



HDR Test Patterns

Training Presentation

September 2025



VideoQ HDR Tools

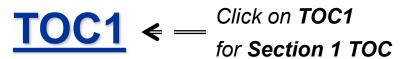
videoq.com

Table of Contents

Val

- 1. General Info
- 2. VideoQ Color Bars Set
- 3. VQMPC Test Patterns Set
- 4. VQLA Test Patterns Set
- 5. VQSP Very Low Light Levels Test
- 6. VQAPL Dynamic Average Light Level Test
- 7. About VideoQ
- 8. Appendix A: VQMPC Test Details
- 9. Appendix B: Additional Tools

Click on **VQL Logo**in the upper-right corner
of any slide for this global **Table Of Content**



1. General Info



- 1.1 Applications of VideoQ HDR Test Patterns
- 1.2 HDR Flavors and Metadata Issues
- 1.3 Color Spaces, Data Ranges, Conversion Options
- 1.4 Color Bars Related Standards
- 1.5 VideoQ HDR Test Patterns Suite Entry Level Set
- 1.6 Audio Component Options
- 1.7 VideoQ HDR Test Patterns Data Formats

1.1 Applications of VideoQ HDR Test Patterns



Picture quality control and calibration tools for general public, video installers, hardware and software developers, video development labs, production, post-production and content distribution facilities in the fields of:

- Broadcast HD & UDH TV
- Consumer Electronics and Video Games
- Video Transcoding
- Video Data Compression
- Digital Cinema
- Home Theatres
- IPTV, CDN
- Cloud video processing and transcoding

1.2 HDR Flavors and Metadata Issues



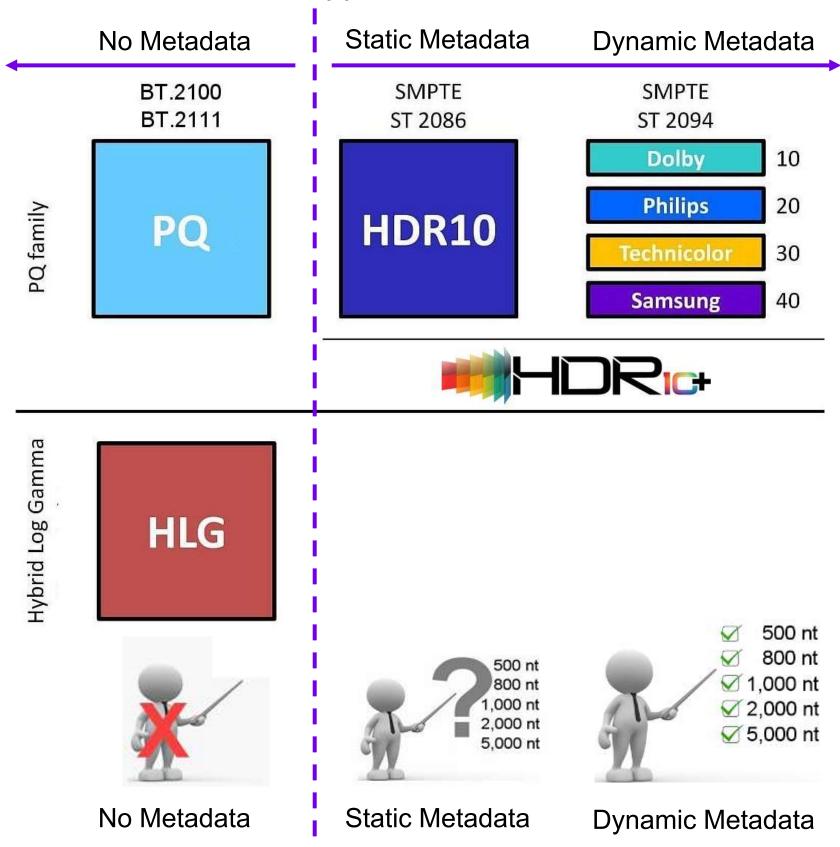
The Rec. ITU-R BT.2100-3 standard specifies *only* two HDR types: HDR-PQ and HDR-HLG. All other flavors are regarded as valid commercial derivatives of these two. The VideoQ approach and HDR Test Patterns follow this fundamental ITU standard.

The **no-metadata HDR** systems are based on the concept of **the Hypothetical Reference Display**.

"Plain" **no-metadata HDR-PQ** and **HDR-HLG** formats **allow** all kinds of derivations from this base **without** restricting content re-purposing and display rendering options.

These formats require only one simple **PQ/HLG switch** in the stream header.

For example, it is possible to use a custom tone mapping for different environments to accurately reproduce details so they remain easily visible in any lighting condition.



The **metadata-driven HDR-PQ** systems are based on the concept of a pre-defined list of **Target Displays**.

This **prevents** any deviation from this base and limits the number of content re-purposing and display rendering options.

Static and dynamic metadata presumably serve for the preservation of a content originator's "creative intent" and related authoring rights.

This concept is **applicable** to **controlled environments**, such as digital cinema or home theater, but it is **not applicable** to **open**, thus **not controlled**, consumer, prosumer, broadcasting and web-casting environments.

1.3 Color Spaces, Data Ranges, Conversion Options



International Telecommunication Union (ITU) Rec. ITU-R BT.2020 defines various aspects of ultra-high-definition television (UHDTV) with standard dynamic range (SDR) and wide color gamut (WCG).

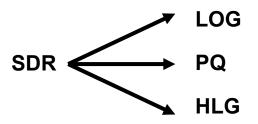
It mandates the use of RGB ⇔ YUV Color Space Conversion **BT.2020 Matrices** for the frame sizes greater than HD. Note that RGB ⇔ YUV conversion in ubiquitous **HD** format relies on significantly different **BT.709 Matrices**.

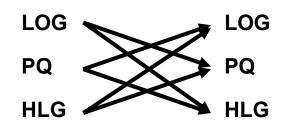
Since the introduction of **BT.601** standard YUV data are generated in **Narrow Range** format (abbreviated as **NR**). Main advantage of the NR format is the availability of extra levels below **Reference Black** and above **Reference White**.

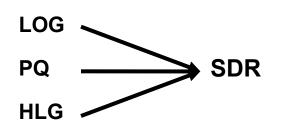
However, the RGB data traditionally used in production and post-production are defined in two formats – **Full Range** format (**FR RGB**, without reserved levels) and **Narrow Range** format (**NR RGB**, similar to NR YUV).

Thus, generic RGB ⇔ YUV conversion workflows should handle FR/NR RGB, NR YUV and BT.2020/BT.709 Matrices.

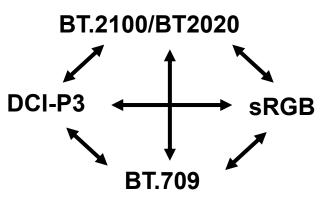
The HDR/SDR conversion processes are even more complicated, note the Unified Reference White concept:











1.4 Color Bars Related Standards



Years ago, ITU-R issued Recommendation **BT.471** "Nomenclature and Description of Color Bar Signals"; it covers only **Full Frame Bars** and does not address modern **UHD**, **HDR** and **WCG** issues.

Widely used in several countries multi-band **SMPTE RP219 Bars** (derived from the legacy **SMPTE EG1** Bars) are suitable *only* for **Standard Dynamic Range** (**SDR**) **YUV** formats.

The HDR and WCG issues are mostly covered by Recommendation <u>BT.2111</u> "Specification of colour bar test pattern for high dynamic range television systems".

However, the Recommendation BT.2111 specifies the reference test patterns *only* for the **High Dynamic Range** (**HDR**) television systems specified in **BT.2100**.

This means that currently there is no *officially recommended* Color Bars Test Patterns matching BT.2111 and suitable for widely used **Standard Dynamic Range** workflows in mixed RGB/YUV, UHD/HD and WCG formats.

VideoQ has filled this gap by developing <u>VQCB</u> – the suite of Color Bars Test Patterns, which includes all **BT.2111 HDR** variants **as well as** the newly developed **SDR** variants for the <u>BT.2020</u> Color Space **and** traditional <u>BT.709</u> Color Space. NB: By some obscure reasons the BT.709 color space was labeled by marketing people as "Narrow Color Gamut".

