



madVR Envy

3D LUT Calibration for ColourSpace

Revision 0.92

Introduction

Welcome to the madVR Envy 3D LUT Calibration Guide for ColourSpace. This guide provides an overview on how LightIllusion's ColourSpace can be used to calibrate the madVR Envy and some general tips and tricks.

Note that ColourSpace is a complex product that require expert knowledge of both ColourSpace and video calibration techniques and procedures to achieve desirable results. This guide is not intended to teach ColourSpace nor video calibration, and there is no substitute for experience and deep learning on these concepts elsewhere.

Support policy: madVR Labs support for video calibration is limited solely to any matters with Envy communicating with the calibration software and LUT management within the Envy. Beyond that, madVR Labs cannot and does not provide any support for how-to's or achieving your desired results. For such matters, please contact the video calibration software manufacturer or consult a professional calibrator.

Prerequisites

Proper calibration with the Envy and ColourSpace **requires Envy firmware 1.5.5.27 or later, and ColourSpace v1.0.0.1337 or later**. Please be sure you are using the latest versions to ensure proper compatibility and the best results.

LUT Management

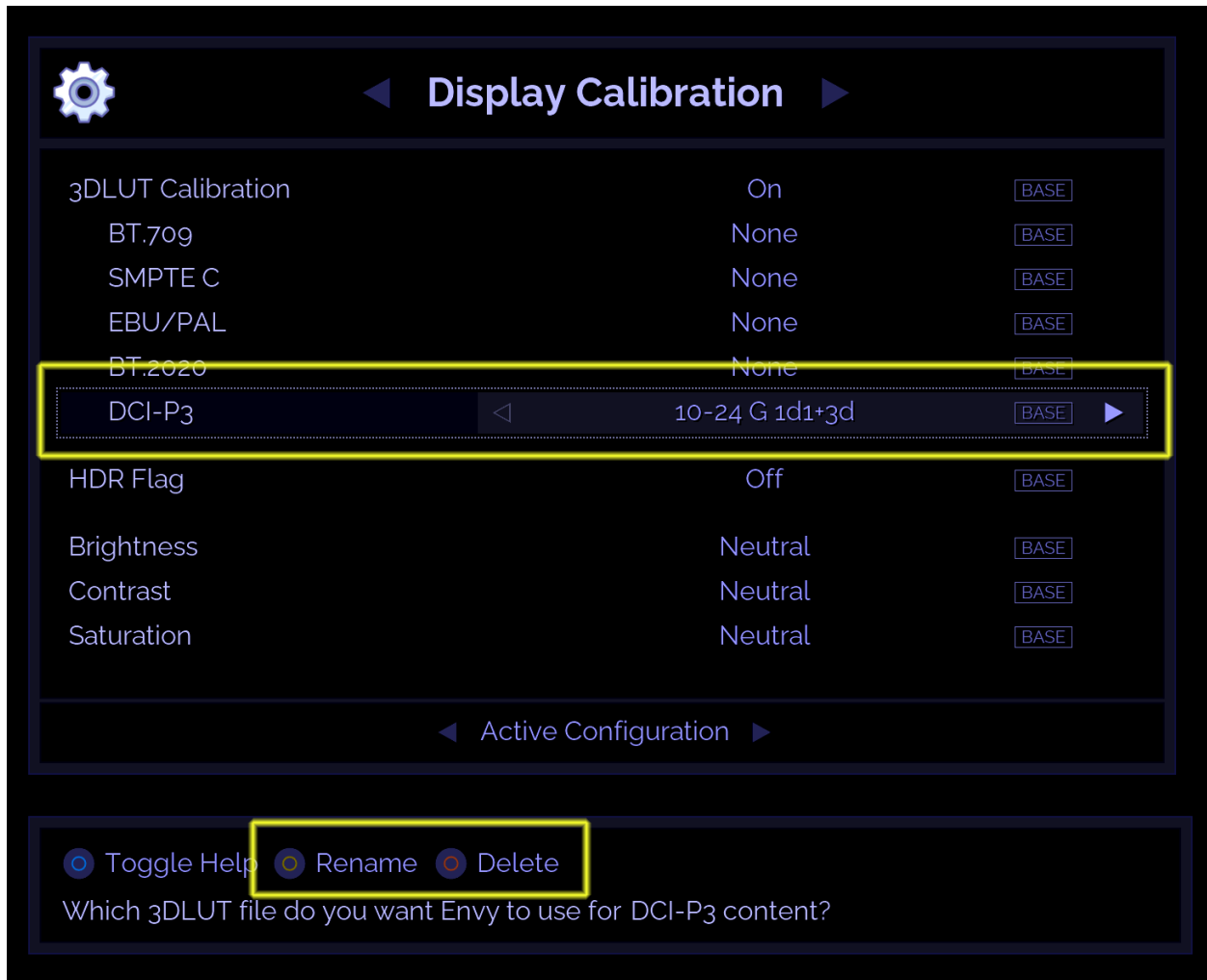
Before getting started, it is important to understand a little about LUT management. The Envy LUT Management enables you to store an unlimited number of 3D LUTs in the Envy, to be used however you see fit. These LUTs can be selected manually or stored as part of a Profile and automatically applied when the Profile is activated (either automatically or manually).

