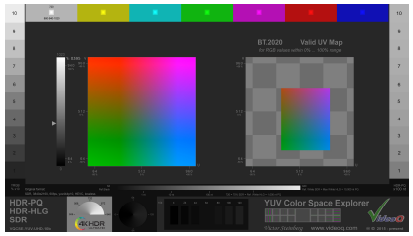


VQCSE

Victor Steinberg

Video**Q** **C**olor **S**pace **E**xplorer
Test Patterns Suite

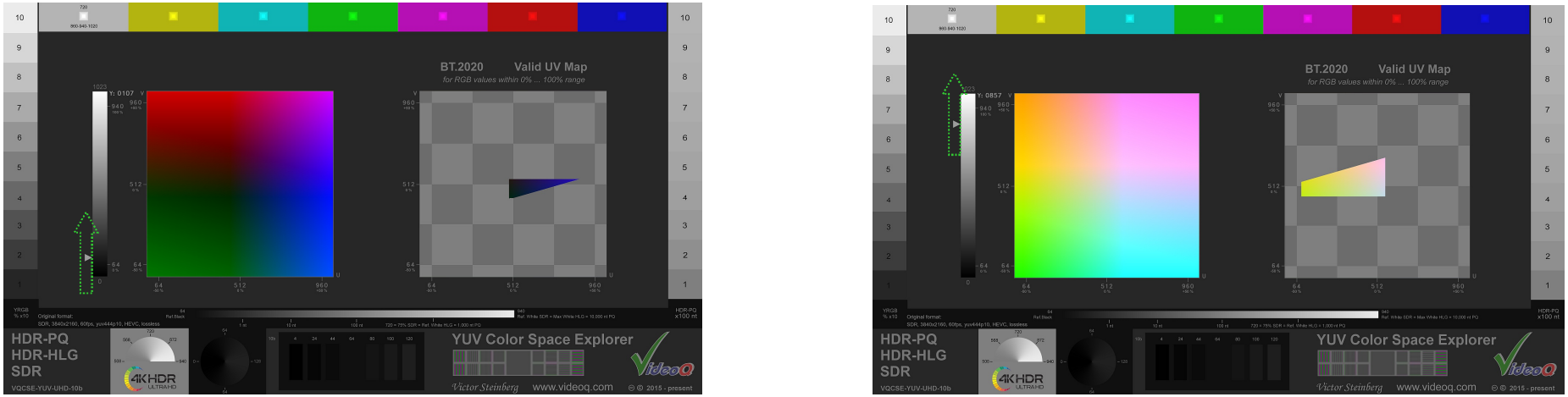
Training Presentation

May 2024

www.videoq.com/vqcse.html

www.videoq.com

VQCSE – Color Space Explorer ™ Dynamic Test



Time

In few seconds this sophisticated dynamic UHD test checks more than one billion (1024^3) colors of the **10 bit YUV** or **10 bit RGB** color space. For example, the VQCSE_YUV variant covers all combinations of Y, U and V values – from 0 to 1023, including all "illegal" colors.

For any given Y 10b value "Valid UV Map" on the right side shows the boundaries of "legal" colors area.

VQCSE is equally suitable for **SDR**, **HDR-PQ** and **HDR-HLG** systems, checking processors, codecs and display performance.

It is suitable for both visual and instrumental tests, the results are visible on regular video monitors, waveform monitors and/or vectorscopes. VQCSE is especially efficient in combination with *the VideoQ **VQV** Viewer-Analyzer tool*.

Applications

VQCSE is the picture quality control, calibration and verification tool for use by general public, video installers, hardware and software developers, video development labs, production, post-production and content distribution facilities in the fields of:

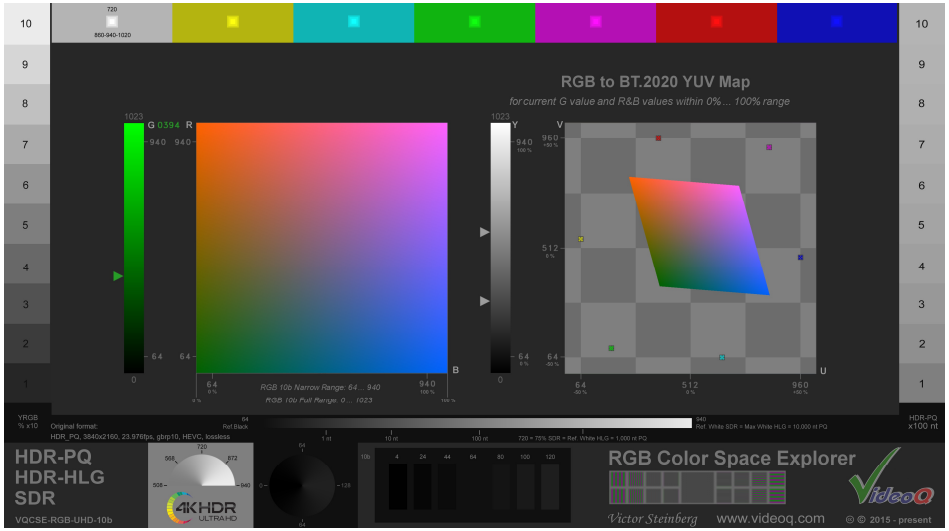
- TV sets, video monitors and displays development, testing and benchmarking
- Software and hardware video players development, testing and benchmarking
- Video transcoding and video data compression
- Consumer electronics
- Digital cinema
- Home theatres
- IPTV, CDN, VOD, OTT
- Cloud video processing, transcoding and streaming

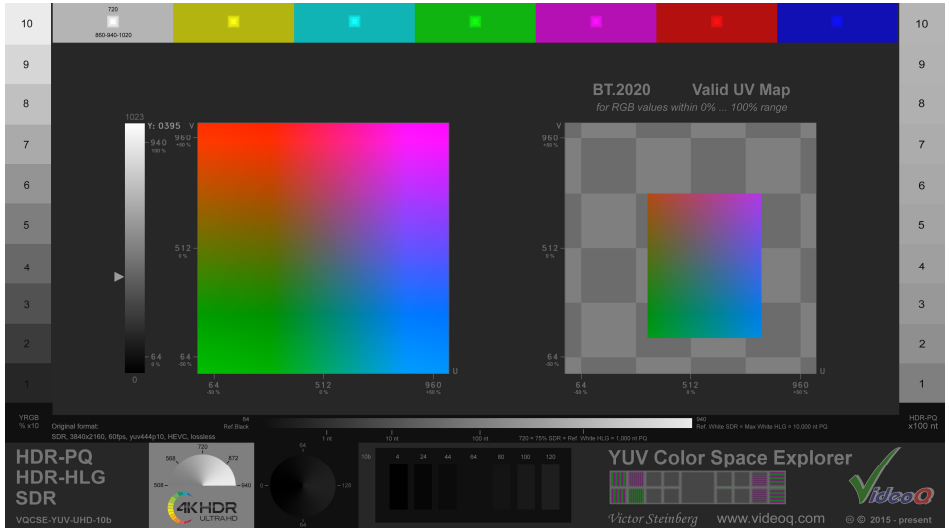
VQCSE tests are useful when processing and delivering in multiple formats or when converting between formats.