The layout, data levels and appearance of the SDR variants of **VQCB** test pattern suite are similar to the HDR variants, which makes much easier the usage of the whole VQCB suite in modern mixed formats environments.

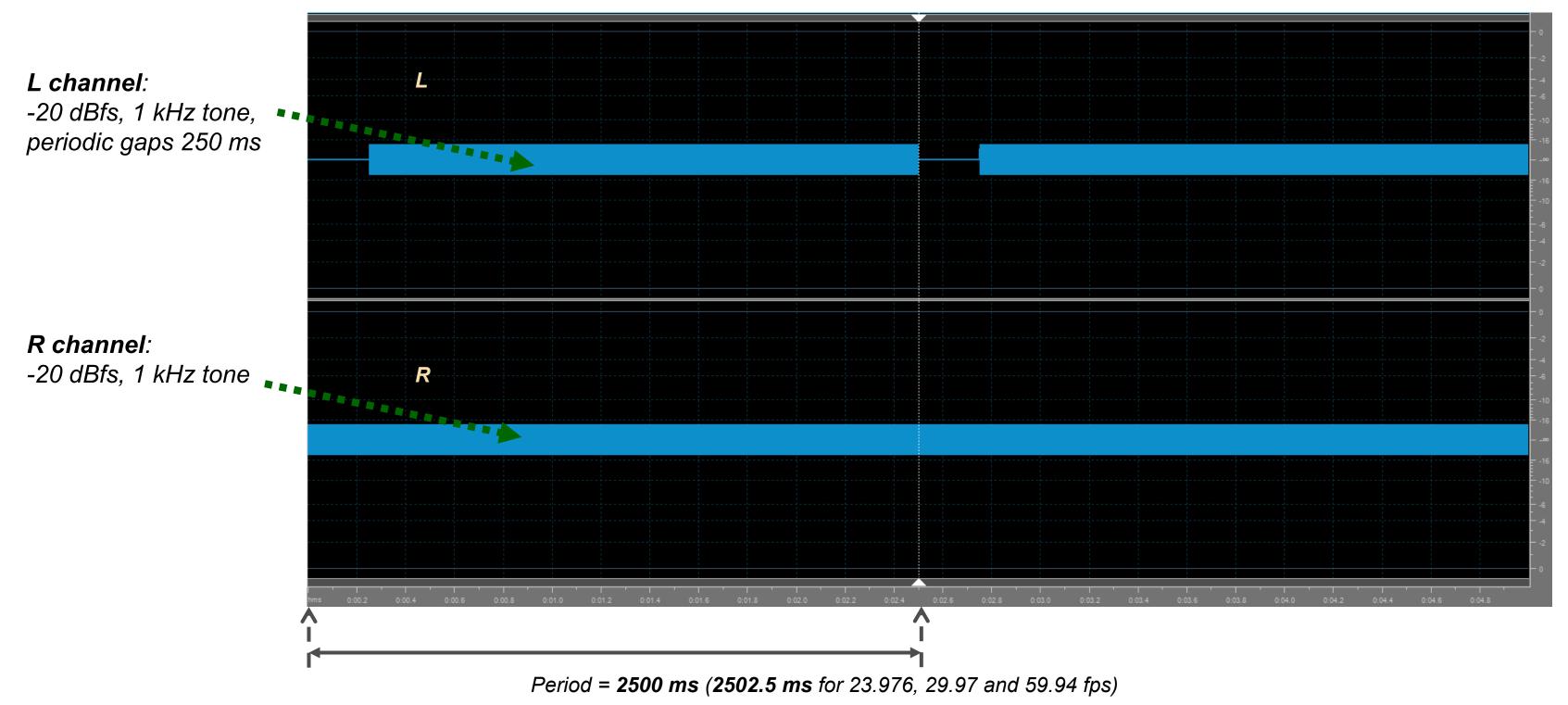
1.5 VideoQ HDR Test Patterns Suite – Entry Level Set



Codename	Description	PQ version	HLG version
VQCB	VideoQ Color Bars specified by ITU BT.2111. Optional text box slate with QR code and text/graphics overlays within side panels show file parameters and customer/source info. Note the availability of VQCBA analyzer and SDR version.	Wilders State Michigan State	Wilson Service (1994) Wilson Service (1994) Wilson Service (1994) Wilson Service (1994) Wilson Service (1994)
VQMPC	VideoQ Multi-Purpose Chart with optional AV Sync components. A sophisticated test pattern for display setup, image quality visual assessment and processing chain performance check. Note the availability of VQMPC SDR version		
VQLA	VideoQ Levels Alignment static test pattern for metadata handling, displayed light levels range and tone-mapping performance check	Supply Algorithmets Treel Physical State Common State Com	Same Alignment last
VQSP	VideoQ Super PLUGE (Conical Grayscale) test pattern for the HDR-PQ displays performance check for very low light levels. The Light Level Range is 0.001 nit 2 nit		N/A
VQAPL	VideoQ Average Picture Level dynamic sequence for testing display auto-brightness control performance. Featuring a static photo on a calibrated variable light level background. FALL range is 75 nit 6340 nit	STATE AND ADDRESS OF THE SAME ADDRESS OF T	N/A

1.6 Audio Component Options





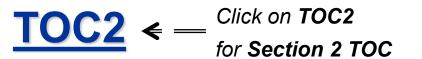
On request this optional audio test stream and optional voice tags can be added to VQLA, VQSP and VQAPL tests. It complies with the generic multichannel audio line-up tones specification of the EBU Tech 3304 standard. Note that VQCB and VQMPC tests always contain the audio streams, described in the related sections of this presentation.

1.7 VideoQ HDR Test Patterns Data Formats



Test patterns are available as media files in the following formats:

- Frame size: 3840x2160 (UHD) = default, 1920x1080 (HD) available on request:
- Media file parameters:
 - MP4 and WEBM containers
 - HEVC, VP9, AV1 lossless codecs
 - Seamless loop duration: 20s, 40s or 400s (typical values),
 - Pixel format: 444 or 420, 10, 12 or 16 bit per component
 - IPPP... GOP size: 1s
 - HDR-PQ or HDR-HLG metadata embedded as appropriate
- Frame rate: 24.0 fps = default, other frame rates available upon request for an additional fee
- Audio codecs: 2.0 stereo, AC3 for MP4, Vorbis OGG for WEBM
- Other video & audio data formats and codecs are available upon request for an additional fee