You can upload an unlimited number of LUTs per color space. For example, you may want to have three different DCI P3 LUTs and two different BT709 LUTs. LUTs can be for use with different displays (such as if you sometimes connect Envys to different displays), or for different viewing conditions, such as having a BT2020 LUT (or DCI P3 LUT) for use with a P3 filter in place, and another for use without the P3 filter (to maximize brightness, for example), or even different LUTS for different viewing conditions, such as daytime vs nighttime.

There are two ways to manage LUTs in the Envy. The first is by using the Envy "Display Configuration" menu. To do so, simply highlight the color space slot in the Envy menu that you

wish to work with, such as DCI P3. Then scroll through the available DCI P3 LUTs (if you have uploaded more than one) and select the one you wish to activate.

To rename the LUT, press the Yellow button on the Envy remote, and type in the new name (you will need to connect a keyboard to the Envy via USB). To delete the LUT, press the Red button. Note that you can only delete LUTs from this main menu, and not when the LUTs are expanded in a submenu. The context sensitive help in the Envy always will give you these “hints”. See the screenshot below.



Alternatively, you can also manage your LUTs by using the Envy IP Control Management tool, (<http://madVR.com/EnvypControl.zip>). This tool provides options to upload, download, rename and delete LUTs. Using the Envy menus to manage the LUTs is usually best for quick changes,

such as selecting the desired LUTs, or deleting older LUTs. However, using the IP Control Management tool is usually preferred if needing to rename LUTs, since you will not need to then connect a keyboard to the Envy. Using the utility is also the only way to download or upload LUTs. Usage of this tool is self-explanatory. Note that while downloading or uploading a LUT to/from the Envy, this can take several minutes depending on your local network speed, with no indication of progress from the tool. When the operation complete, the tool will show “OK” in the command window.

Tip: You can use the Envy’s Profile system to assign different LUTs to different Displays or Profiles. For more information about using Profiles with the Envy, consult the Envy Introduction to Profiles Guide.

Let us Get Started - ColourSpace Calibration Workflow for Envy

General

- Turn on all equipment and plug in all meters. Allow at least 30 minutes of warm up time on all devices before starting calibration.
- Make sure all lights are off in the room.

