used in both signal ranges, the range conversion becomes more and more important.

The HDR EVIE+ Constellation enables conversion functionality between full and narrow range signals, including full-to-narrow range conversion, which corresponds to a "down-conversion" and narrow-to-full range* conversion, which corresponds to an "up-conversion". Whereas a conversion from narrow to full range results in the narrow code value range being "pulled apart" over the entire value range, the inverse conversion from full to narrow range basically results in a kind of compression of the full code value range into the limited range.

Note: *Over-shoots that extend above the nominal peak luminance into the so called "super-white" region and under-shoots that extend below black into the so called "sub-black" regions of narrow range signals using 109% of nominal full scale are not yet considered by the HDR EVIE+ Constellation and are therefore simply clipped of.*

Since full range has only been specified in BT.2100, this range is only defined for HDR signals in the Rec. 2020 color space. In the HDR EVIE+ Constellation, using full range in combination with an SDR characteristic (Gamma BT.709) and the color space Rec. 709 is nevertheless allowed. The use of full range in combination with the proprietary characteristics and gamuts of the camera manufacturers as well as the cine gamuts as common combinations is also available in the HDR processor. Therefore, full range can be used in combination with all included transfer characteristics and color spaces.

Only the resolution of the used signal must comply with the BT.2100 standard, i.e. an HD or 4K/UHD resolution, in order to make use of the full range in the HDR processor. Signals with SD or 720p resolution in combination with full range are therefore considered inadmissible. An overview of all applicable restrictions and conditions can be found in the tables of the appendix.

Basically the "Input Range" should always be selected as "Full" whenever a full range signal is present at the input, while the "Output Range" should be selected as "Full" whenever a full range signal is required as target range.

According to ITU Report BT.2408, the use of full range is useful for PQ signals providing an incremental advantage against the visibility of banding/contouring and in terms of processing. Since the range of PQ signals is as large as it is, it is rare for content to contain pixel values close to the extreme values of the range. Therefore, over- and under-shoots are unlikely to be clipped.

6.3. Auto Range

By selecting "Auto" as "Input Range" and/or "Output Range" it is possible to use the auto feature for setting the input and/or output range automatically. By activating "Auto" as "Input Range", the HDR processor automatically selects the range of the signal being present at the input.

However, the presence of this information as ancillary data in the video stream, i.e. in the vertical blanking region as VANC (vertical ancillary data) of an SDI signal, is necessary for using this feature.* If the information regarding the used range is not contained in the data stream of the signal, this feature should not be used.

**Note: Markings in the VANC are read and inserted by the processor according to ITU-R BT.1120-9 for HD and SMPTE - ST2082-10:2018 for 4K/UHD. These standards allow the markings of both narrow and full range signals.*

Using "Auto" as "Input Range" has the advantage that, regardless of which signal is present at the input, it is always ensured that the correct conversion is carried out if the desired "Output Range" has been selected.

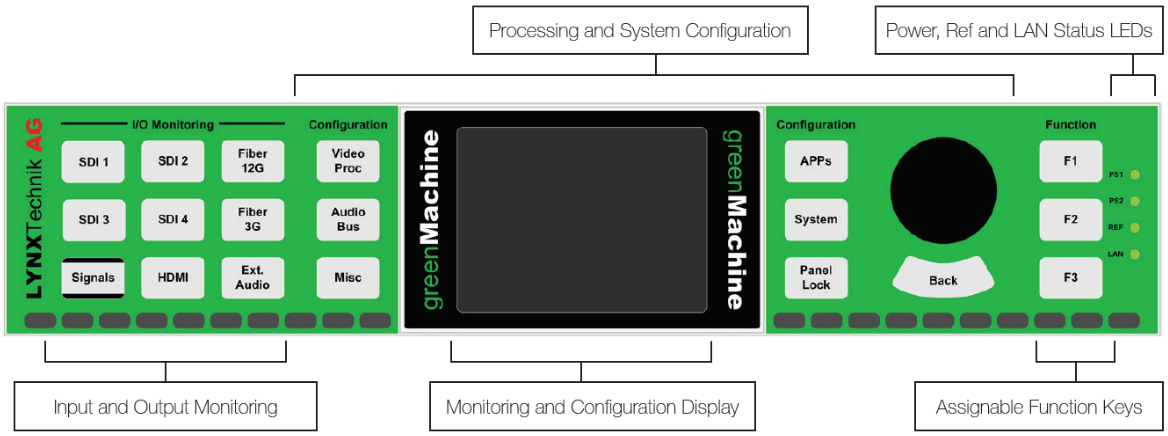
By selecting "Auto" as "Output Range", the output range is set according to the "Input Range", assuming this output format corresponds to one of the standards supported by the HDR EVIE+ Constellation. An overview of all permissible and impermissible combinations can be found in the tables of the appendix.