They can simplify test procedures and reduce the opportunity for misinterpretation of signal parameters and misalignment of systems.

VQCSE UHD Test Patterns Suite Features

VideoQ **VQCSE UHD** test patterns suite consists of **48** variants covering **RGB** and **YUV** color spaces, **SDR**, **HDR-PQ** and **HDR-HLG** modes, and **8** different **frame rates**.





The following **Appendix A** provides general background information, whilst the **Appendix B** provides more details about VQCSE test sessions scenarios, VideoQ software tools usage examples and test patterns features.

VQCSE Test Suite Video Formats

VQCSE suite includes 48 different **combinations** of

- 1 **frame size**: **UHD 3840x2160**
- 2 **color spaces**: **YUV** and **RGB**
- 3 **dynamic range** formats: **SDR**, **HDR_PQ** and **HDR_HLG**
- 8 **frame rates**: 23.976, 24, 25, 29.97, 30, 50, 59.94, and 60 fps

Special frame sizes, e.g. down-scaled HD 1920x1080 or other sizes, are available on request

VQCSE suite files are encoded into 2 default formats:

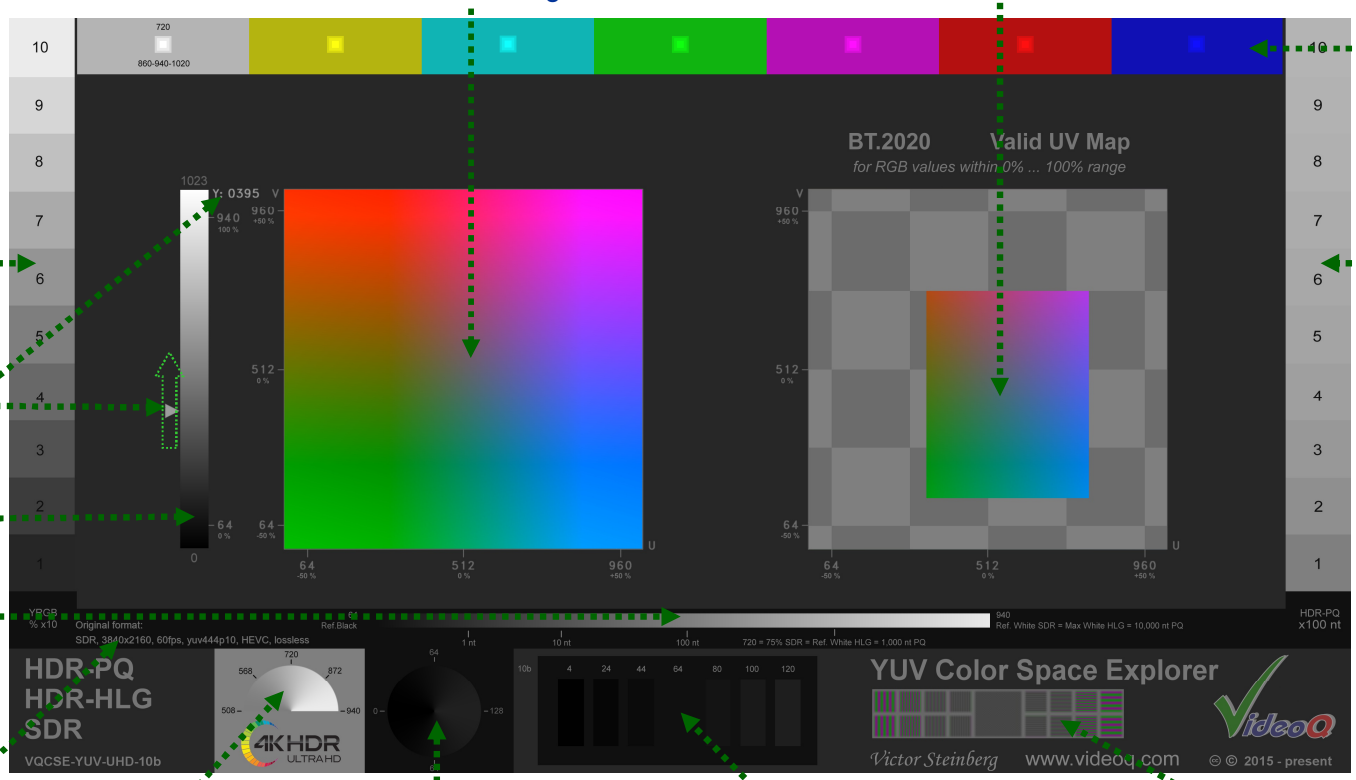
- YUV variants:
  - Lossless yuv444p10le HEVC, MP4, EAC3 LR audio
- RGB variants:
  - Lossless gbrp10le HEVC, MP4, EAC3 LR audio

Other formats, e.g. uncompressed RGB (r210) or YUV (v210) MOV, or lossy yuv420p10le MP4, are available on request.