Pre-Calibration Video Chain Setup

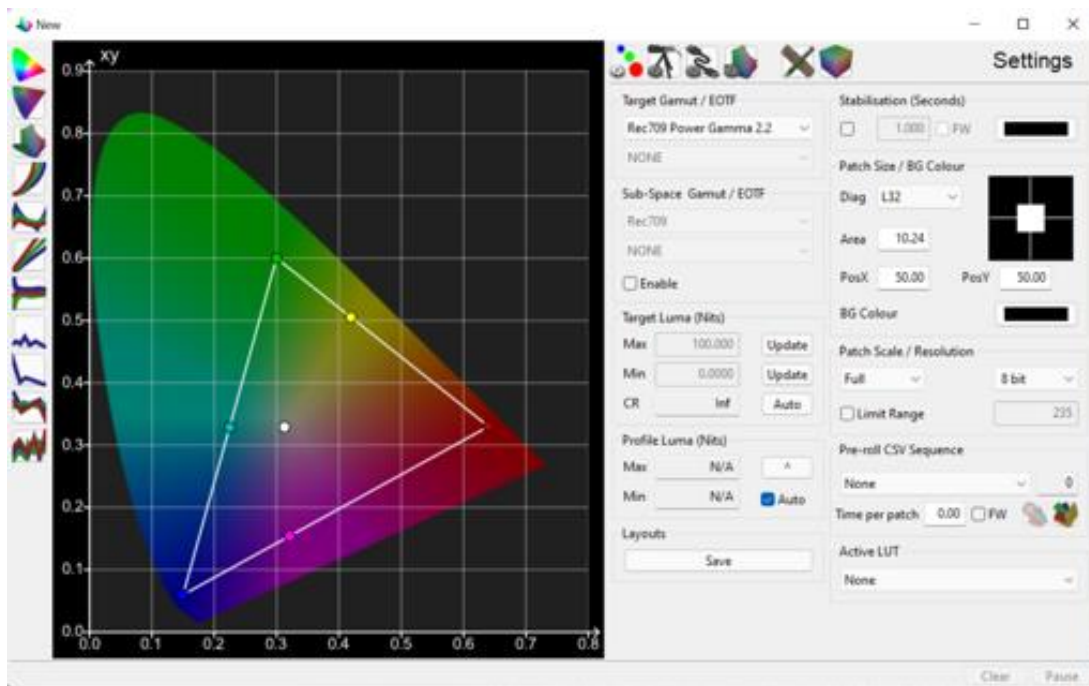
- Play the type of content you wish to calibrate for. For example, to calibrate for 4K HDR, play a 4K 24 HDR movie that outputs in the BT2020 color space. Or to calibrate for 1080p, play a 1080p24 movie that outputs BT709. Pause playback and make sure there is no screen saver or enabled sleep function, so that the movie will not end and cause an HDMI handshake. Otherwise, your calibration session could be interrupted.
- Confirm that the bit depth (e.g., 8-bit, 10-bit, 12-bit) and color space (e.g., RGB, YUV) are configured as you plan to use for your normal viewing. For instance, if you plan to run your display at RGB 8 bit, or YUV 10 bit, make sure the Envy Display Configuration menu is set to output that.
- Disable any video processing features in the projector, if possible. For example, turn off any dynamic iris or dynamic laser adjustments, Clear Motion Drive, and so forth. Set any manual iris positions as you intend to use for your viewing.
- Set the proper white point, gamma, and ColourSpace for calibration. Ideally, turn off all color management (e.g., profile off) or to a colorspace as wide as possible in the projector. We recommend setting the display to gamma of 2.2. This does not mean that you will have a 2.2 gamma post-calibration, as tone mapped gamma is dynamic. You can set the display to a gamma of 2.4, however if you follow the calibration properly you will

still wind up with a 2.2 gamma, by design. However, in that case, if you turn off the LUT in the Envy, you will conveniently have a 2.4 gamma (if the displays 2.4 setting really does yield 2.4).

Initial ColourSpace Setup

Settings

- Set the Target Gamut to whatever you are targeting. For HDR calibration, it is recommended the user target the widest color gamut the display can cover with its native capabilities. This guide uses a target of DCI P3 with gamma of 2.2 for the HDR calibration, **but the user should calibrate to a target best suited to the display's native capabilities.**
- Under "Patchscale / Resolution" set the Patch Scale to "Full", select "8 bit" and make sure the "Limit Range" checkbox is unchecked.



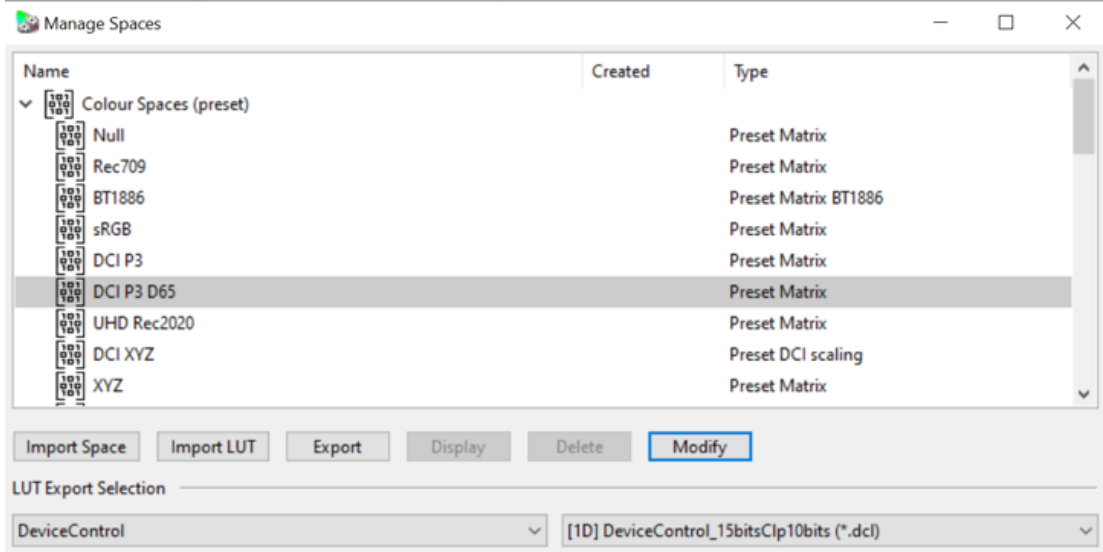
- **NOTE:** These settings are completely unrelated to the Video (16-235) or PC Levels (0-255) used for the Envy output and should not be confused with that. To be clear, **the Envy requires the full range (0-255) Patchset regardless of Video vs PC levels set in the Envy Display Configuration menu.** It does not matter to the calibration software or procedure whether Envy outputs Full (PC) or Limited (TV) levels to the display. However, the projector and Envy do have to be set to use the same levels (or both on Auto, which is usually the default).