By using "Auto" as both "Input Range" and "Output Range" simultaneously, the system will basically bypass the signal range of the input signal.

Note: The Operation Mode "bypass HDR/SDR" prevents conversions between signal ranges in connection with HDR characteristics from being performed. In this mode, range conversions are only performed correctly in connection with SDR (Gamma BT.709) signals. Moreover, this Operation Mode prevents HDR-to-SDR down-conversions from being performed. When using Auto, attention should be paid to which signal is present at the input and which Operation Mode and settings are selected to ensure the correct operation will be performed.

7. Local Control

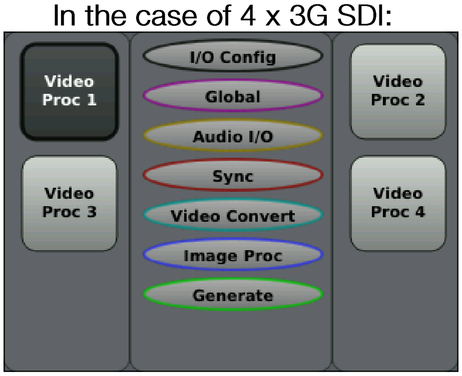
The HDR EVIE+ Constellation can also be controlled from the local control panel.



For more information on how to use the local control panel please read the greenMachine titan manual, which is available on the LYNX website: www.lynx-technik.com

To get access to the control parameters of the HDR EVIE+ Constellation please press the button “Video Proc” next top left of the display. The following menu will show up.

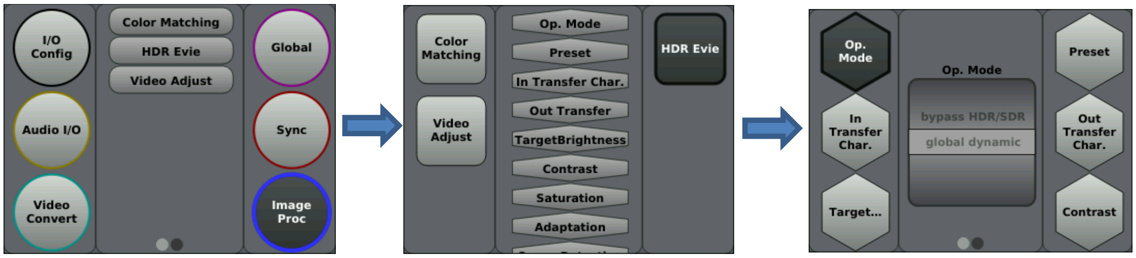
In the case of 4 x 3G SDI:



In the case of 4K/UHD:

Using the rotary push encoder, select the processing channel you would like to adjust. Rotate the push encoder and select “Image Proc”. In the next menu, select HDR. The followings are the menu displayed.