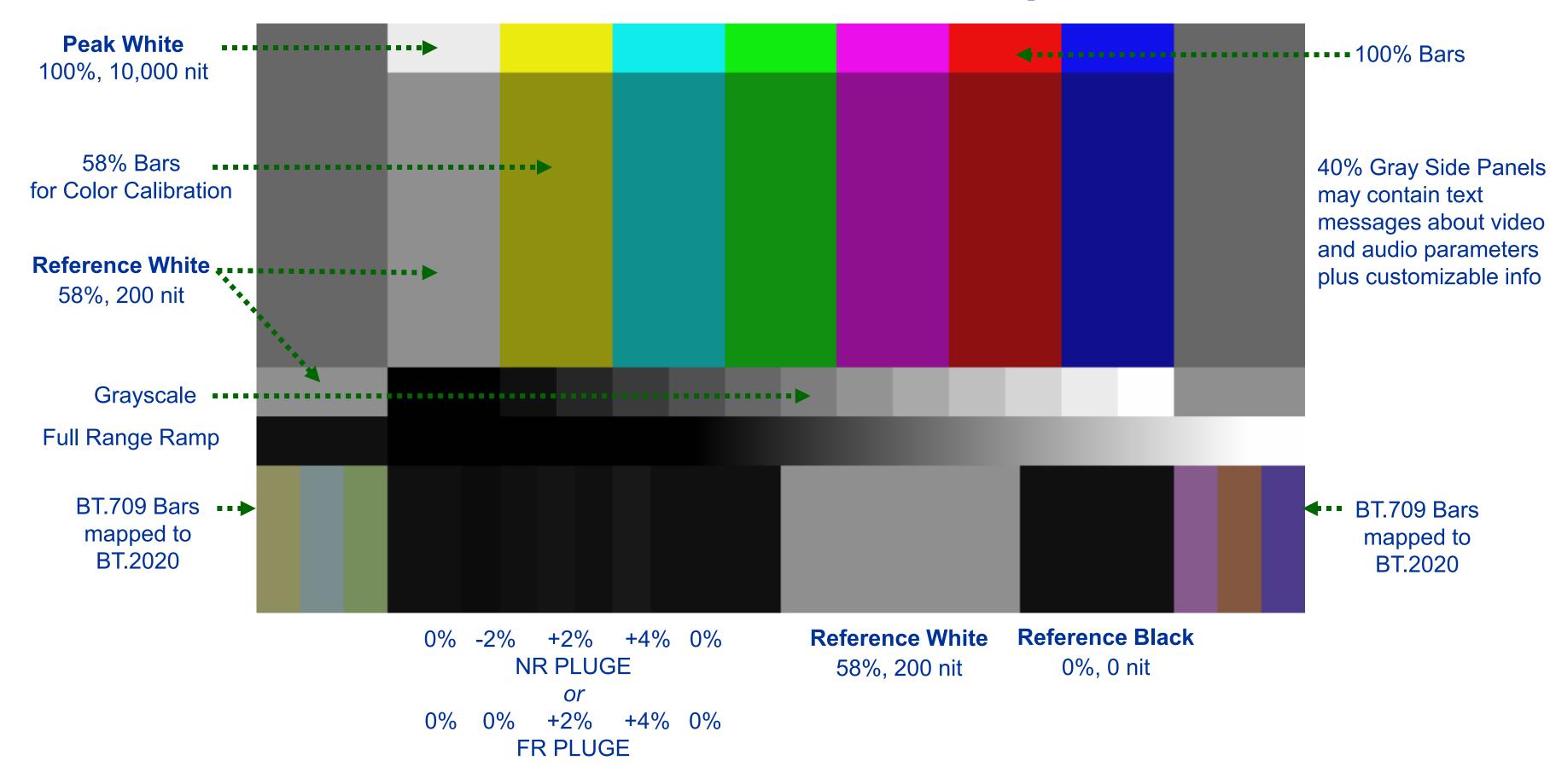
2. VideoQ Color Bars Set



- 2.1 VQCB HDR-PQ Test Composition
- 2.2 VQCB HDR-HLG Test Composition
- 2.3 VQCB Sequence Timeline Segments

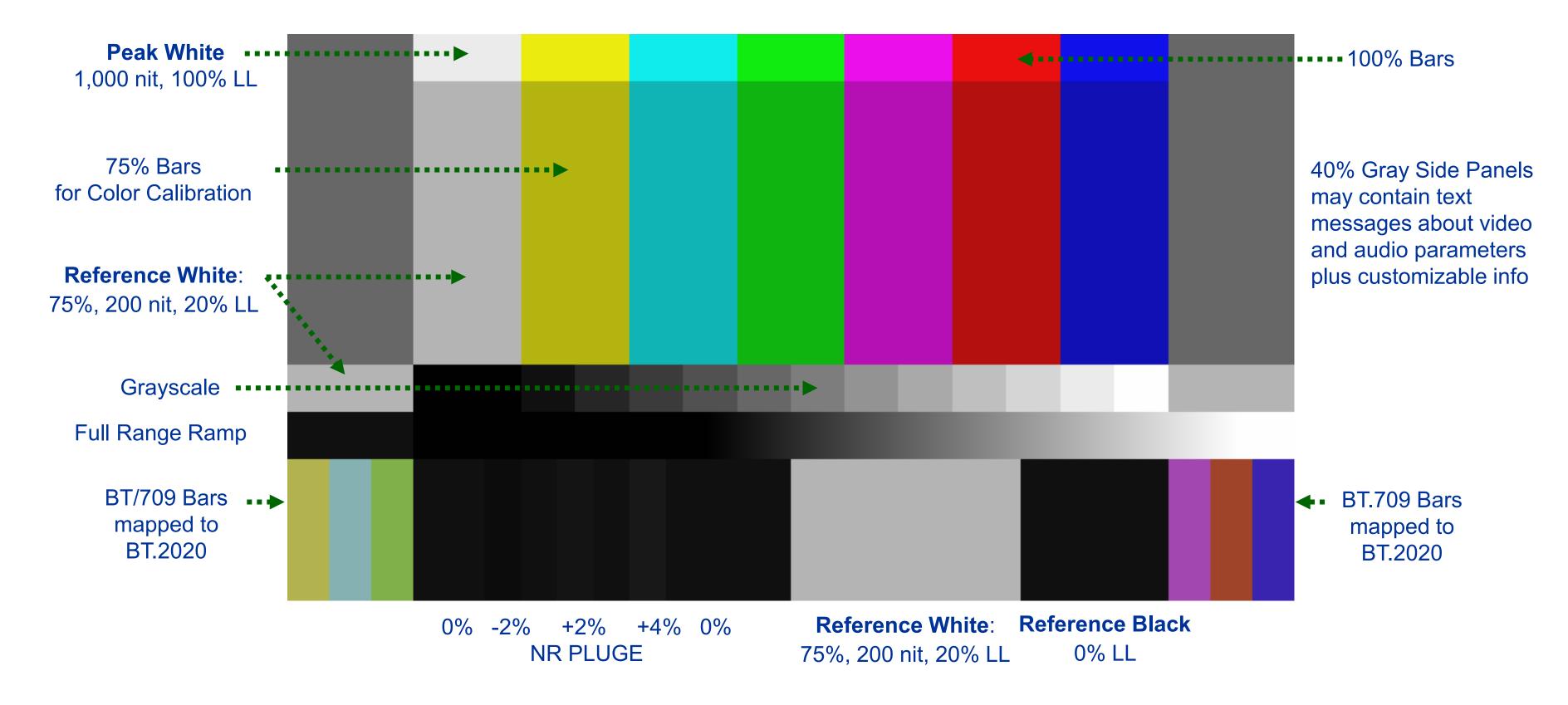
2.1 VQCB HDR-PQ Test Composition





2.2 VQCB HDR-HLG Test Composition



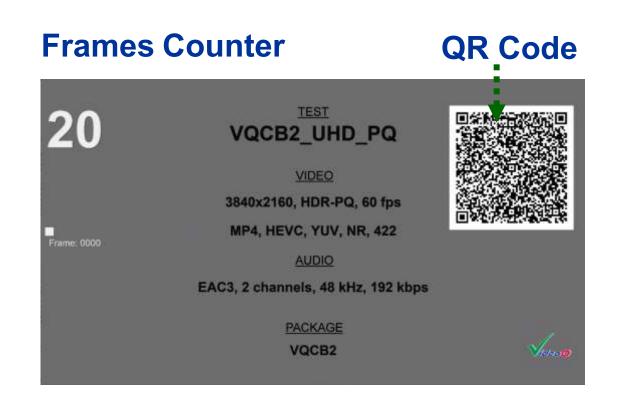


2.3 VQCB Sequence Timeline Segments



VQCB sequence is suitable for automated repetitive lab testing. The sequence consists of three segments:

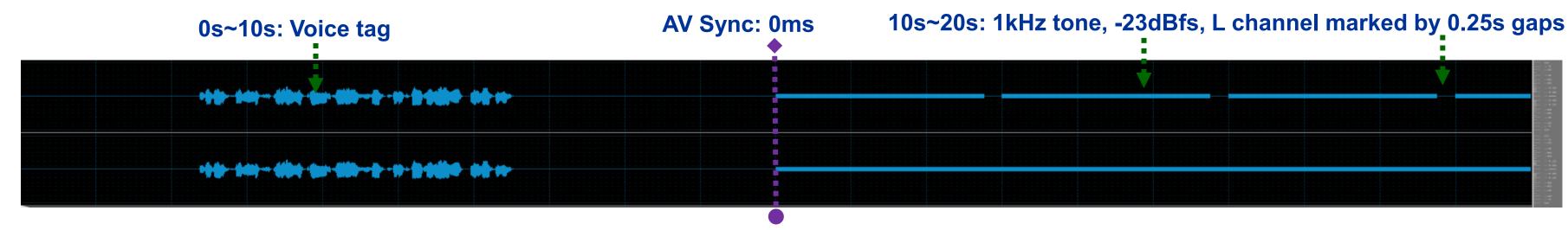
- 0s~10s: Text Box containing all test pattern details and machine-readable QR Code,
- 10s~18s: Color Bars test pattern,
- 18s~20s: **Black**.