- The default DCI P3 profile in CS uses a target gamma of 2.6. If you are targeting a different gamma (such as 2.2 in this example) a custom DCI P3 profile needs to be created. Use the following procedure to change the gamma of the DCI P3 profile:

- Open ColourSpace and click on “Space Management”



- Expand the preset color spaces by clicking on “Colour Spaces (preset)”
- Select the DCI P3 D65 present and select modify



	RED	GREEN	BLUE	WHITE
X	0.6800	0.2650	0.1500	0.3127
Y	0.3200	0.6900	0.0600	0.3290
EOTF	2.2000			

Output name: DCI P3 D65 Gamma 2.2

Buttons: Save, Close

- Change the EOTF setting to 2.2 and change the output name to something for the new profile (e.g., “DCI P3 D65 Gamma 2.2).
- Click save.
- Your new color space will now be displayed under “Colour Spaces (user).” This is the color space you should use for your DCI P3 calibration.
- If you plan to use BT2020, simply repeat the same steps above, but start by selecting the default BT2020 colorspace instead of DCI P3.
- Check the Profile Luma Auto box. This populates the measured max and min nits values.
- Use L32 (10%) patches or another desired size such as 25%. Whatever is selected, be consistent.
- Stabilization Off.

Probes

- Connect probe
- Review Probe options. Some typical values are below. Your mileage may vary, so experimentation may be necessary to find the best settings for your particular setup.
 - Klein 10A
 - No intelligent integration.
 - No average low light.
 - Max Integration Time: 1.250 seconds.
 - Extra delay: .25 seconds - .50 seconds.
 - Remember to open probe matching and select files.
 - Remember to turn off meter laser aiming, or CS will give an unspecific error when you take measurements.
 - i1Display Pro
 - Integration: 0.25.
 - Intelligent Integration: 2.0 (some people do not use this option)

- Extra Delay: 0.25 – 0.50 seconds. 0.50 is safer. Experiment to make sure readings are consistent.
- Sync Mode: Try BURST and AIO. Depending on the light source (bulb vs laser vs LED) you may get more consistent readings with one setting vs the other.

Hardware Options

- Connect to Envy (enter IP).
- Select color profile slot (for example BT709, DCI P3, or BT2020).
- Click the “Disable” checkbox to disable any loaded LUT.
- Select automatic Calibration Patches (this locks in the LUT settings just made, if changing you must turn off the calibration patches).

Graph Options

- Select Probe Matching Active.
- Set dE to dE2000.

Probe Placement

- Setup probes facing the center of the screen using the relative measurements in the table. Here are some commonly recommended distances.

Probe	Distance from Screen	Reading area (Diam)
i1Display Pro/C6	2'	4.4"
i1Pro 2	2'8"	4.4"
Klein K-10A	2'4"	4.4"
Discus	1'10"	4.4"

- Bring up a 1% patch size at 100% IRE (RGB 255,255,255) in the manual measurement tab.
- Try and get the shadow of your device slightly below the 1% patch and centered below the patch left/right. Also make sure the probe to facing directly at the screen if possible (e.g., not angled left/right).
- Click repeat, then measure. This should continuously take measurements of the 100% white patch point.
- Adjust the probe by adjusting its vertical angle and look at the nits measurement (dE is not important for this process!). Maximize the nits measurement and lock the probe into place when you have the highest nits reading.
- Repeat process for any other probes.

Probe Matching

Method One - Stay connected to the Envy, but switch between connected probes

- Open a profiling window.