VQCSE_YUV_SDR Test Composition

Main YUV Palette
Fixed current Y value, Full Range UV values

Valid YUV Palette
Valid colors fragment of Main YUV Palette



75% Color Bars and Two-tones Clipping Test Patches

11 steps Grayscale, YRGB NR 10% steps

11 steps Grayscale, PQ 100 nit steps, from 0 to 1000 nit

Current Y 10b value, sliding marker and numerical readout

Full Range Y Ramp, one 8 bit level steps

Narrow Range Ramp, 10 bit resolution, critical levels markers

Original Format Media Info Message

White SPLUGE Conical Grayscale

Black SPLUGE Conical Grayscale

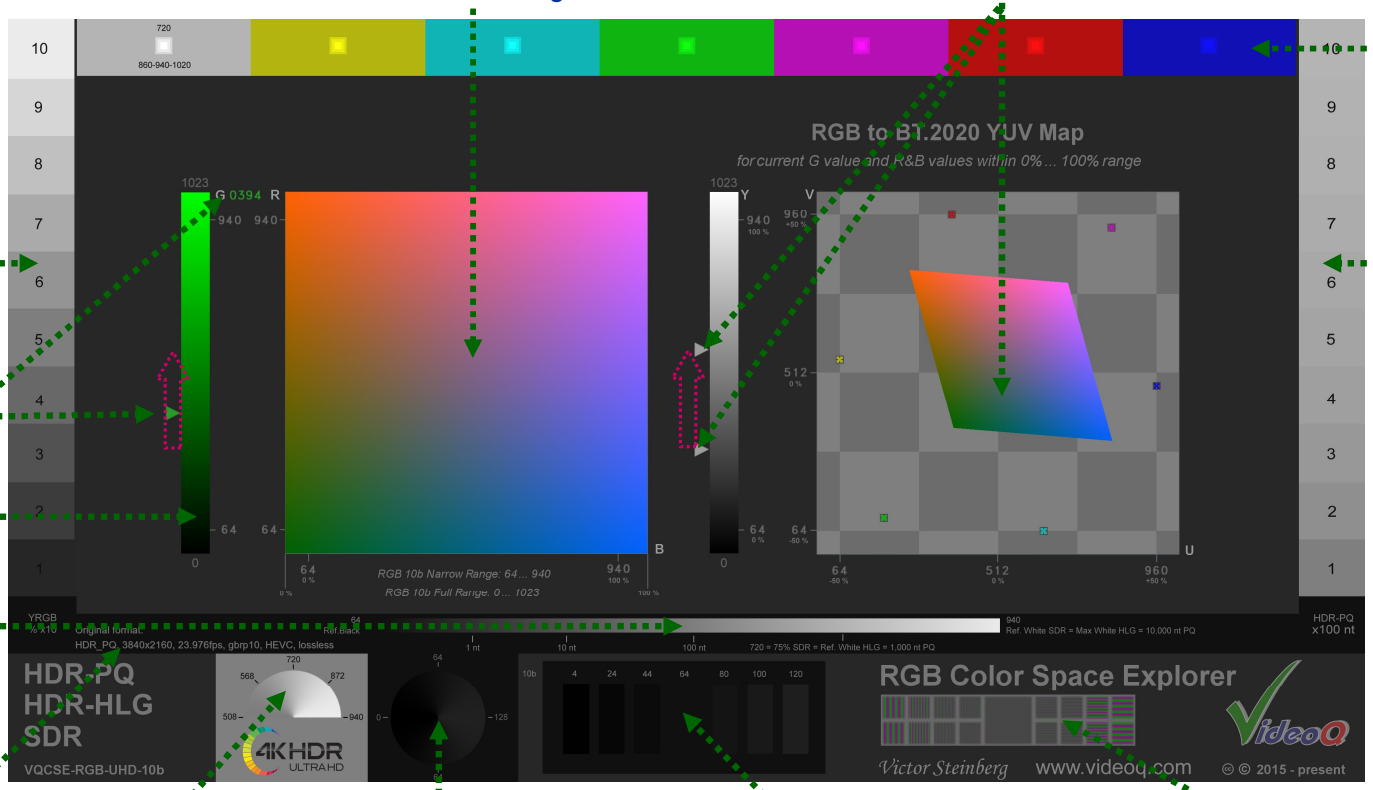
Narrow Range PLUGE, Reference Black and 6 Gray Bars

Color sub-sampling and scaling test

VQCSE_RGB_HDR_PQ Test Composition

Main RGB Palette
Fixed current G value, Full Range RB values

Valid YUV values: Y Ramp sub-range and UV Palette
mapped from main RGB Palette Narrow Range values



75% Color Bars and Two-tones Clipping Test Patches

11 steps Grayscale, YRGB NR 10% steps

11 steps Grayscale, PQ 100 nit steps, from 0 to 1000 nit

Current G 10b value, sliding marker and numerical readout

Full Range G Ramp, one 10 bit level steps

Narrow Range Ramp, 10 bit resolution, critical levels markers

Original Format Media Info Message

White SPLUGE Conical Grayscale

Black SPLUGE Conical Grayscale

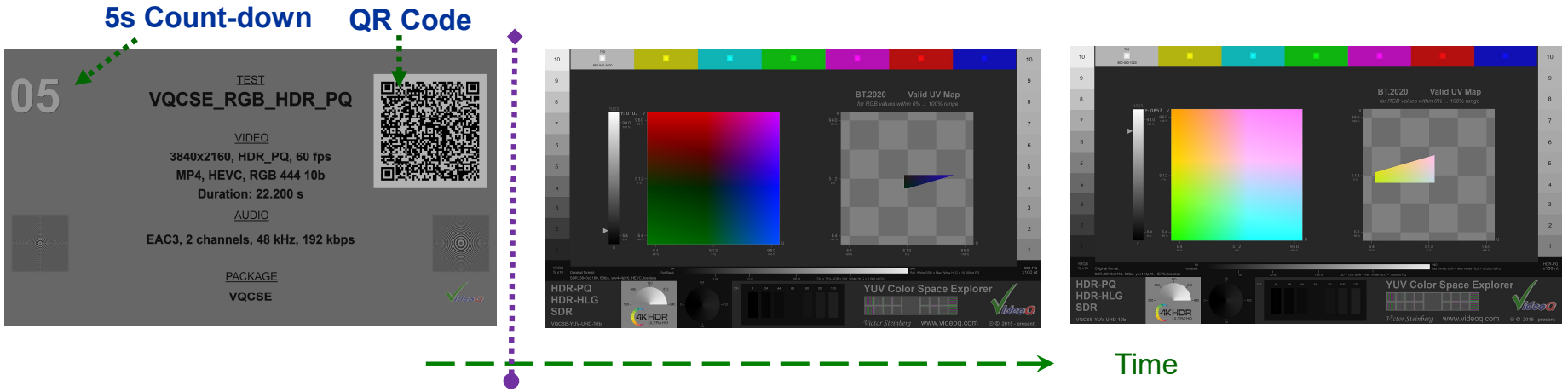
Narrow Range PLUGE, Reference Black and 6 Gray Bars