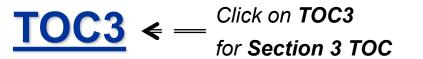






Optional audio stream composition (LR stereo, 48kHz, PCM 24b or AC3 192kbps):





3. VQMPC Test Patterns Set



- 3.1 VQMPC Test Features
- 3.2 VQMPC Test Composition
- 3.3 VQMPC Test PQ version
- 3.4 VQMPC Test HLG version
- 3.5 VQMPC Usage Example HDR-PQ to SDR Conversion
- 3.6 VQMPC Optional AV Sync Test Audio Component
- 3.7 VQMPC Optional AV Sync Test Video Component

3.1 VQMPC Test Features



Multi-purpose test pattern to check at glance:

- Geometry: Aspect Ratio, Overscan and "Ultra-wide Mode" effects of the display
- Scaling Quality or proof of no-scaling, especially in case of DHCP conflict in STB
- Colors, Gradations and Light Levels:
 - PLUGE, SPLUGE, special HDR Color Bars and Grayscales for display setup,
 - Central Photo Insert for general quality evaluation
- 2D Frequency Response
- Sharpness Correction settings & controls
- Display setup and Dynamic Range Mode settings & controls
- Frames Continuity and AV Sync Errors



3.2 VQMPC Test Composition



Four Corner Radial Plates aimed at testing Geometry & Sharpness

Vertical Ruler,
Vertical Frequency Bursts

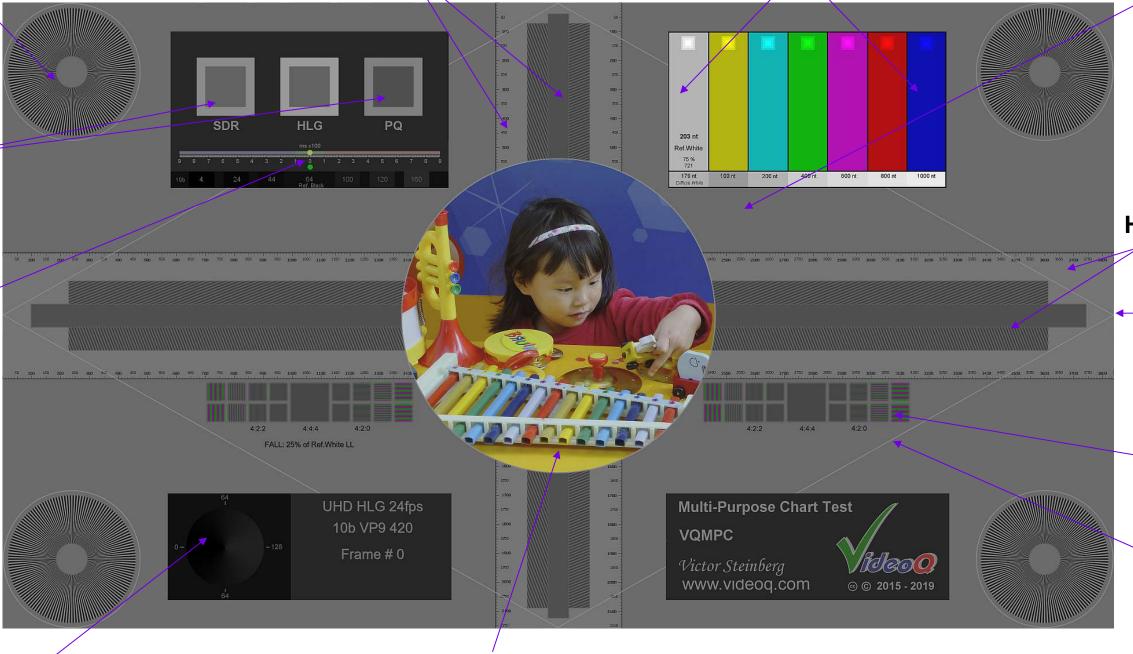
Special HDR Color Bars
aimed at testing
HDR Display Light Output Profile

Mid-gray background aimed at testing

Display Light Output Uniformity

3 OETF Curve Tests aimed at testing Display Tone-mapping Mode Selection

Sliding Yellow Marker and Flashing Green Marker aimed at testing Frames Continuity and AV Sync Errors



Horizontal Ruler, Horizontal Frequency Bursts

Four H & V

Edge Markers

White line width = 1 pixel

Chroma Sampling Test
aimed at testing
Encoded YUV Pixel Format

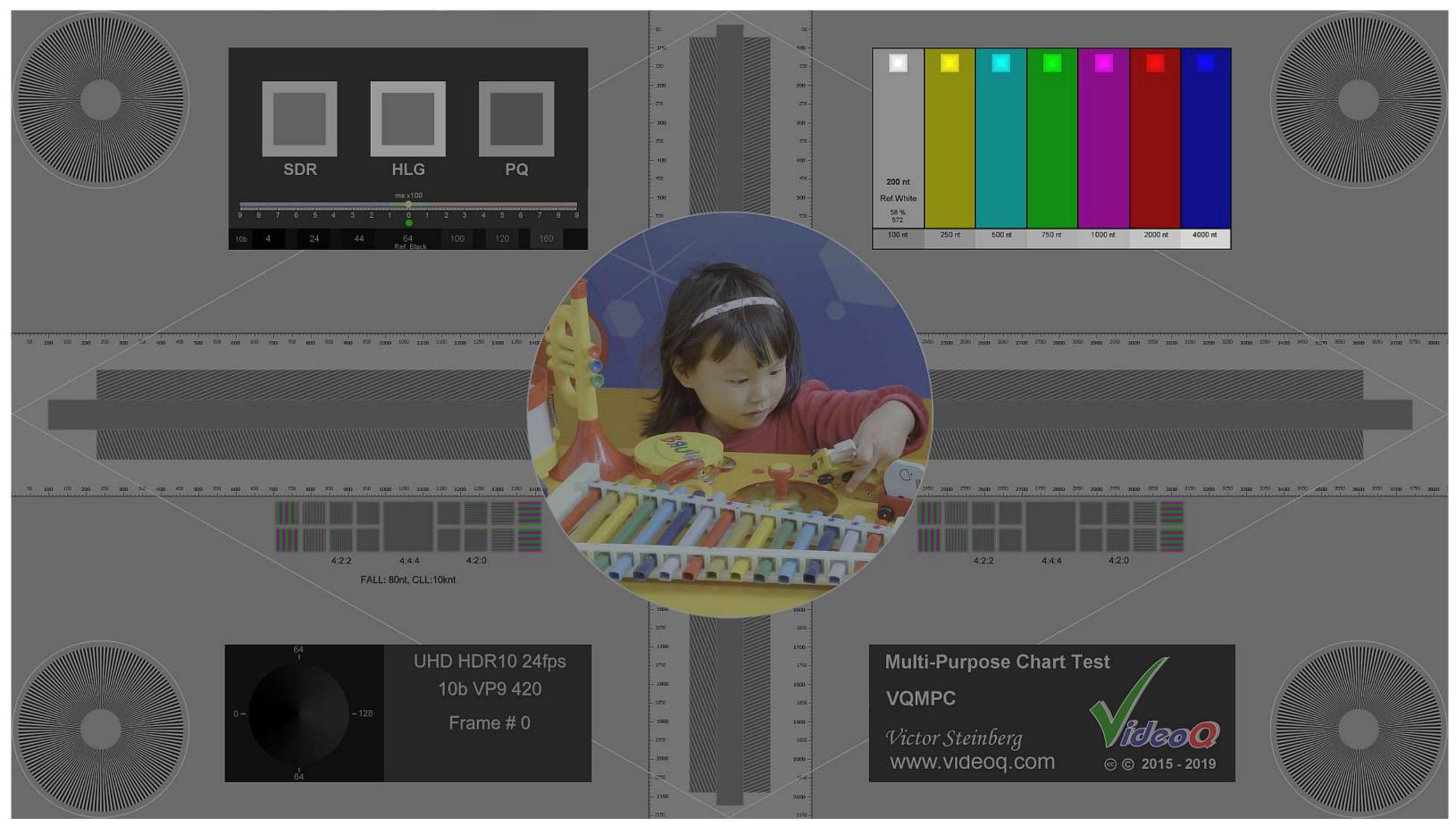
Diamond Lines aimed at testing picture **Geometry**