- Set patch size under settings (e.g., L32 patch sizes).
- Connect to your spectro and initialize it (if necessary).
- Confirm proper settings for probe (e.g., integration time, extra delay).
- Connect to the Envy under hardware settings for the spectro profile window you opened. Select the LUT slot used for calibration, but make sure LUT is disabled.
 - NOTE: You must create a new probe matching any time the target gamut changes. For instance, when calibrating with the projector in a native color space, vs its BT709 color space, vs its BT2020 color space, etc.
- Select Automatic under Calibration Patches.
- Under Probe Options click on Configure in the Probe Matching area.
 - Select New.
 - Name Probe Profile (e.g., RS4500 i1Pro2 PM (date)).
 - ColourSpace will measure the three primaries and the white point.
 - When measurements complete close the window.
- Disconnect from the spectro under probe settings.
- Connect to the colorimeter under probe settings.
- Confirm proper settings for probe (e.g., integration time, extra delay).
- Under Probe Options click on configure in the Probe Matching area.
 - Select New.
 - Name Probe Profile (e.g., RS4500 Klein PM (date)).
 - ColourSpace will measure the three primaries and the white point.
 - When measurements complete the file name you just gave should be listed in the active probe drop down.
 - Select the name of the spectro run previously performed from the drop down under Reference Probe/Display Presets.
 - Close the window.

Method Two - Stay connected to both probes at once, but switch which one is connected to the Envy (Useful if you switch between probes and do not want to keep initializing a spectro)

- Open two profiling windows in ColourSpace.
- Confirm settings for both Profile Windows (should be identical settings for measurements).
 - Set both windows to same patch size under settings (e.g., L32 patch sizes).
- Connect each probe and initialize (if necessary).
- Confirm proper settings for probe (e.g., integration time, extra delay).
- Connect to Envy under hardware settings for the spectro profile window you opened. Select the LUT slot used for calibration, but make sure LUT is disabled.
 - NOTE: You must create a new probe matching any time the target gamut changes. For instance, when calibrating with the projector in a native color space, vs its BT709 color space, vs its BT2020 color space, etc.
- Select Automatic under Calibration Patches.
- Under Probe Options click on configure in the Probe Matching area.

- Select New.
- Name Probe Profile (e.g., RS4500 i1Pro2 PM (date)).
- ColourSpace will measure the three primaries and the white point.
- When measurements complete close the window.
- Disconnect from the Envy under Hardware Options.
- Switch to the colorimeter's profiling window.
- Connect to the Envy under hardware settings.
- Select the LUT slot used for calibration, but make sure LUT is disabled.
- Select Automatic under Calibration Patches.
- Under Probe Options click on configure in the Probe Matching area.
 - Select New.
 - Name Probe Profile (e.g., RS4500 Klein PM (date)).
 - ColourSpace will measure the three primaries and the white point.
 - When measurements complete the file name you just gave should be listed in the active probe drop down.
 - Select the name of the spectro run previously run from the drop down under Reference Probe/Display Presets.
- Close the profiling window for your spectro and use the colorimeter profiling window for your calibration run.

Setting 100% IRE White point (Optional)

- Note in our experience, these steps are not necessary, as ColourSpace will take care of the white point calibration as part of the 3D LUT. However, we have left these details here for those who prefer this.
- Go to manual measure.
- Adjust sliders to 100% RGB.
- Click repeat, then measure. This should continuously take measurements of the 100% white patch point at the target color temperature for the color profile selected under settings.
- Adjust the RGB gains to try and get a low dE at the 100%.

Characterization Run

- A recommended sanity check before proceeding is to run a Grayscale Only measure (which also measures the gamut). Make sure that your measured gamut (connected lines that form a triangle within the measured gamut) are reasonably close to what you expect. If the gamut appears largely undersaturated beyond what you expect, something is wrong with your ColourSpace and or display setup, and you must figure that out before proceeding. Otherwise, your efforts will be wasted, as the result will be poor.
- Set characterization to cube. Pick the desired size. A 21pt cube may provide best results but can take 3+ hours, depending on your meters. There are also custom patch sets

available from ColourSpace, including a 17pt with 33 pt. grayscale which many users have had exceptional results with.

- Enable drift compensation with a value of 50, if desired.
- Make sure all LUTs are disabled (ColourSpace->hardware options-> disable checkbox is selected).
- (Optional) Select a pre-roll CSV sequence, not of much use with modern displays but you may like to see the points measured "in order".
- Confirm probe matching settings.
- Take one last 100% reading and confirm values as expected.
- Click start on the characterization run.
- When the run completes go to Graph Options and select rename and give the profile run a name (e.g., RS4500 No Color Profile 21^3 PM).
- Make sure you have the Probe Matching Active Check Box Selected.
- Click Save.