Color sub-sampling and scaling test

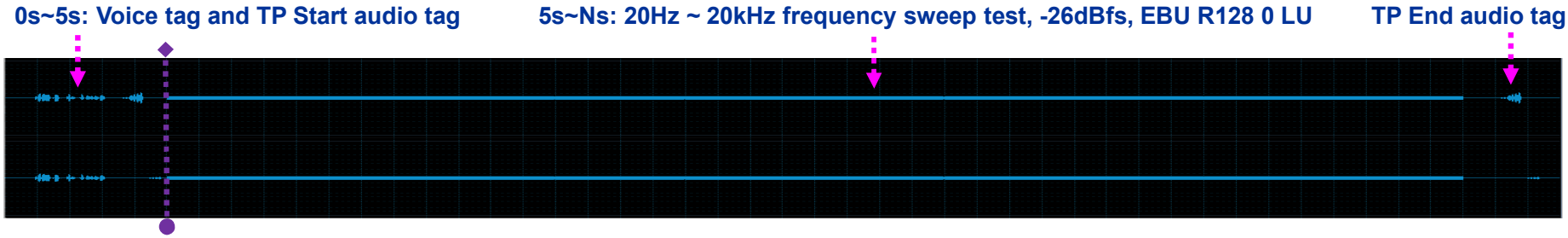
Media File Timeline Segments

VQCSE sequence is suitable for automated repetitive lab testing. The sequence consists of two segments:

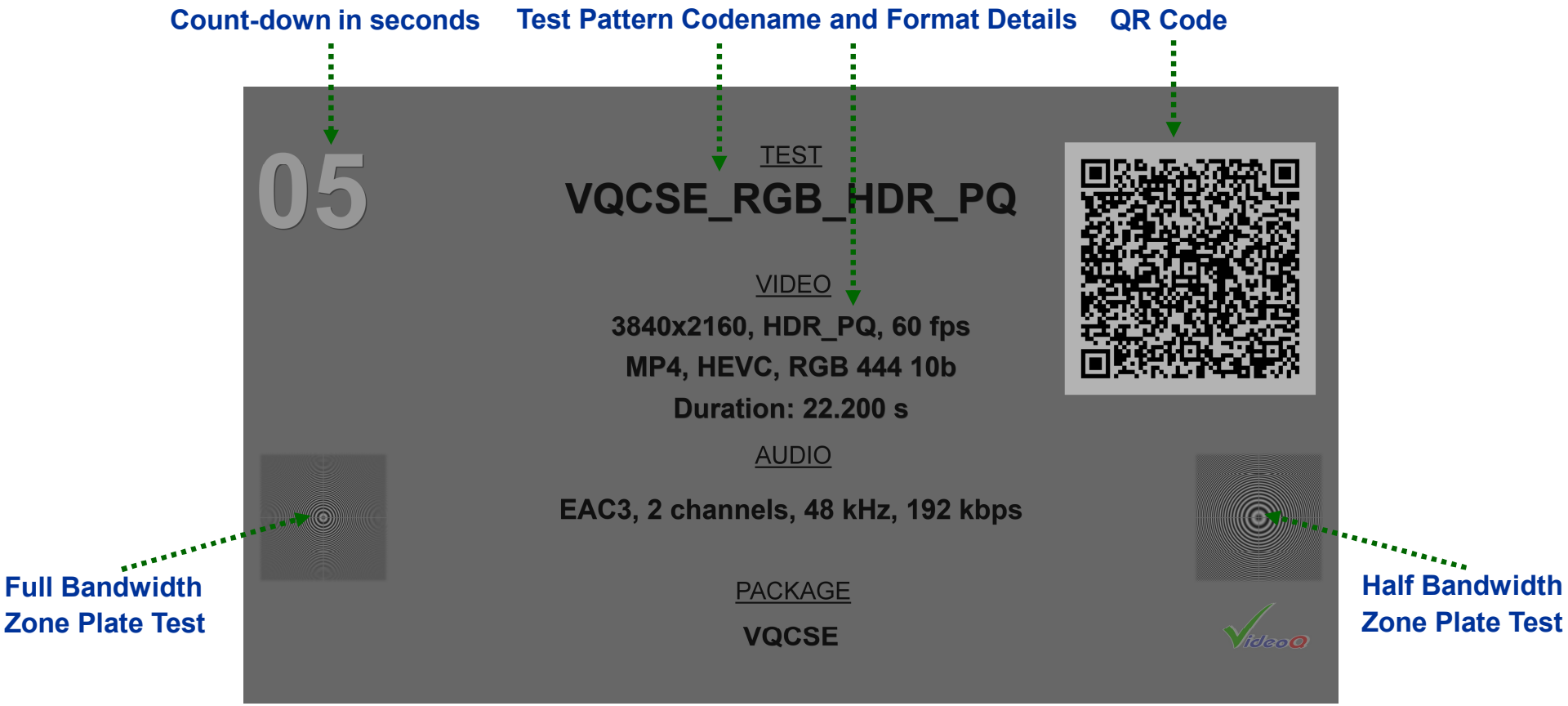
- 0s~5s: **Text Box** containing all test pattern details and machine-readable **QR Code**,
- 5s~Ns: **Color Space Explorer** test pattern, *test pattern and total sequence durations depend on the selected frame rate.*



Optional audio stream composition (LR stereo, EAC3):



VQCSE Text Box Example



About VideoQ

Company History

- Founded in 2005
- Formed by an Engineering Awards winning team sharing between them decades of global video technology.
- VideoQ is a renown player in calibration and benchmarking of Video Processors, Transcoders and Displays, providing tools and technologies instantly revealing artifacts, problems and deficiencies, thus raising the bar in productivity and video quality experience.
- VideoQ products and services cover all aspects of video processing and quality assurance - from visual picture quality estimation and quality control to fully automated processing, utilizing advanced VideoQ algorithms and robotic video quality analyzers, including latest UHD and HDR developments.

Operations

- Headquarters in CA, USA
- Software developers in Silicon Valley and worldwide
- Distributors and partners in several countries
- Sales & support offices in USA, UK

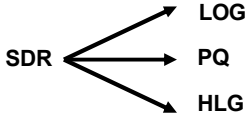
Appendix A: Background Info

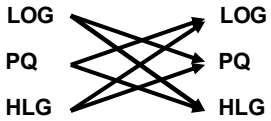
International Telecommunication Union (**ITU**) Recommendation **BT.2020** defines various aspects of ultra-high-definition television (**UHDTV**) with standard dynamic range (**SDR**) and wide color gamut (**WCG**).
It mandates the use of RGB ⇔ YUV Color Space Conversion **BT.2020 Matrices** for the frame sizes greater than HD.
Note that RGB ⇔ YUV conversion in ubiquitous **HD** format relies on significantly different **BT.709 Matrices**.