Black SPLUGE Conical Grayscale on Reference Black background aimed at testing Display Min Brightness Central "Katie" Photo Insert aimed at checking **Tone-mapping** and **Color Rendition**



3.3 VQMPC Test PQ version

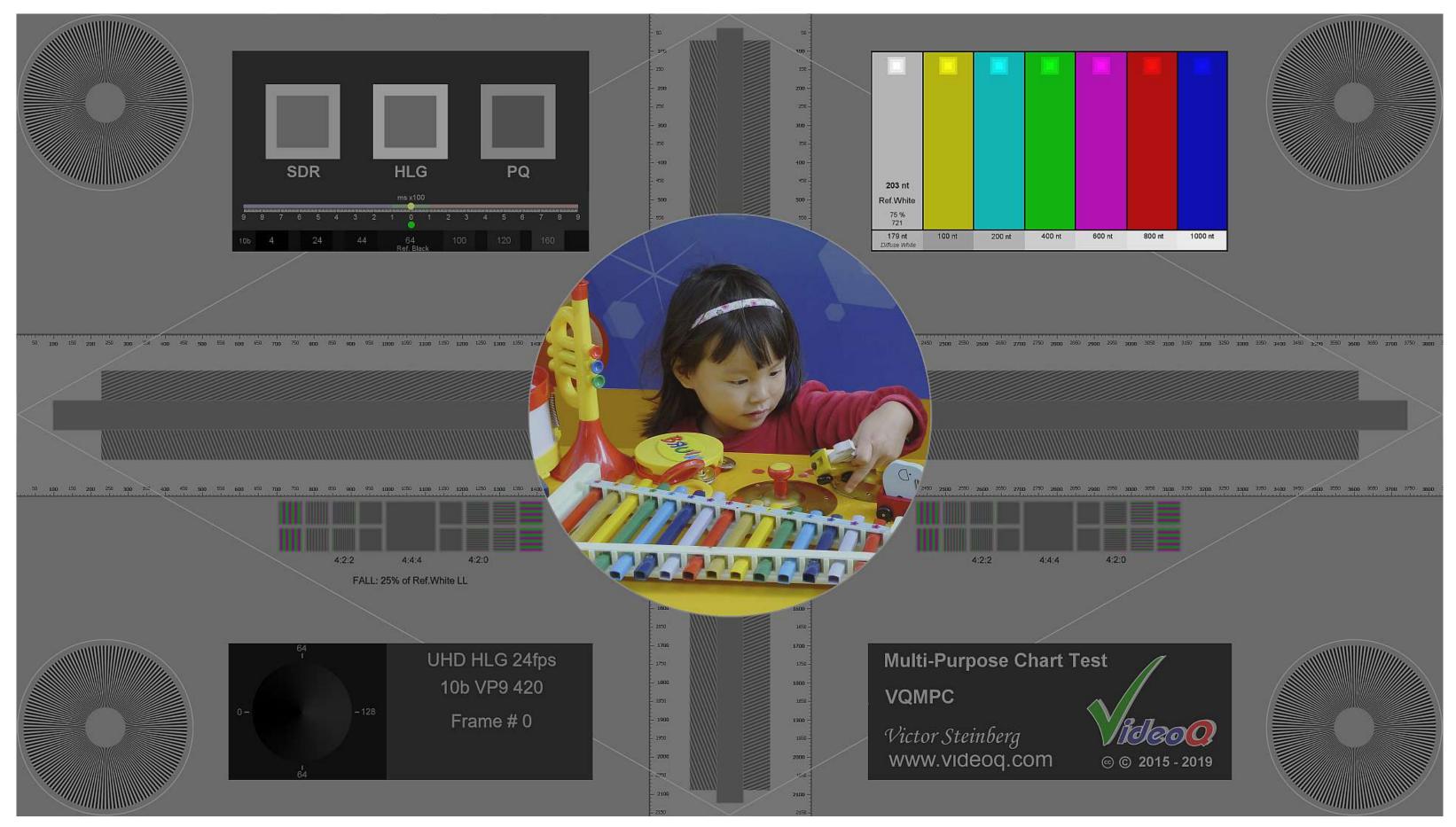






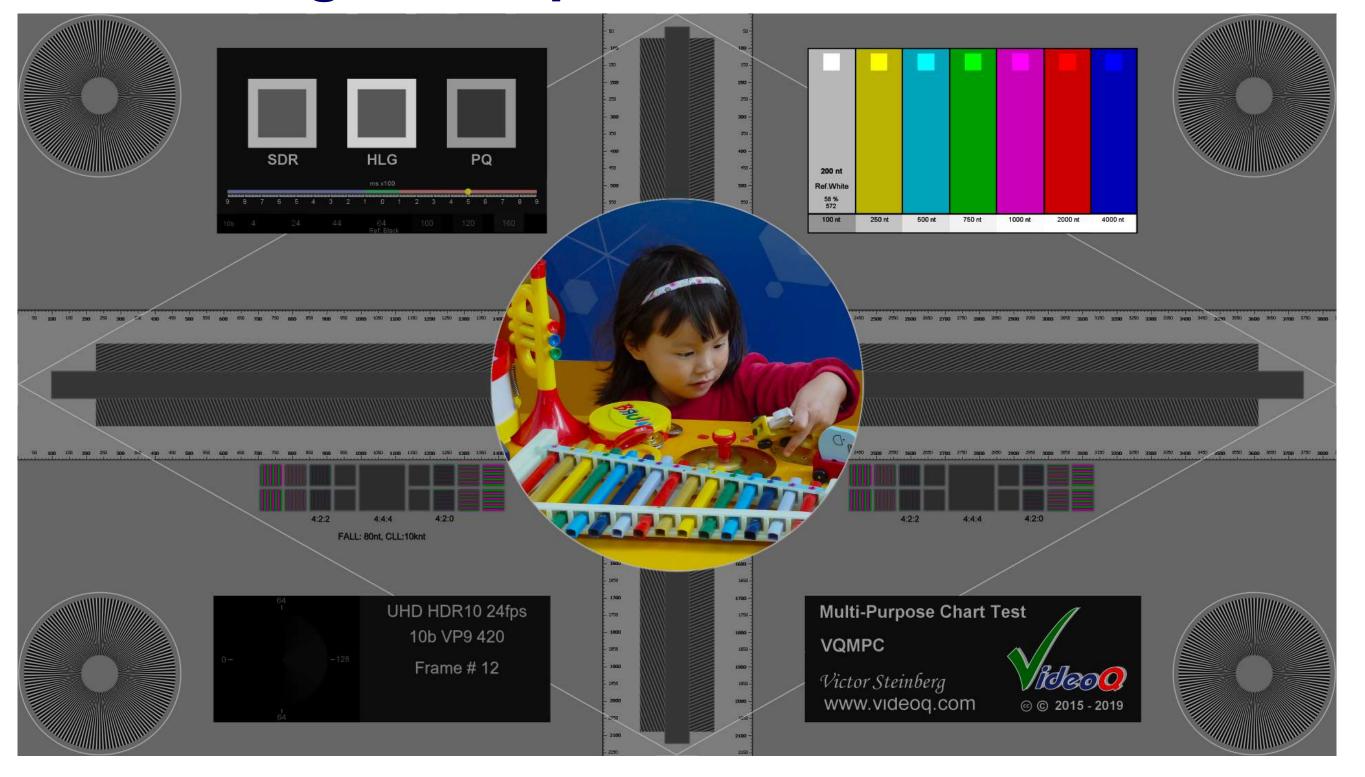
3.4 VQMPC Test HLG version





TOC3 3.5 VQMPC Usage Example – HDR-PQ to SDR Conversion





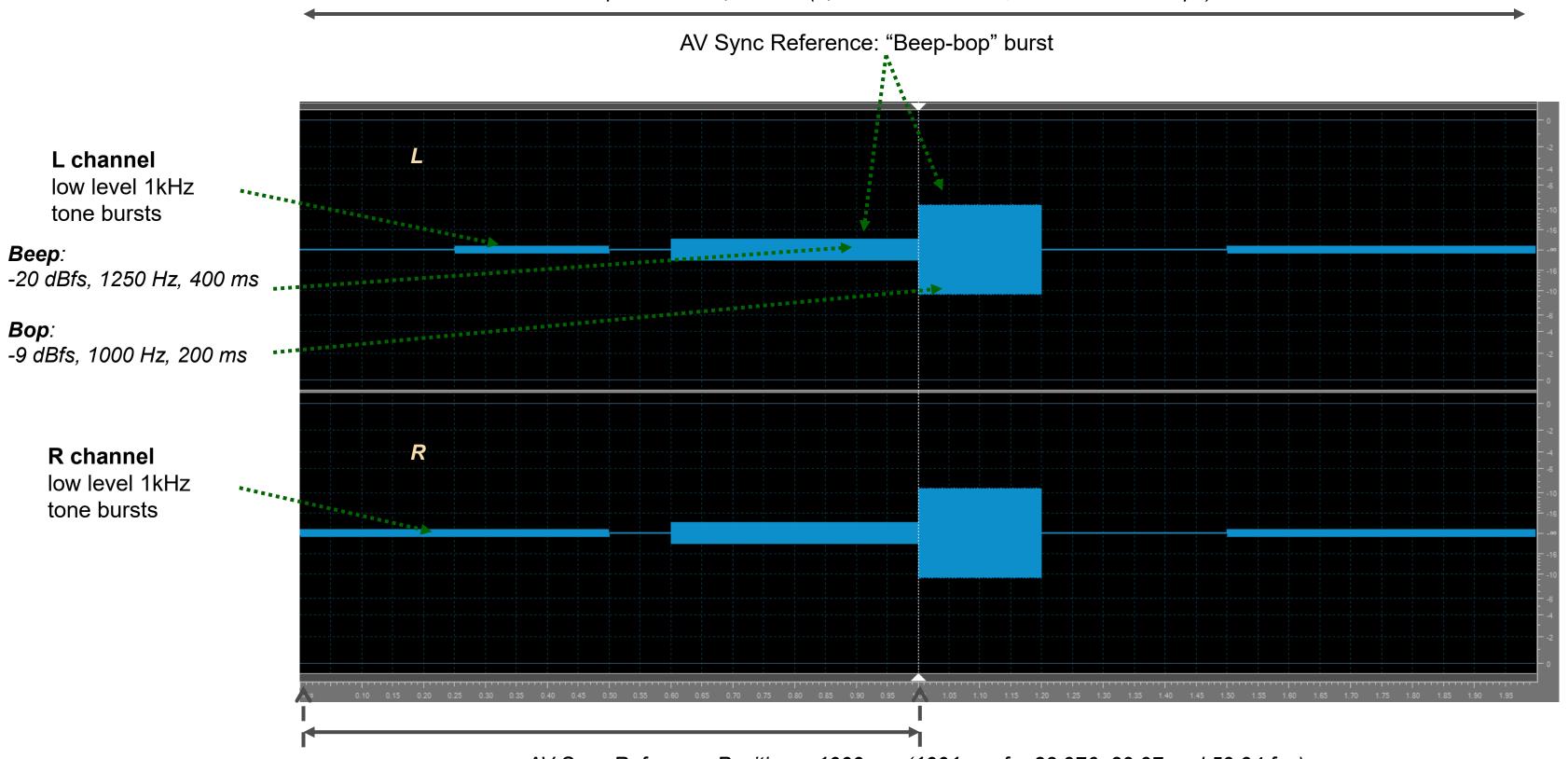
The HDR10 to SDR conversion (in this example – by **VLC** player) looks good. The most critical issues are the central photo **color rendition** and absence of noticeable **quantization artifacts** ("banding") on the gradients.