LUT Generation

- If you have not done so already, create a proper target color space for your LUT target
 - Open manage spaces.
 - Select the closest preset ColourSpace from the list of color spaces (e.g., For DCI use the custom created (per earlier) DCI P3 D65).
 - Click Modify.
 - Change the values to match your target. You want the RGB values to be the primaries for the target color space, the white value to be D65 (.3127, .3290) and the gamma to be 2.2. For example, for DCI using the DCI P3 D65 present as a starting point I only needed to change the gamma from 2.6 to 2.2.
 - Give your ColourSpace a name in the field labeled output name (e.g., DCI P3 D65 Gamma 2.2).
 - Click Save.
- Open the ColourSpace LUT Tool.
- Under Source Gamut (Profile) select the target ColourSpace you just created (e.g., DCI P3 D65 Gamma 2.2).
- Under Destination Gamut (Profile) select the characterization run you just completed (e.g., RS4500 No Color Profile 21^3 PM).
 - If you used drift compensation, make sure the check box for this is active.
- Give your LUT a name (e.g., DCIP3 Peak Chroma).
- Choose the LUT generation technique from the drop down on the bottom left.
 - The most common choice is Peak Chroma.
 - **Critical:** When your display's actual gamut is undersaturated compared to the target gamut, you must use Fit Space or Map Space as the LUT generation method. Otherwise, your resulting calibration will be very undersaturated (particularly the Green point).
- Click Create.

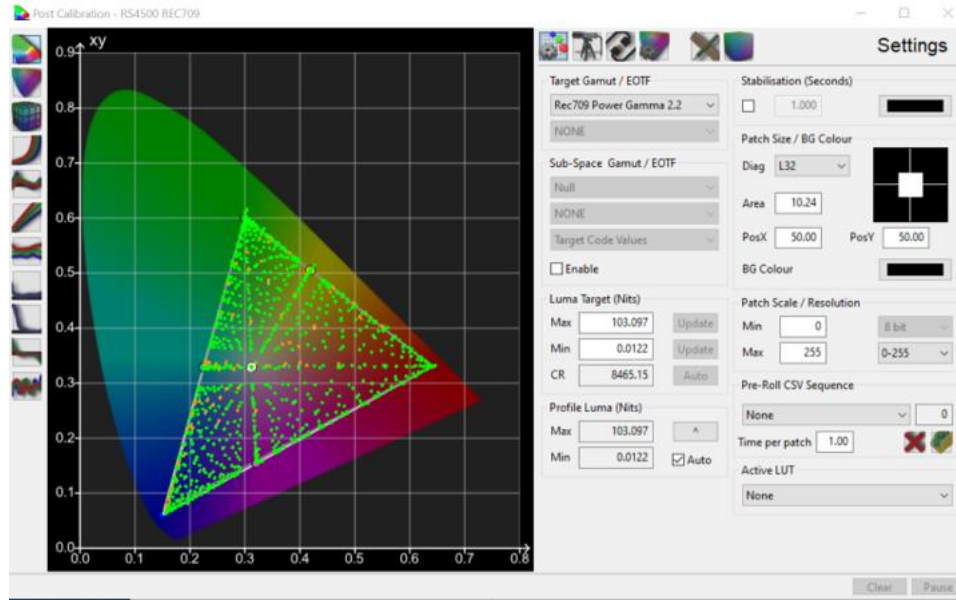
- **Important:** In previous versions of ColourSpace, it was necessary to apply the Pass Black filter to the generated LUT. However, **you should not use Pass Black anymore**, as using that it will cause poor results with modern Envy firmware versions.
- 2 Options - Validate LUT after upload (simpler) or Validate LUTs before Upload to Envy (allows easy comparison of multiple LUTs).
 - **Option 1 - Upload LUT to Envy and validate**
 - Click the Manage LUT tab.
 - Click Save.
 - Go to the ColourSpace Profile tool.
 - Go to Hardware Options.
 - Disable Calibration patches.
 - Confirm the correct Envy 3D LUT ColourSpace slot is selected.
 - Select the name of the LUT you generated under select LUT.
 - Confirm “1D1+3D” is selected under Load. By choosing this option, Envy will apply a 4,096-point 1D LUT in addition to the 3D LUT!
 - Click Upload.
 - Proceed to LUT Verification step below.
 - Per the LUT Management section above, rename your LUT to something meaningful, if you plan to keep it.
 - **Option 2 - If comparing multiple LUT generations (peak chroma vs fit space) or you already have a LUT loaded in the Envy you do not want to overwrite until validation**
 - Click the Manage LUT tab.
 - Save LUT.
 - Generate additional LUTs using above procedure, but with different generation techniques (Peak Chroma, Fit Space, Map Space, etc.) and save each with a unique name you can remember what each represents (e.g., DCIP3 Peak Chroma, DCIP3 Fit Space).
 - Perform LUT Verification (steps below) on each LUT but keep the LUT tool open with your generated LUTs still available.
 - Once you identified the LUT you want to upload to the Envy for that ColourSpace slot in the Envy go to the ColourSpace Profile tool.
 - Go to Hardware Options.
 - Disable Calibration patches.
 - Confirm the correct Envy 3D LUT ColourSpace slot is selected.
 - Confirm “1D1+3D” is selected under Load
 - Select the name of the LUT you generated under select LUT.
 - Click Upload.
 - You are done! (If you are still feeling ambitious you can run another validation run to confirm you selected the correct LUT and nothing was degraded/lost in process of upload).