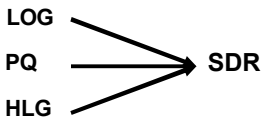
Since the introduction of **BT.601** standard YUV data are generated in **Narrow Range** format (abbreviated as **NR**).
Main advantage of the NR format is the availability of extra levels below **Reference Black** and above **Reference White**.

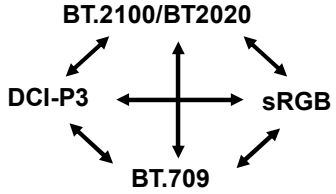
However, the RGB data traditionally used in production and post-production are defined in two formats – **Full Range** format (**FR RGB**, without reserved levels) and **Narrow Range** format (**NR RGB**, similar to NR YUV).
Thus, generic RGB ⇔ YUV conversion workflows should handle FR/NR RGB, NR YUV and BT.2020/BT.709 Matrices.

The **HDR/SDR** conversion processes are even more complicated, note the **Unified Reference White** concept:
http://www.videoq.com/hdr_ref_white.html









Challenge and Solution

The major effort in capturing, delivering, and rendering of high-quality moving images, demands the guidance and commonly accepted rules. The issues of tone mapping, color legalization, color banding and bit depth handling, are not yet fully resolved and often misunderstood. The solution, is to establish easy-to-use rules and related tools, through the expanded derivatives of VideoQ Color Space Explorer Test Patterns suite.

The so-called “three-point monitoring” approach provides for the correct detection of workflow parts responsible for the overall color distortions:

1. Insert test pattern at the source or any other test point within the workflow, e.g. encoder input
2. Check colors representation at the output of the encoder, transcoder or packager
3. Finally, check it again at the player/display screen output

The long history of broadcast TV demonstrates the path, from the usage of physical reflectance test charts, to the extremely successful practice of using color bars test patterns, and finally to modern sophisticated dynamic test patterns used to check, calibrate and ensure reliable exchange of video images on a global scale.

VideoQ has been active in standards and test patterns creation, so we can now publish and release the calibrated **V**ideo**Q** **C**olor **S**pace **E**xplorer (**VQCSE**) test tools suite that meet this challenge.
The best way to reliable QA is via reliable QC!

Appendix B: Usage Examples

This section provides more details about VQCSE test sessions scenarios,
VideoQ software tools usage examples and test patterns features.

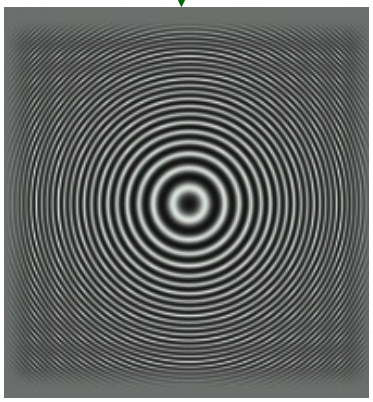
The screenshots and measurement results shown in this section are taken from VideoQ **VQV** – Media Files Viewer-Analyzer:

http://www.videoq.com/vqv.html

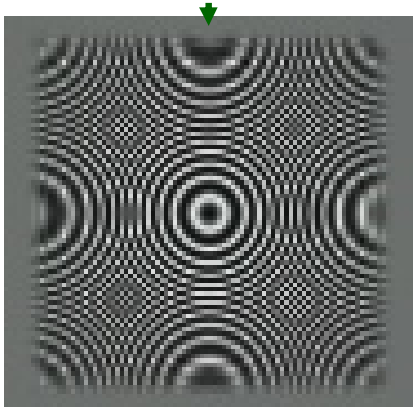
Full Bandwidth Zone Plate Test Usage

Player window size scaling distortions:

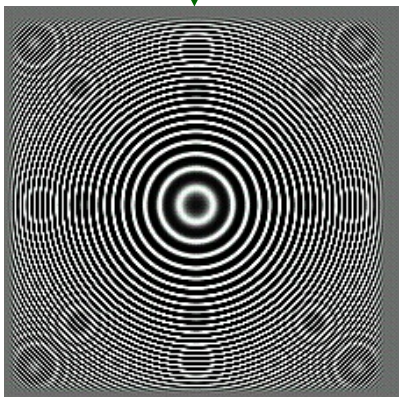
"Banding"



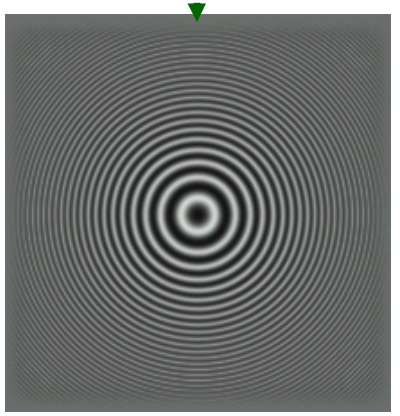
"Beating"