3.6 VQMPC Optional AV Sync Test Audio Component



Loop duration: **2,000 ms** (**2,002 ms** for 23.976, 29.97 and 59.94 fps)



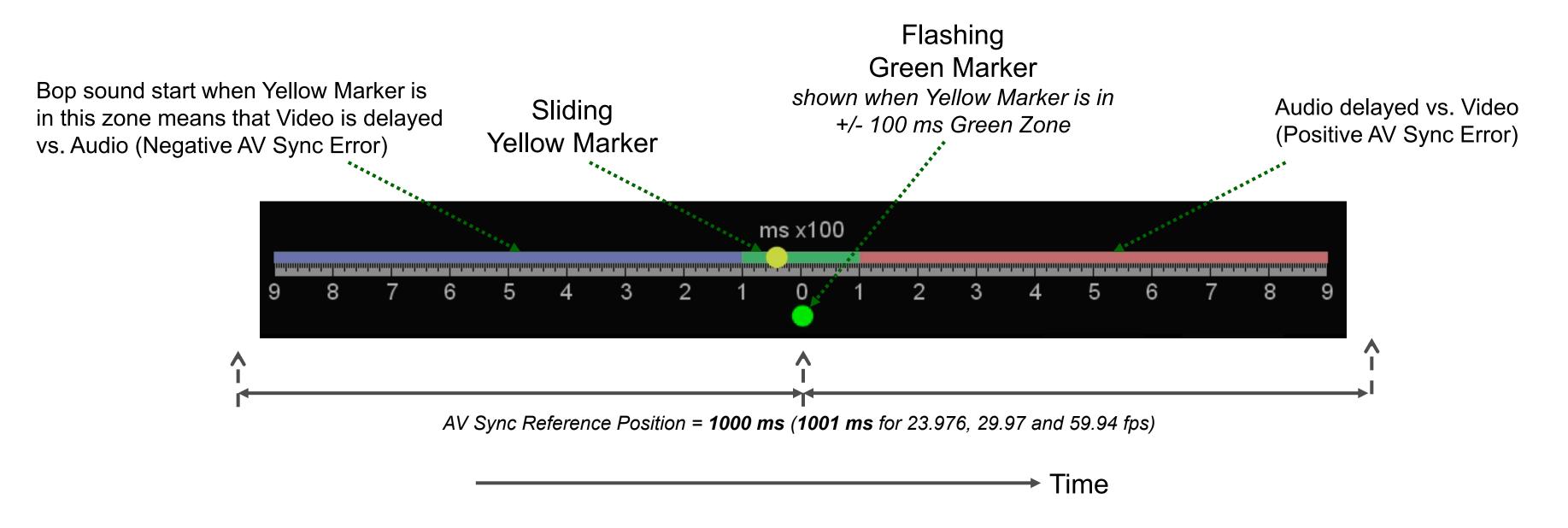
AV Sync Reference Position = **1000 ms** (**1001 ms** for 23.976, 29.97 and 59.94 fps)



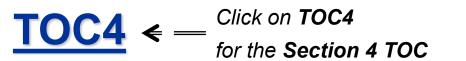
3.7 VQMPC Optional AV Sync Test Video Component



AV Sync Test period is 2000ms, thus the reliably detectable AV Sync error range is +/- 900 ms.



Sliding Marker can be also used as frames continuity indicator. If the decoded video frames are skipped or frozen, normally smooth marker movement becomes jerky and erratic.