- Per the LUT Management section above, rename your LUT to something meaningful, if you plan to keep it.

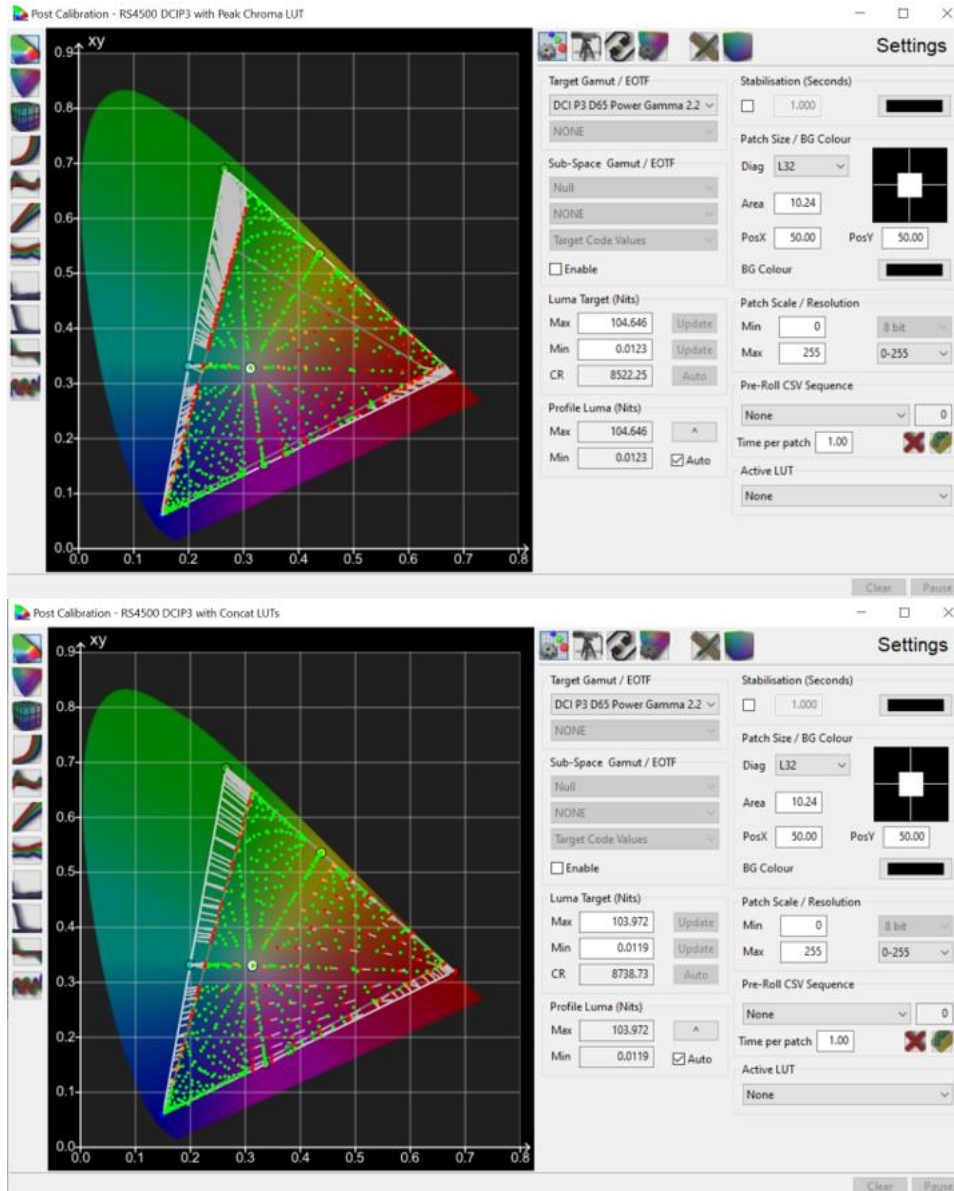
LUT Verification

Option 1 - LUT was uploaded to the Envy for validation

- Go to the Profile Window you have open with the colorimeter connected
 - Confirm all settings in the settings, probe options, hardware options, and graph options are correct.
 - Settings
 - The target gamut should be the user color space you made for the LUT generation and used as the source for the LUT.
 - The patch size should be the same as used for the characterization run (e.g., L32).
 - Probe Options
 - Confirm the probe matching has been configured correctly. Click configure and make sure the Active Probe and the Reference Probe file names are the ones you used during the probe matching process.
 - Hardware Options
 - Confirm you are connected to the Envy.
 - Select the LUT slot for the envy to which you uploaded the LUT for testing (e.g., DCI-P3).
 - Confirm the checkbox for disabling the LUT is unchecked.
 - Select automatic from the Calibration Patches dropdown - this locks the Envy to the selected LUT and LUT activation status.
 - Graph Options
 - Make sure the Probe Matching Active checkbox is active.
- Click on the Display Characterization tab.
- Select cube mode.
- Change cube size to at least 10^3 but can go up to 21^3 for more thorough, but longer validation. Typically, 17^3 will be sufficient. But ideally, you would use the same exact cube for verification that you used for the profiling in the above section.
- Recommended - enable drift compensation with a value of 50.
- For a Rec709 validation, make sure you are playing content through the Envy that is outputting at BT709. If you have not changed anything since performing the Characterization, then you should still be outputting BT709 without changing anything or needing to recheck.
- Click start on the characterization run.
 - You should see mostly green on the CIE xy graph like shown below, as an example successful calibration run.



- If you do not see a lot of green check that you have the probe matching active and you have the right color space profile selected under target gamut.
 - If you confirmed the above, run through your other settings and confirm you have not missed something in your configuration.
- If you do see mostly green, congratulations! You have successfully performed a calibration!
- For a calibration run where you are trying to target a colorspace wider than your displays capabilities (e.g., Rec2020 and or DCIP3 when not using the P3 filter) you will likely see red dots along the gamut edges on the CIE xy graph, but the graph interior should mostly be green. There may still be some red and orange dots within the gamut as the LUT is making some compromises to accommodate the limited gamut it is working with in the projector. Therefore, you may want to experiment with different LUT generation choices to see what give you the best results. A couple of example charts are shown below of successful results.



