madVR Envy

3D LUT Calibration for ColourSpace

Revision 0.81

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.

Important: LUT Management (New!)

The Envy now supports full LUT management, starting with firmware 1.1. This 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).

For example, you can have one 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, if desired). Or you may wish to have different LUTS for use with different viewing conditions, such as Daytime vs Nighttime. Or you may wish to have different LUTs stored for use with different displays / projectors within the same Envy.

To manage the LUTs we recommend using the Envy IP Control Management tool, available here: http://madVR.com/EnvyIpControl.zip. The tool has options to upload, download, rename and delete LUTs. Usage of this tool is self-explanatory.

Important tip: When you upload a 3D LUT with ColourSpace, Envy will assign it a unique file name and activate that LUT. This is convenient as you experiment, but once you have a LUT you are happy with, we recommend you use the LUT renaming option in the IP tool or in the Envy menus and give it a meaningful name. For example, "BT.2020NF.Sony" or "BT.2020Filter.Sony". This way as the LUTs pile up from your experimenting, you will know which is which. When done, we recommend deleting any unneeded LUTs. You can then use the Envy's Profile system to assign different LUTs to different Displays or Profiles. You may also wish to use the IP tool to

download your LUTs for safe keeping, as LUTs are not currently backed up otherwise. For more information about using Profiles with the Envy, consult the Envy menu context sensitive help.

Let's 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 colorspace. 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 (i.e. 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, a target DCI P3 with **gamma of 2.2 must be used**. Please do not use a gamma of 2.4, thinking that is the best gamma. HDR gamma as mentioned earlier is dynamic, and Envy expects a 2.2 target as its reference to render its tone mapping accurately (and again, by doing this you will not wind up with a 2.2 gamma for HDR anyway).

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- The default DCI P3 profile in CS uses a target gamma of 2.4. Therefore, a custom DCI P3 profile must be created with a target gamma of 2.2. Use the following procedure:

  o Open ColourSpace and click on "Space Management"

  o Expand the preset color spaces by clicking on "Colour Spaces (preset)"
  o Select the DCI P3 D65 present and select modify
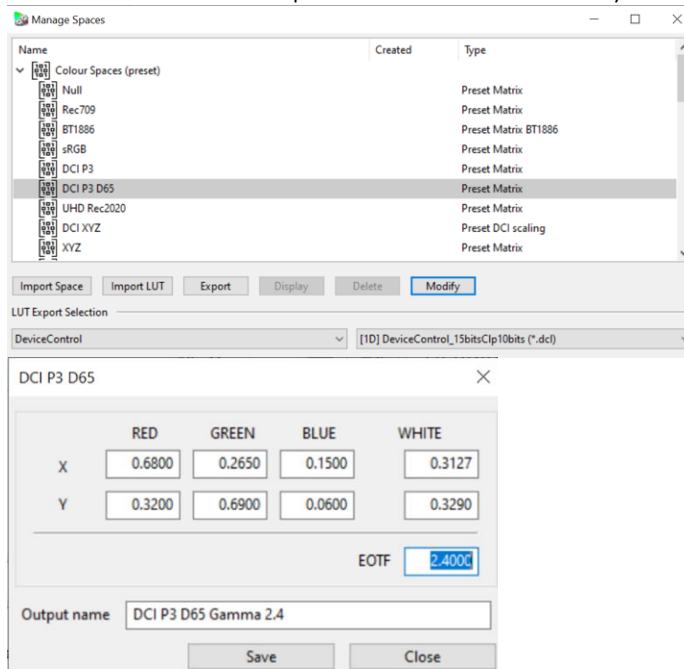
  o Change the EOTF setting to 2.4 and change the output name to something for the new profile (e.g. "DCI P3 D65 Gamma 2.2).
  o Click save.
  o Your new color space will now be displayed under "Colour Spaces (user)." This is the color space you should use for your DCI P3 calibration.
  o If you plan to 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 values. Example values are below.
  - Klein 10A
    - No intelligent integration.
    - No average low light.
    - Max Integration Time 1.250 seconds.
    - Extra delay .25 seconds.
    - Remember to open probe matching and select files.
  - i1Display Pro
    - Integration 0.25.
    - Intelligent Integration 2.0.
    - Extra Delay 0.25.

