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Visualization & Analysis of HDR/WCG Content

Application Note

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Introduction

The adoption of High Dynamic Range (HDR) and Wide Colour Gamut (WCG) content is accelerating for both 4K/UHD and HD applications. HDR provides a greater range of luminance, with more detailed light and dark picture elements, whereas WCG allows a much wider range of colours to be displayed on a television screen. The combined result is more accurate, more immersive broadcast content.

Hand-in-hand with exciting possibilities for viewers, HDR and WCG also bring additional challenges with respect to the management of video brightness and colour space for broadcasters and technology manufacturers. To address these issues, an advanced set of visualization, analysis and monitoring tools is required for HDR and WCG enabled facilities, and to test video devices for compliance.

HDR: managing a wider range of luminance

Multiple HDR formats are now used worldwide. In broadcast, HLG10, PQ10, S-log3, S-log3 (HDR Live), HDR10, HDR10+, SLHDR1/2/3 and ST 2094-10 are all used.

Hybrid Log-Gamma (HLG), developed by the BBC and NHK, provides some backwards compatibility with existing Standard Dynamic Range (SDR) infrastructure. It is a relative system that offers ease of luminance mapping in the SDR zone.

The PQ (Perceptual Quantizer) HDR format, developed by Dolby, is a display referred system that can describe luminance levels from 0.0001cd/m2 (nits) up to 10,000 cd/m2.

For production, there is one HDR standard called ITU-R BT.2100, which describes PQ and HLG. For transmission, there is HDR10, HDR10+ and SL-HDR1/2/3, as well as SMPTE ST 2094-10 (aka Dolby Vision).

The challenges of multiple HDR standards, and the greater range of luminance in HDR signals, need to be managed carefully in view of the limitations of current HDR and legacy television displays. SDR mastering display luminance is limited at around 100 cd/m2, and high end consumer SDR TV's are around 300-400 cd/m2.
Current HDR mastering display technology supports up to 4,000 cd/m2, although most consumer LCD and OLED monitors do not go much past 1000 cd/m2.

It is therefore crucial to accurately measure luminance levels during HDR production to avoid displaying washed out, desaturated images on consumers' television displays. It's also vital in many production environments to be able to manage both HDR and SDR content in the same facility using similar workflows.

WCG: managing a broader colour space

In environments with WCG and regular colour space video, it's essential to be able to swiftly identify WCG content to ensure its correct processing. Incorrect treatment of colour space can lead to out of specification mapping of video signals, and poor colour reproduction. This type of issue can be encountered when content, such as advertisements and graphics, needs to be correctly mapped from SDR to HDR / WCG. Monitoring the results of a colour space conversion can prevent a lot of problems down the line.

The testing of devices to ensure compliance with WCG, ITU-R Rec. BT.2020 colour space specifications is also of fundamental importance. With rapidly evolving products and standards, ensuring consistent settings across all equipment is key.

Original HDR content

Example of 'washed out' display of HDR content

HDR visualization using *HDR Heat-map* tool

Measuring HDR brightness is important

With HDR production, it's important to accurately measure luminance levels to successfully handle any chosen clipping of light areas or suppression of dark areas in a picture, without losing key detail, or ending up with 'washed out', desaturated images on the intended displays.

Important questions when analysing video signal brightness include:

- What are the peak luminance levels in my HDR signal?
- Where are my image bright spots?
- Which elements of my picture are in the HDR zone?
- What colour grading is required to adjust my signal brightness levels for the target displays?

Easily measure brightness levels

It is really helpful to be able to visually identify HDR content 'at a glance'. It is often also important to know which elements of your image have HDR brightness levels, particularly when making colour grading decisions. A key tool for measuring luminance is a HDR heat-map, which overlays all pixels within a picture that are in the HDR luminance zone.

A configurable, colour-coded heat-map scale can allow the operator to isolate luminance in up to 7 adjustable zones of their choice – be it, HDR zones above 100 cd/m2, SDR levels, very low levels between 0.0001 and 0.1 cd/m2, or whatever is required. This can simplify the identification of shadows, mid-tones and specular highlights.

The ability to set these user defined luminance thresholds is helpful when identifying HDR ceilings for different devices and systems.

HDR content without Heat-map

HDR Heat-map applied, clearly highlighting HDR level heat spots

WCG colour space analysis using CIE chart tool

WCG colour space confirmation

To successfully manage video colour space, it's important to know the answers to questions like:

- What is my signal colour space?
- Is my signal chromaticity within the bounds of my expected colour space?
- Does my WCG signal chromaticity fit within the ITU-R Rec. BT.709 colour space without the need for significant modification?
- Has my signal been successfully mapped to another colour space?

A quick colour space sanity check is essential, and such questions can be promptly answered with a CIE 1931 X Y chart tool.