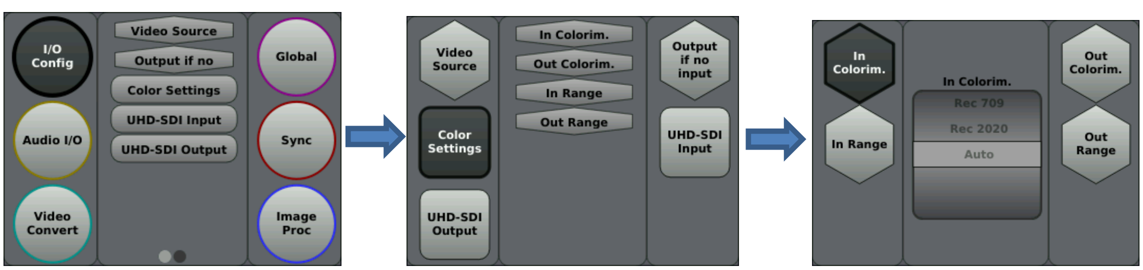
(Select Video Proc > image Proc > HDR EVIE+)



In this menu you can set/select the specific parameters of the HDR EVIE+ Constellation:

- Operation Mode
- Preset
- Input Transfer Characteristic
- Output Transfer Characteristic
- Brightness
- Contrast
- Saturation
- Adaptation Speed
- Scene Detection Percentage
- Clipping Intensity
- Dynamic Ratio
- Homogenization
- Black Lift

For general color settings, select “I/O config” in the main menu of the selected channel and then select color settings.



In this menu you can set/select the following parameters:

- Input Color Space (In Colorim.)
- Output Color Space (Out Colorim.)
- Input Range
- Output Range

8. Appendix

Format Limitations designated as “invalid” and shown in red:

Format Limitations		Formats			
		SD	720p	HD	4K/UHD
Transfer Characteristic	SDR	valid	valid	valid	valid
	PQ	invalid	invalid	valid	valid
	HLG	invalid	invalid	valid	valid
	SLog3	invalid	invalid	valid	valid
	Manufacturers’ characteristics	invalid	invalid	valid	valid
Colorimetry	Rec. 601	valid	invalid	invalid	invalid
	Rec. 709	invalid	valid	valid	valid
	Rec. 2020	invalid	invalid	valid	valid
	Cine Gamuts (DCI-P3, ACES)	invalid	invalid		
	Manufacturers’ Gamuts	invalid	invalid	valid	valid
Range	Narrow	valid	valid	valid	valid
	Full	invalid	invalid	valid	valid

Colorimetry Limitations designated as “invalid” and shown in red:

Colorimetry Limitations		Colorimetry				
		Rec. 601	Rec. 709	Rec. 2020	Cine Gamuts	Manufacturers’ Gamuts
Transfer Characteristic	SDR	valid	valid	valid	valid	valid
	PQ	invalid	valid	valid	valid	valid
	HLG	invalid	valid	valid	valid	valid
	SLog3	invalid	valid	valid	valid	valid
	Manufacturers’ characteristics	invalid	valid	valid	valid	valid
Range	Narrow	valid	valid	valid	valid	valid
	Full	invalid	valid	valid	valid	valid

Range Limitations designated as “invalid” and shown in red:

Range Limitations		Range	
		Narrow	Full
Transfer Characteristic	SDR	valid	valid
	PQ	valid	valid
	HLG	valid	valid
	SLog3	valid	valid
	Manufacturers’ characteristics	valid	valid
Colorimetry	Rec. 601	valid	invalid
	Rec. 709	valid	valid
	Rec. 2020	valid	valid
	Cine Gamuts (DCI-P3, ACES)	valid	valid
	Manufacturers’ Gamuts	valid	valid

Mapping Type Limitations designated as "invalid" shown in red

Tone Mapping Scene Light		to
		SDR
from	SDR	none
	PQ-ST2084	valid
	PQ-BT2100	valid
	HLG	valid
	SLog3	valid
	Manufacturers' characteristics	valid

Tone Mapping Display Light		to
		SDR
from	SDR	none
	PQ-ST2084	invalid
	PQ-BT2100	valid
	HLG	valid
	SLog3	invalid
	Manufacturers' characteristics	invalid

Technical Support

If you have any questions or require support, please contact your local distributor for further assistance.

Technical support is also available from our website:

http://support.lynx-technik.com/

Please do not return products to LYNX without an RMA. Please contact your authorized dealer or reseller for more details.

More detailed product information and product updates may be available on our website:

www.lynx-technik.com

Contact Information

Please contact your local distributor; this is your local and fastest method for obtaining support and sales information.

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