Hardware Options
- Connect to Envy (enter IP).
- Select color profile slot (for example BT709, DCI P3, or BT2020).
- Click the "Disable" button to disable any loaded LUT. It can be a little confusing as to what the button label means – just remember that the label represents the desired action by clicking the button – in this case clicking it when it says Disable means that clicking it will disable the LUT.
- Select automatic Calibration Patches (this locks in the LUT settings just made, if changing you have to 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 (i.e 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 (eg. RS4500 i1Pro2 PM (date)).
    - ColourSpace will measure the three primaries and the whitepoint.
    - 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 (eg. RS4500 Klein PM (date)).
    - ColourSpace will measure the three primaries and the whitepoint.
    - 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 what to keep initializing a spectro)

- Open 2 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 (eg. RS4500 i1Pro2 PM (date)).
  - ColourSpace will measure the three primaries and the whitepoint.
  - 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 (eg. RS4500 Klein PM (date)).
  - ColourSpace will measure the three primaries and the whitepoint.
  - 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 Whitepoint (if you want; not usually necessary)

- Note in our experience, these steps are not necessary, as ColourSpace will take care of the whitepoint calibration as part of the 3D LUT, and there appears to be no benefit to doing this step manually. However, we have left these details here for those who prefer this.
- Go to manual measure.

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- Adjust sliders to 100% RGB.
- Click repeat, then measure. This should continuously take measurements of the 100% white patch point at the target color temp 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 end 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 we have had exceptionally good results with.
- Enable drift compensation with a value of 50, if desired.
- Make sure all LUTs are disabled (ColourSpace->hardware options->calibration patches off->select correct color slot->click the enable/disable button with last click being when the button is labeled "Disable".
- (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 ColourSpaces (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 RGP 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).

- o 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).
    - o 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.
    - o The most common choice is Peak Chroma.
    - o **Critical**: When your display's actual gamut is undersaturated compared to the target gamut, you must use Fit Space as the LUT generation method. Otherwise, your resulting calibration will be very undersaturated (particularly the Green point).
- Click Create.
- 2 Options - Validate LUT after upload (simpler) or Validate LUTs before Upload to Envy (allows easy comparison of multiple LUTs) .
    - o **Option 1 - Upload LUT to Envy and validate**
        - Click the Adjust LUT tab.
        - Depending on your sources and display, and HDMI chain, you may (likely) need to apply the ColourSpace "Pass Black" filter under scaling. If so, select Pass Black and Apply it. A general rule of thumb is to apply Pass Black, but if you notice any banding introduced by the calibration, then repeat this step but do not apply Pass Black.
        - 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 with the pass black filter applied (if you used Pass Black) under select 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.