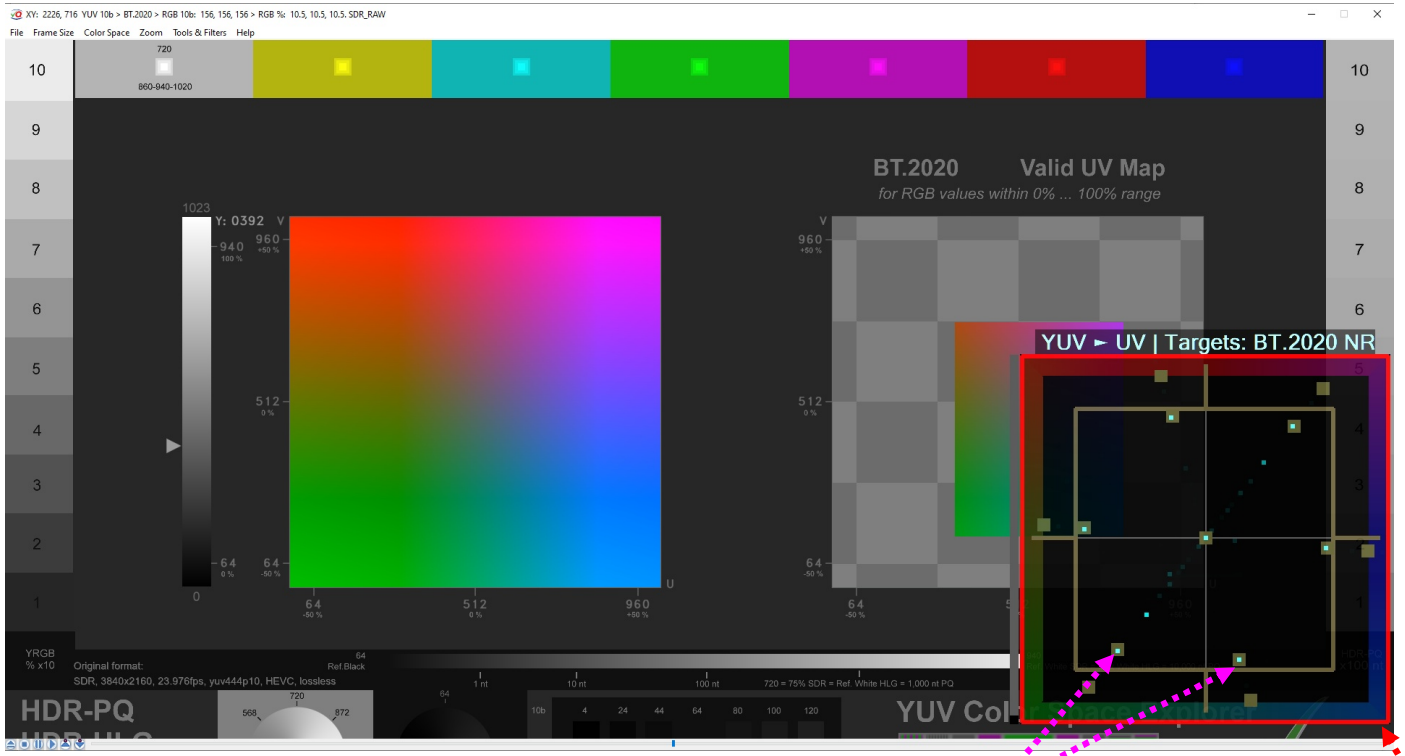
Display over-enhancement



Frame size reduction



Checking UV Data Levels – VectorScope



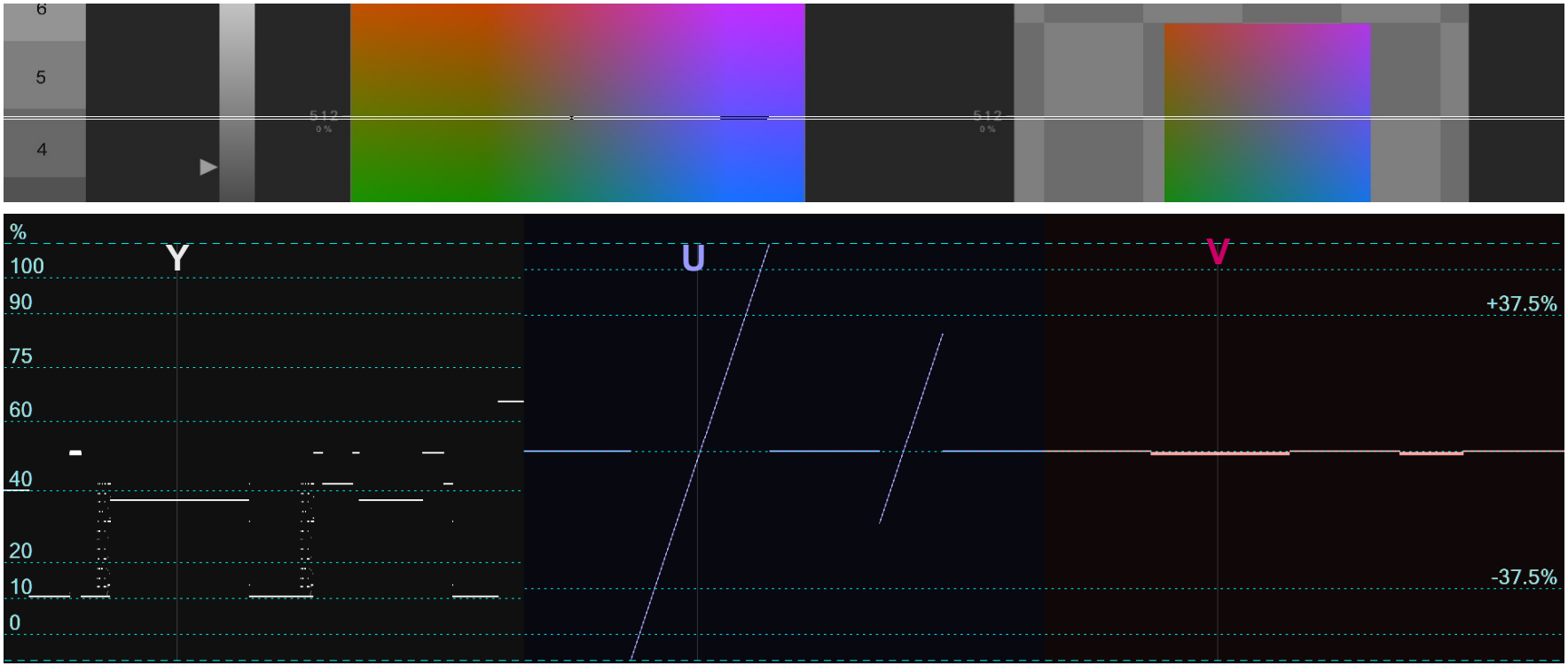
Color Bars UV data are **correct** – all vectors hit the **centers of 7 target boxes**.

Palette UV values are reaching the **boundaries** of UV **Full Range** as emphasized by VectorScope **Red Frame**

It means that UV data of the original VQCSE test are **not clipped**.