4. VQLA Test Patterns Set



- 4.1 VQLA-PQ version
- 4.2 VQLA-PQ Test Composition
- 4.3 VQLA Usage Example HDR-PQ to SDR Conversion
- 4.4 VQLA-HLG version
- 4.5 VQLA-HLG Test Composition

4.1 VQLA-PQ version







4.2 VQLA-PQ Test Composition



10 Two-tones Patches and 14 Overload Indicators aimed at testing **Display Clipping Levels**

200 nt

7 White SPLUGE **Conical Grayscales** aimed at testing **Display Clipping Levels**

Black PLUGE rectangles and **Black SPLUGE** Conical Grayscale on Reference Black background aimed at testing **Display Min Brightness**

UHD HDR10 24fps 10b VP9 444 **VQLA** Frame # 0 **Valid Range 10 bit Linear Ramp** with critical levels markers aimed at testing **Display Tone-mapping Uniformity** (checking the "banding" artifacts)

Precise FALL & CLL readout aimed at calibration & testing of **Content Levels Analyzers**

Levels Alignment Test

FALL: 400 nt CLL: 10,000 nt

Victor Steinberg www.videoq.com

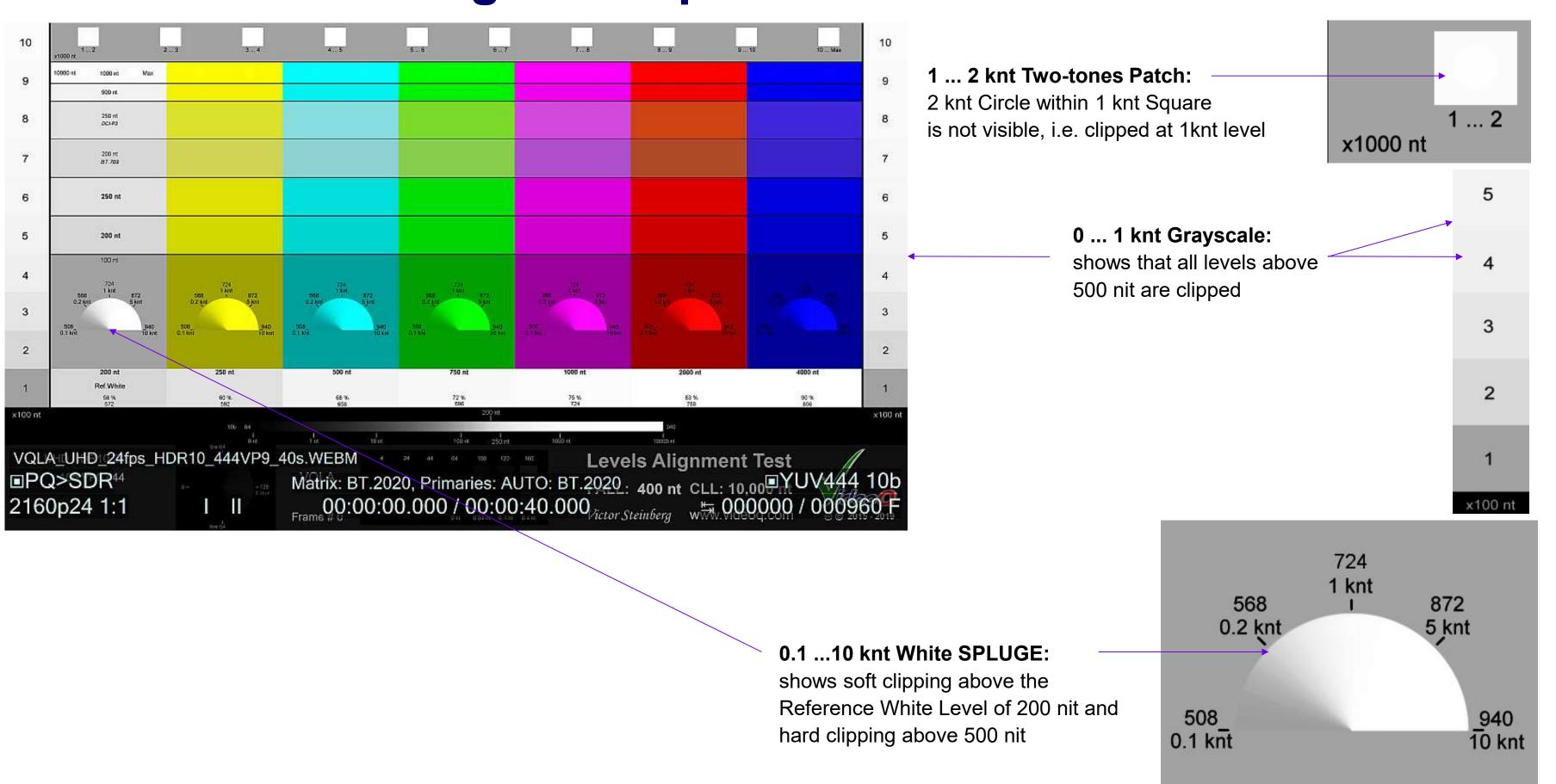
Special set of HDR Color Bars aimed at testing **Display Light Output Profile** and Color Space Conversion

Special **HDR Grayscales** (light and signal levels set) aimed at testing **Display Light Output Profile**

