

KMS Color Management Workshop

Melissa Wen

XDC 2023 - A Coruña - Spain



Shell & Display Next Hackfest

- **Brno, 24-26 April inclusive**

<https://wiki.gnome.org/Hackfests/ShellDisplayNext2023>

Agreements:

- **Short-term plan:** [AMD driver-specific color properties](#)
- **Long-term plan:** KMS Generic API
 - Prescriptive: A list of available hardware blocks
 - Testing: writeback, VKMS, etc.
 - New property: color_pipeline
 - New KMS object type: COLOROP



Hackfest Follow-Up

[RFC] Plane color pipeline KMS uAPI - **Simon Ser**

[RFC 00/33] Add Support for Plane Color Pipeline - **Uma Shankar**

[RFC PATCH 00/10] Color Pipeline API w/ VKMS - **Harry Wentland**

[PATCH v4 00/32] drm/amd/display: add AMD driver-specific properties for color mgmt - **Melissa Wen**



[RFC] Plane color pipeline KMS uAPI

https://lore.kernel.org/dri-devel/QMers3awXvNCQlyhWdTtsPwkp5ie9bze_hD5nAccFW7a_RXIWjYB7MoUW_8CKLT2bSQwIXVi5H6VULYIxCdgvryZoAoJnC5IZgyK1QWn488=@emersion.fr/

Plane 10

└ "type": immutable enum {Overlay, Primary, Cursor} = Primary

└ ...

└ "color_pipeline": enum {0, 42, 52} = 0



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Color operation 42

- └ "type": enum {Bypass, 1D curve} = 1D curve
- └ "1d_curve_type": enum {LUT, sRGB, PQ, BT.709, HLG, ...} = LUT
- └ "lut_size": immutable range = 4096
- └ "lut_data": blob
- └ "next": immutable color operation ID = 43



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Color operation 42

- └ "type": enum {Bypass, 3D LUT} = 3D LUT
- └ "lut_size": immutable range = 33
- └ "lut_data": blob
- └ "next": immutable color operation ID = 43



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Color operation 42

- └ "type": enum {Bypass, Matrix} = Matrix
- └ "matrix_data": blob
- └ "next": immutable color operation ID = 43



[RFC PATCH 00/10] Color Pipeline API w/ VKMS

<https://lore.kernel.org/dri-devel/20230908150235.75918-1-harry.wentland@amd.com/>

Each `drm_colorop` has three core properties:

TYPE: The type of transformation, such as enumerated curve, custom (uniform) 1D LUT, 3x3 matrix, 3x4 matrix, 3D LUT, etc.

BYPASS: A boolean property that can be used to easily put a block into bypass mode.

NEXT: The ID of the next `drm_colorop` in a color pipeline, or 0 if this `drm_colorop` is the last in the chain.



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COLOR_PIPELINE Plane Property

- Color Pipelines are created by a driver and advertised via a new COLOR_PIPELINE enum property on each plane.
- 0 is the default and means all color processing is disabled



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Color Pipeline Discovery:

DRM_IOCTL_MODE_GETCOLOROPRESOURCES

DRM_IOCTL_MODE_GETCOLOROP

Color Pipeline Programming:

Set the properties for all `drm_colorop` objects in the pipeline to the desired values



Intel Pre-blending Color API

<https://patchwork.freedesktop.org/series/90825>

1. **Plane Degamma LUT:** 4096 entries
2. **Plane CTM/CSC 3x3**
3. **Plane Gamma LUT:** 4096 entries



AMD Pre-blending Color API

<https://patchwork.freedesktop.org/series/116862>

1. **Plane Degamma TF (EOTF):** sRGB, BT709 (inv OETF), PQ, HLG, Gamma 2.x
2. **Plane Degamma 1D LUT:** 4096 entries
3. **Plane CTM 3x4**
4. **Plane HDR Multiplier**
5. **Plane Shaper TF (inverse EOTF) + 1D LUT:** sRGB, BT709 (OETF), PQ, HLG, Gamma 2.x
6. **Plane 3D LUT:**
 - a. single-dimension size: 17 or 9
 - b. bit-depth: 10-bit or 12-bit
 - c. tetrahedral interpolation
7. **Plane Blend Gamma TF (EOTF) + 1D LUT:** sRGB, BT709 (inv OETF), PQ, HLG, Gamma 2.x



Discussions

- BYPASS vs Default ?
 - Everything that modifies pixel values in a pipeline MUST be exposed from the very moment the COLOR_PIPELINE property is added to a KMS object.
 - HW blocks that a driver hardcodes to pass-through and so do not modify any values do not need to be exposed;
- Current drm_plane properties: **COLOR_ENCODING** and **COLOR_RANGE**: Input CSC



Discussions

```
struct drm_color_lut_range
```

```
    __u32 flags; /* DRM_MODE_LUT_* */
```

```
    __u16 count; /* number of points on the curve */
```

```
    __u8 input_bpc, output_bpc; /* input/output bits per component */
```

```
    __s32 start, end; /* input start/end values */
```

```
    __s32 min, max; /* output min/max values */
```



Discussions

Flags:

- DRM_MODE_LUT_POST_CSC
- DRM_MODE_LUT_PRE_CSC
- DRM_MODE_LUT_INTERPOLATE
- DRM_MODE_LUT_REUSE_LAST
- DRM_MODE_LUT_NON_DECREASING
- DRM_MODE_LUT_REFLECT_NEGATIVE
- DRM_MODE_LUT_SINGLE_CHANNEL



MORE



KMS Color Management Workshop Report

Melissa Wen

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Participants

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Abhinav Kumar (Qualcomm)

Marijn Suijten (Traverse Research)



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Discussions

- **Conflicts between existing pre-blending and post-blending color properties**
- **New generic API implementation on VKMS: lessons learned**
- **Better testing with a writeback connector**
- **Variety of capabilities for color transformations and NVIDIA color singularities**
- **Latency issue when updating 3D LUTs**
 - **Async LUT update**
 - **Benchmarks**
 - **Looking for a general uAPI solution**



Discussions

- **Precision guarantees**
 - **Hardware specific implementations: segmented LUT**
 - **Bit-by-bit equality is a lost cause**
 - **Evaluate it throughout each iteration**
- **Very simple API first and a more complex later**
- **Userspace needs to always be able to fallback to shaders: no implicit assumptions**



Next steps

Reference/start point: "[RFC PATCH 00/10] Color Pipeline API w/ VKMS - Harry Wentland"

- Focus on having more vendors build upon that ^^
- Check 3D LUT performance
- Don't go too deep with VKMS



2024 Display Hackfest

Igalia HQ - A Coruña, Spain - April/May 2024

Melissa Wen :)

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