- Note that ColourSpace has a few options for the dE formula. When using dE2000 it is much more forgiving, and you should see mostly green with some orange and red (particularly along the edges when the full target gamut cannot be reached). When using the ITP dE formula, your results will likely have quite a bit less green and more orange and red.
- If you do not see a lot of green, check that you have the probe matching active and you have the right color space selected under target gamut
 - If you confirmed the above, run through your other settings and confirm you might not have missed something in your config for the calibration.

- If you do see mostly green, congratulations! You have successfully performed a calibration!

Option 2 - LUT held in memory for validation

- Go to the Profile Window you have open with the colorimeter connected
 - Confirm all settings in the settings, probe options, hardware options, and graph options are correct.
 - Settings
 - The target gamut should be the user color space you made for the LUT generation and used as the source for the LUT.
 - The patch size should be the same as used for the characterization run (e.g., L32).
 - Under Active LUT select the LUT you want to test.
 - If you do not see it from the dropdown, you did not save it in the LUT tool. Just go back and save it now and it will show up.
 - Probe Options
 - Confirm the probe matching has been configured correctly. Click configure and make sure the Active Probe and the Reference Probe file names are the ones you used during the probe matching process.
 - Hardware Options
 - Confirm ColourSpace is connected to the Envy.
 - Select the LUT slot for the envy to which you uploaded the LUT for testing (e.g., DCI-P3).
 - Confirm the checkbox for disabling the LUT is unchecked.
 - Alternatively, you could upload a unity LUT to the Envy using ColourSpace to be safe. Then you can use the IP tool (discussed earlier) or Envy menu to make your LUT active again if you do not plan to keep the new LUT.
 - Select automatic from the Calibration Patches dropdown - this locks the Envy to the selected LUT and LUT activation status.
 - Graph Options
 - Make sure the Probe Matching Active checkbox is active
 - Follow the instructions in the LUT Verification - Option 1 instructions above, starting at “Click on the Display Characterization tab”.
 - Evaluate results of validation as also described in that section. If you do see mostly green, congratulations! You have successfully performed a calibration!

We hope you found this document helpful. If you would like to contribute any suggested changes or additions, please email hello@madvr.com.

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