Checking YUV Data Levels – Waveform Monitor

User-selected Waveform Monitor Analysis Area: Lines Range & Pixels Highlight Mask



VQCSE Main Palette YUV data are **correct** – **Y** and **V** values are **constant** within the selected area (waveform horizontal lines);

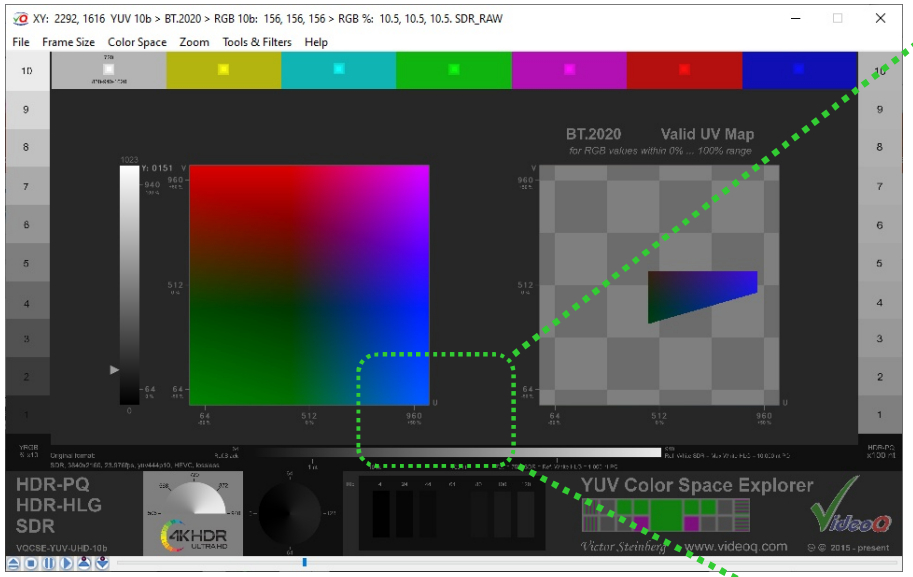
U values are **linearly rising** covering **Full Range** – as it should be for the original **unclipped** VQCSE test.

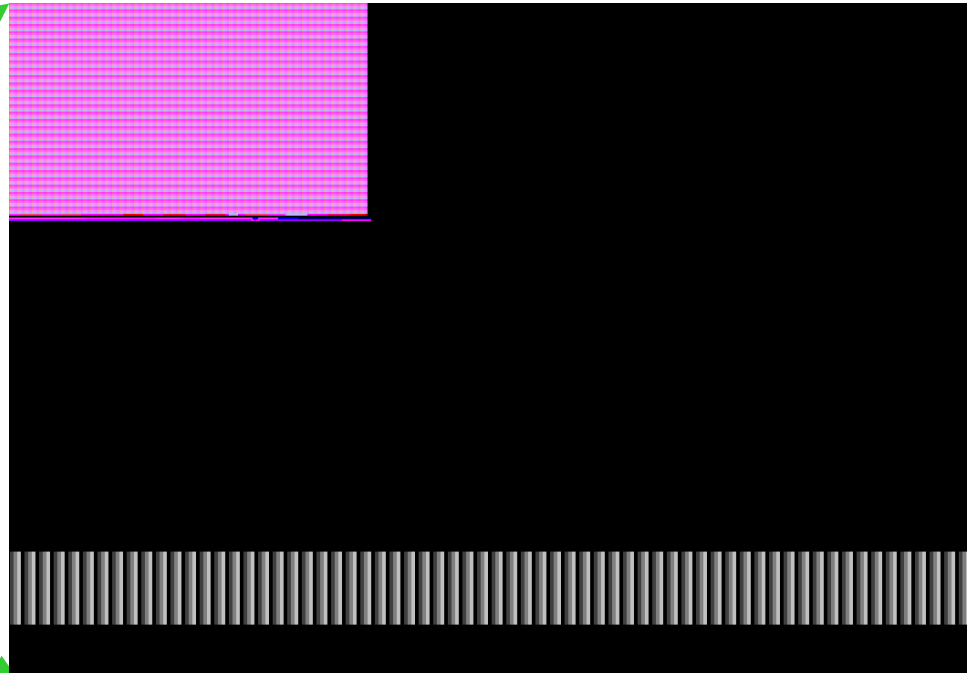
The **absence of bends or breaks** indicates the **absence of color processing or distortions.**

Checking Bit Depth – LSB Image

VQCSE_YUV_SDR MSBs Image

Within the Main UV Palette and Y Ramp areas:
LSBs image shows **4 gradations**, i.e. **2 LSBs** are active.
It means that actual bit depth is: 8 MSBs + 2 LSBs = **10 bit**

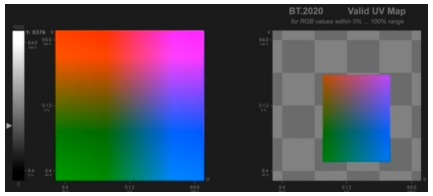


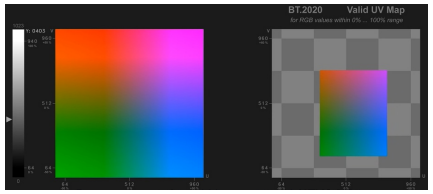


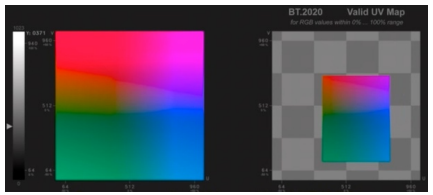
Max 4:1 Zoom centered on the selected area

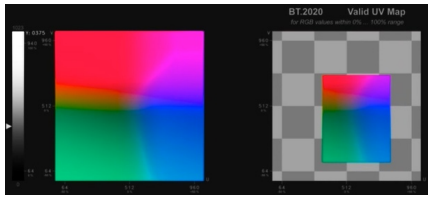
LSB image gradations patterns are **uniform**, it means that the original data **have been not scaled**: – preserving **one 10b increment per pixel**

Checking Video Players Rendered RGB Images









Click on the links below to see the screen-grabber video:

VQCSE-YUV_Player1_SlightBanding.webm

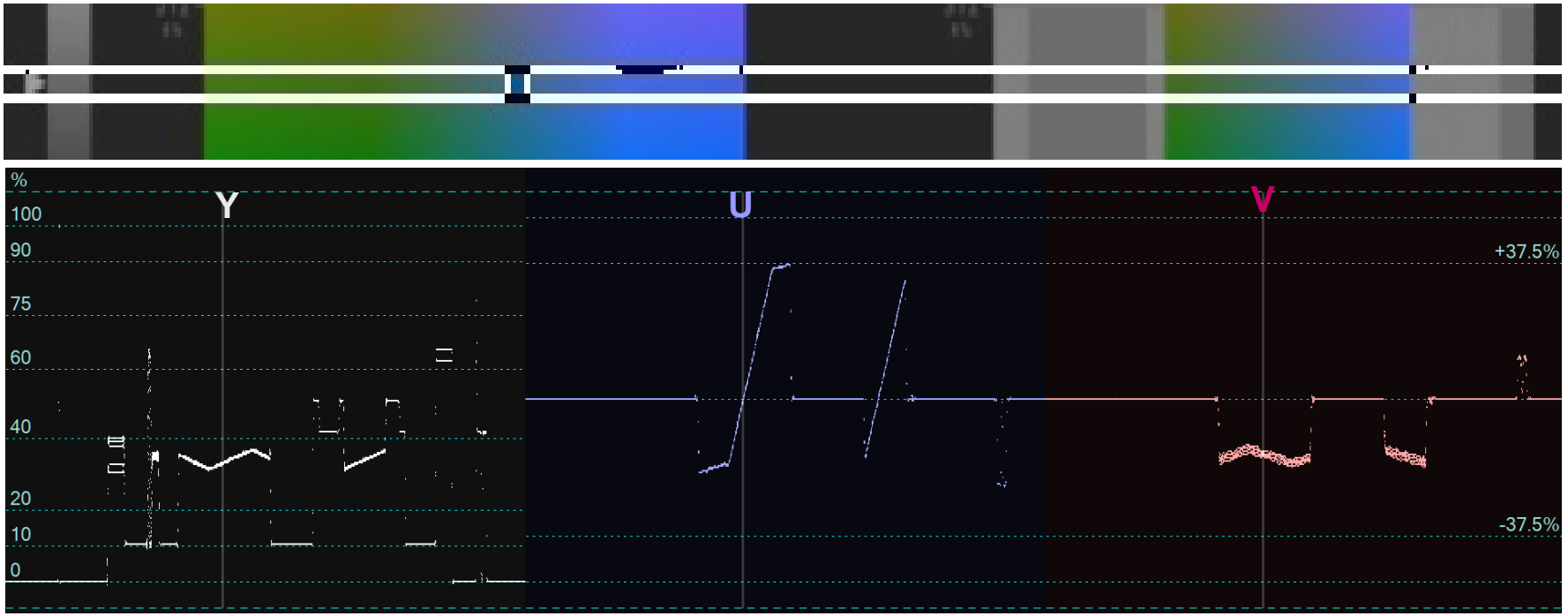
VQCSE-YUV_Player2_SlightBanding.webm

VQCSE-YUV_Player1_SevereBanding.webm

VQCSE-HDR2SDR_SevereBanding.webm

Checking Players – Screen Grabber Video #1 Waveforms

User-selected Waveform Monitor Analysis Area: Lines Range & Pixels Highlight Mask



Palette YUV data are **not exactly correct** – **Y** and **V** values are **not perfectly flat** or **linear ramps** within **Valid YUV Range**;

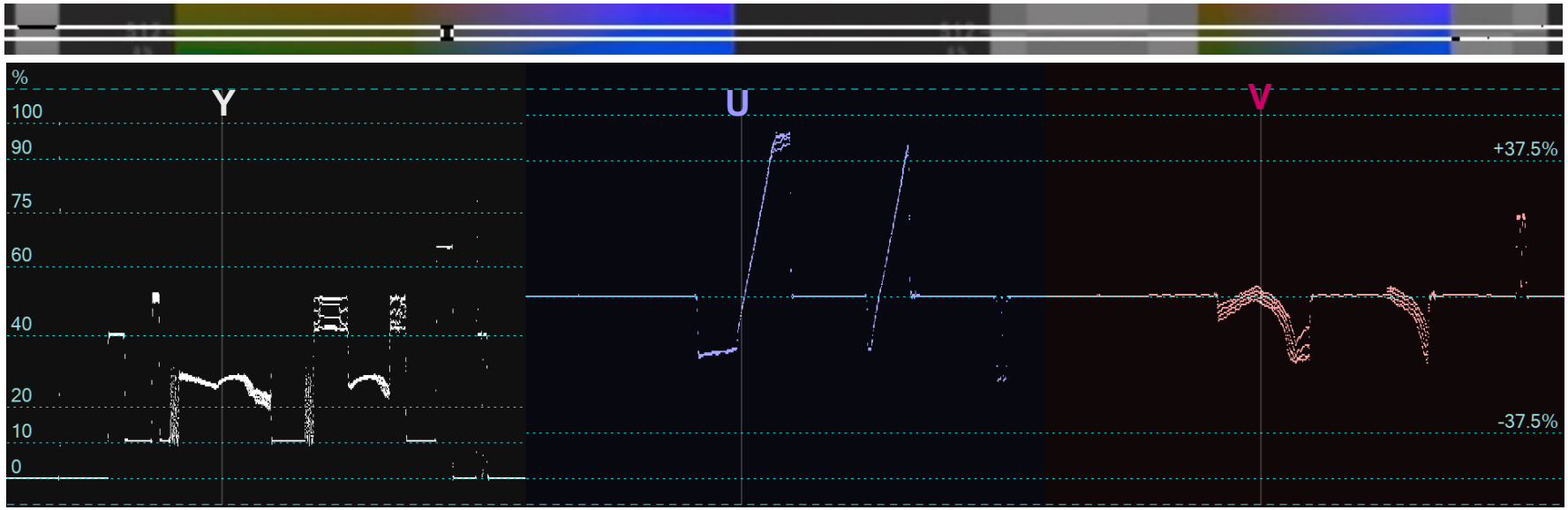
U values rise within **Valid YUV Range** is almost **linear**, but they are **clipped beyond its boundaries** (YUV to RGB conversion result).

The **absence of strong bends or breaks** within the **Valid YUV Range** indicates the **absence of strong color distortions**.

VQCSE-YUV_Player1_SlightBanding.webm

Checking Players – Screen Grabber Video #2 Waveforms

User-selected Waveform Monitor Analysis Area: Lines Range & Pixels Highlight Mask



Palette SDR YUV data are **seriously distorted** – within the **Valid YUV Range Y** and **V** waveforms are **visibly bent**;

U values rise within **Valid YUV Range** is almost **linear**, but they are **clipped beyond its boundaries** (YUV to RGB conversion result).

Strong bends and breaks within the **Valid YUV Range** indicate **strong color distortions**.

VQCSE-YUV_Player1_SevereBanding.webm