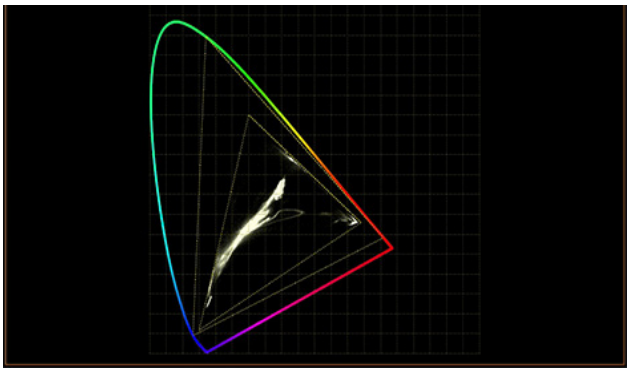
How the colour space of a video signal can be identified

The colour space observable to the human eye is defined in the CIE 1931 x y chromaticity diagram. The colour space of a video signal lies within this range, and a CIE Chart analysis tool provides information on the chromatic make-up of a video signal.

Wide Colour Gamut is defined by ITU-R Rec. BT.2020. This is an expansion beyond the colour gamut earlier defined by ITU-R Rec BT.709.

A CIE chart tool with ITU-R Rec. BT.2020 (WCG) and ITU-R Rec. BT.709 overlays can be used to observe and confirm a video signal's colour space 'at a glance'. The inclusion of a DCI-P3 overlay is advantageous for Digital Cinema colour space compliance, and consumer Ultra HD Premium label designation testing.

A further application of the CIE Chart tool is in identifying HDR content with signal chromaticity entirely within ITU-R Rec. BT.709 bounds. It can also be used to confirm the colour space of a video signal before and after a colour space conversion.



CIE 1931 x y chart tool showing signal chromaticity within ITU-R Rec BT.709 and ITU-R Rec BT.2020 overlays

Other key HDR and WCG tools

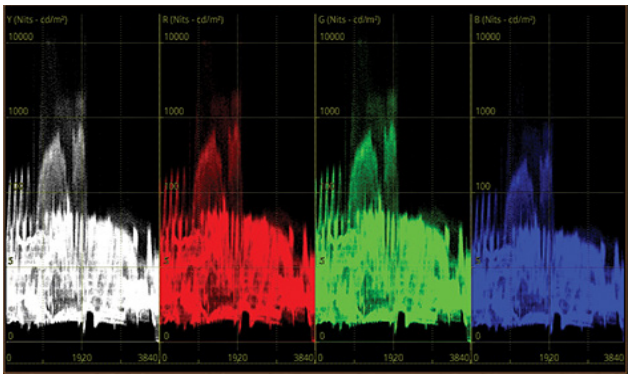
Waveform analysis of HDR/WCG

When dealing with HDR and WCG content, it's important for the test tools to display HDR range luminance and WCG traces. For example, they need to allow users to ensure that HDR levels for skin tone and grass areas are correct. To achieve this, a waveform instrument with Wide Colour Gamut support for ITU-R Rec. BT.2020, and PQ scale up to 10,000 nits is needed.

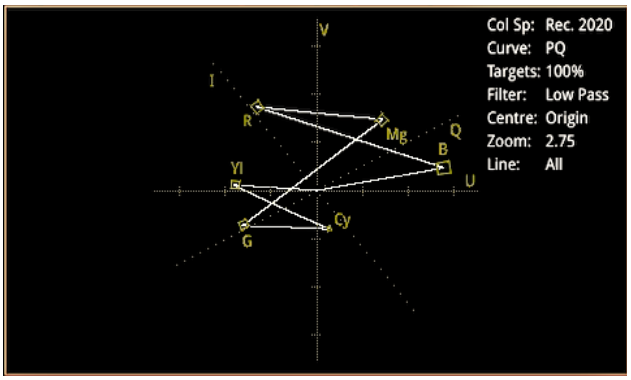
YCbCr/YRGB traces at full 12-bit resolution are required to support the highest required HDR bit depth in BT.2100.

Vectorscope analysis

Another key instrument for analysing HDR and WCG signals is a vectorscope with support for the ITU-R Rec. BT.2020 colour space, with coefficients adjusted for the analysis of HDR, and full 12 bit processing.



Waveform tool displaying YRGB trace of HDR signal with luminance up to 10,000 cd/m2



Vectorscope tool with ITU-R Rec. BT.2020 colour space signal display capability showing the location of Rec. BT.709 primaries within Rec. BT.2020

HDR test pattern generator

Another valuable HDR analysis tool is a signal generator which delivers ITU-R Rec. BT.709 and ITU-R Rec. BT.2020 colour space patterns.

A HDR generator should offer test patterns to debug HDR/WCG up and down mapping, and patterns with minimum and maximum PQ values.

Ideally, the HDR signal generator should support SDR patterns in HDR containers, and also deliver a pathological overlay in a full range of HD to UHD standards.

HDR test pattern generator

Conclusion

HDR and WCG video, at 4K/UHD or HD resolution, presents additional challenges to broadcast engineers with respect to managing the greater video brightness and expanded colour space. Unless it's carefully controlled, HDR/WCG content can cause multiple problems, such as clipped, 'washed out', desaturated images, and poor colour grading and conversion outcomes. Fortunately, new signal generation, analysis and monitoring tools are now available to enable engineers to confidently manage HDR luminance levels and Wide Colour Gamut content.

For more information about
HDR/WCG test and
measurement, contact:

www.phabrix.com