    - o **Option 2 - If comparing multiple LUT generations (peak chroma vs fit space, or using Pass Black vs not) 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, With and without Pass Black 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 back to the LUT Tool and click the tab in the bottom right of the window for the LUT you want to upload.
  - Click the Adjust LUT tab.
  - Select Pass Black video scale under scaling and click Apply, if Pass Black option is desired (see discussion under Option 1 above).
  - Save new LUT with Filter Applied.
- 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 with the pass black filter applied under select LUT, if you used Pass Black.
  - 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 ColourSpace 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).
  - • Click the Enable/Disable button a couple of times with the last click being enable and confirm the button is showing disable (implying the LUT is currently active).
  - • 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.
  - o You should see mostly green on the CIE xy graph like shown below, as an example successful calibration run.
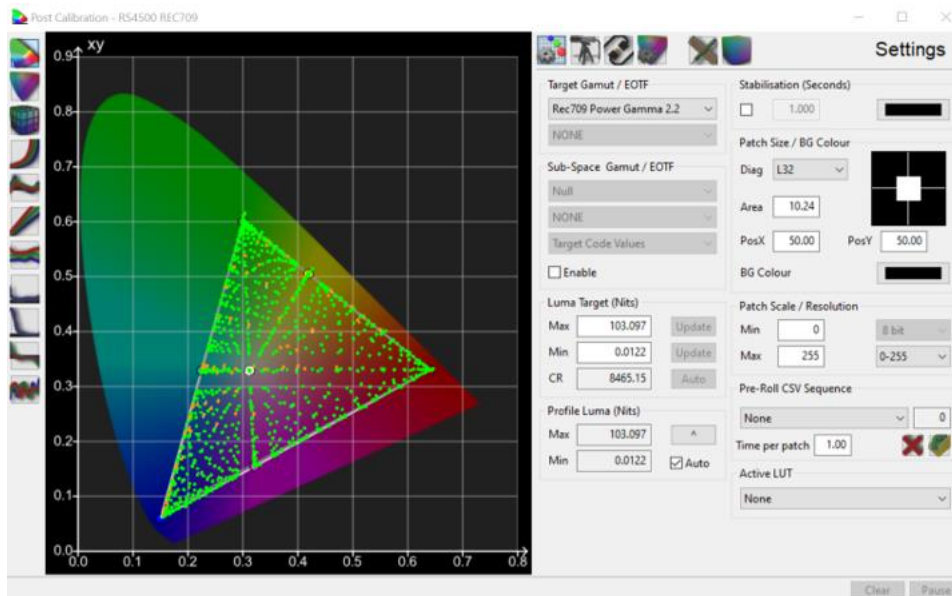
- If you do not see a lot of green check that you have the probe matching active and you have the right color space profile selected under target gamut.
  - If you confirmed the above, run through your other settings and confirm you have not missed something in your configuration.
- If you do see mostly 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. This is why you may want to experiment with different LUT generation choices to see what give you the best results. A couple of example charts are provided below of successful results.
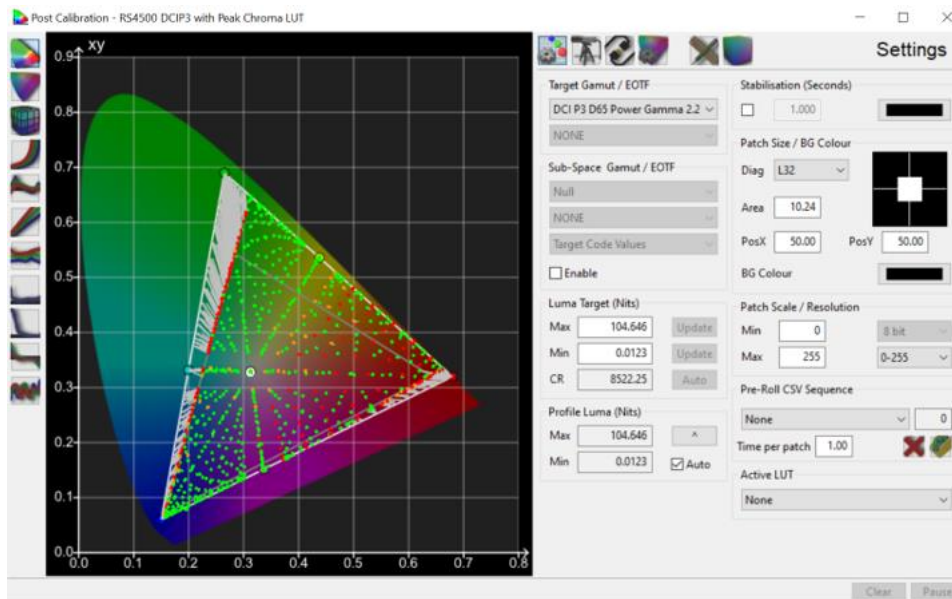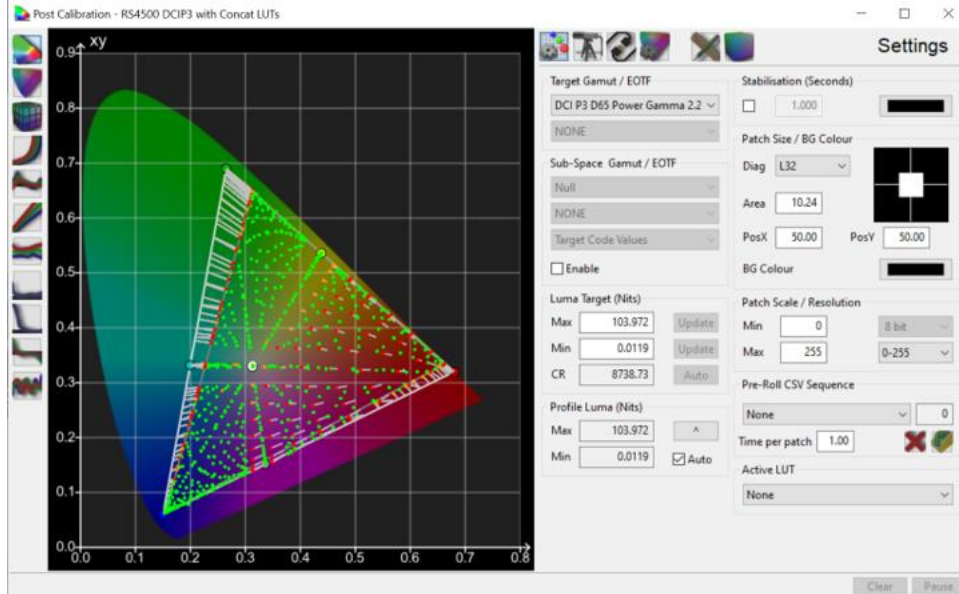
- Note that ColourSpace has a few options for the dE formula. When using dE2000 it is much more forgiving, and you should see mostly green with some orange and red (particularly along the edges when the full target gamut cannot be reached). When using the ITP dE formula, your results will likely have 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 ColourSpace 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.

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- Note when you load LUTs here you should NOT have applied the pass black filter.
    - 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).
        - Click the Enable/Disable button a couple of times with the last click being when the button says "Disable" and confirm the button is showing enable (implying the LUT is currently disabled).
            - 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! You now need to go back and optionally apply the Pass Black filter to the LUT (per the prior discussion in this document) and upload it to the Envy (covered in the section on LUT generation).

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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