and Clipping Levels

TOC4 4.3 VQLA Usage Example – HDR-PQ to SDR Conversion





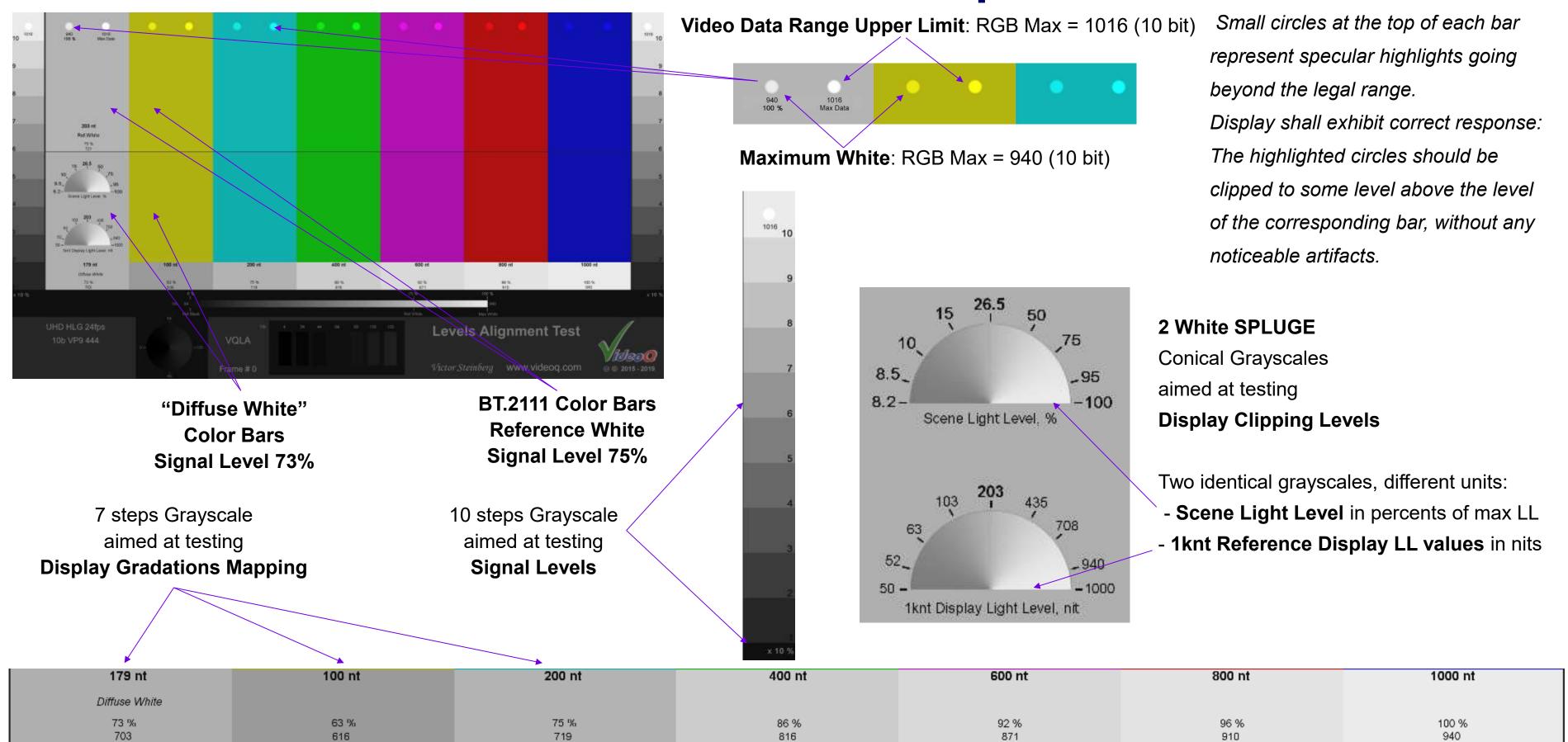
4.4 VQLA-HLG version





4.5 VQLA-HLG Test Composition

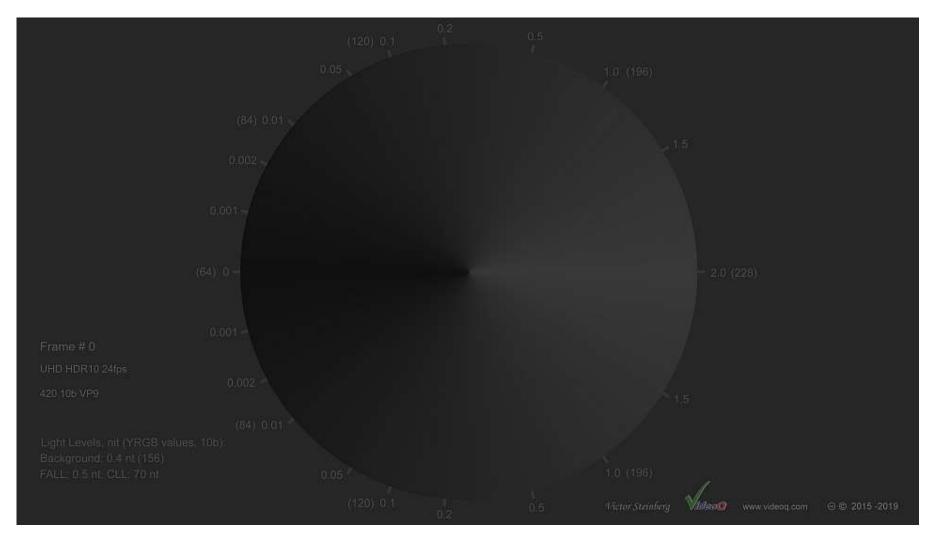




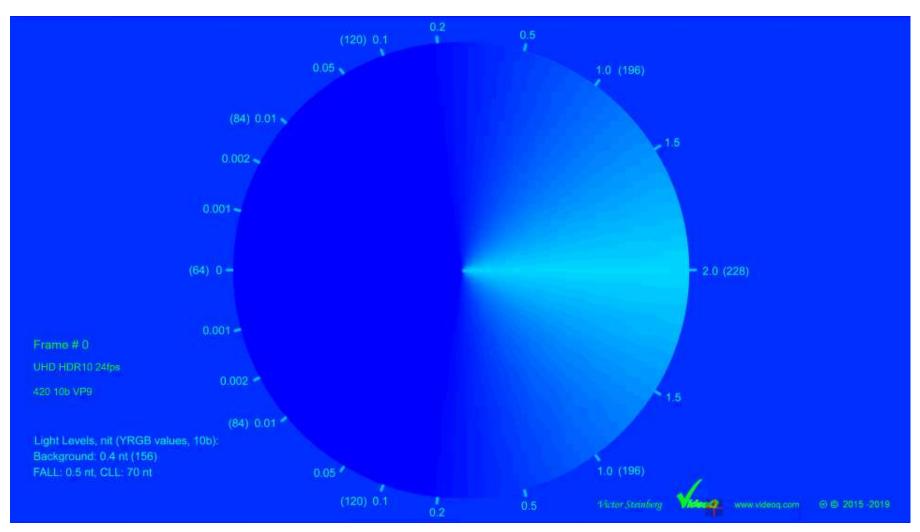
5. VQSP – Very Low Light Levels Test



Raw YUV Data Image



VideoQ VQV "Heat Map" Image



If the processing chain preserves the full 10bit resolution and the display black level cut-off point setup is correct (i.e. the display under test EOTF complies with the standard PQ curve), then all the gray levels, even the very low, e.g. 0.001nt, should be visible.

This test is for viewing in a dark room (i.e. very low ambient light levels), and the observer should be given enough time for the visual system adaptation to these conditions. Rendering of low light levels is relatively easy for not so bright displays, for brighter displays this test would be much more challenging.

6. VQAPL – Dynamic Average Light Level Test



Part 1/15 – lowest FALL value = 75nt (Window LL = 0nt)



Part 15/15 – highest FALL value = 6340nt (Window LL = 10knt)



Time

This dynamic sequence serves to test the display's auto-brightness control (ABC) and auto-brightness limiting (ABL) systems. It consists of 15 parts with different brightness levels of the large window surrounding central photo insert. Each part is displayed for 4s, total test sequence duration is 60s.

Modern HDR displays may include eye safety and power consumption protective measures, e.g. automatic reduction of the light output, when the content variable light level (FALL value) goes above some threshold.

However, such protection should not be accompanied by a significant distortion of the central insert image, and the recovery time (recovery here means full return to normal mode after FALL value drop-down) should not be too long.

7. About VideoQ



Customers & Partners

























































































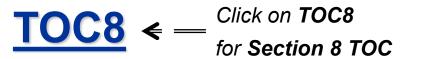
Company History



- 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



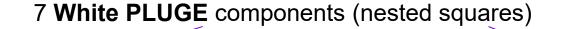
8. Appendix A: VQMPC Test Details

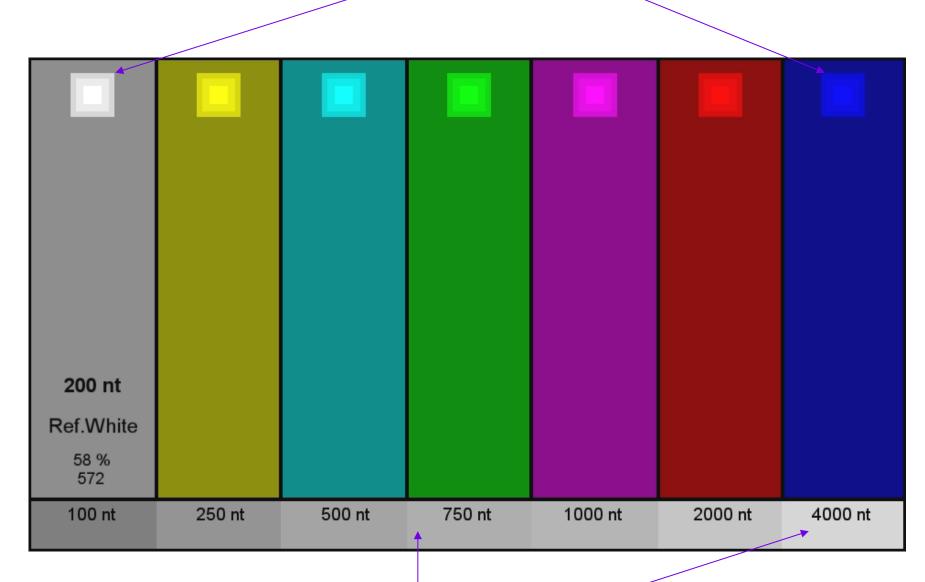


- 8.1 VQMPC: HDR Color Bars Details and Usage
- 8.2 VQMPC: Diamond Pattern and Crop Markers Usage
- 8.3 VQMPC: Tri-band Bursts Pattern
- 8.4 VQMPC: Tri-band Bursts Pattern Usage
- 8.5 VQMPC: Radial Plates Usage
- 8.6 VQMPC: Chroma Sampling Test Details
- 8.7 VQMPC: Chroma Sampling Test Usage Example
- 8.8 VQMPC: Black PLUGE & Black SPLUGE Usage
- 8.9 VQMPC: OETF Test Details and Usage Example

8.1 VQMPC: HDR Color Bars Details and Usage



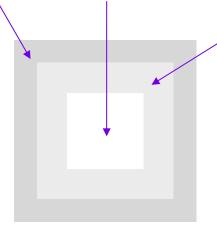




7 steps **HDR-PQ Grayscale** features critical Light Levels up to 4000 nt

White PLUGE 10 bit levels:

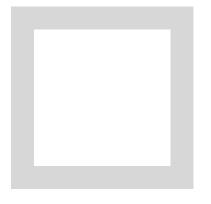
1016 = upper limit of full 10 bit video data range



Case 1:

The HDR display renders the full 10 bit video data range without clipping at the level 940; this is not allowed by any HDR standard (PQ or HLG)

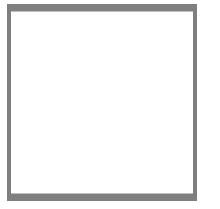
940 = upper limit of valid ("Narrow") 10 bit video data range



Case 2:

Clipping at 10 bit value of 940 as required by HDR standard:

- It is normal for all HLG displays,
- It is also normal for the PQ displays capable of rendering the full valid range, i.e. if TDMB = 10,000 nit



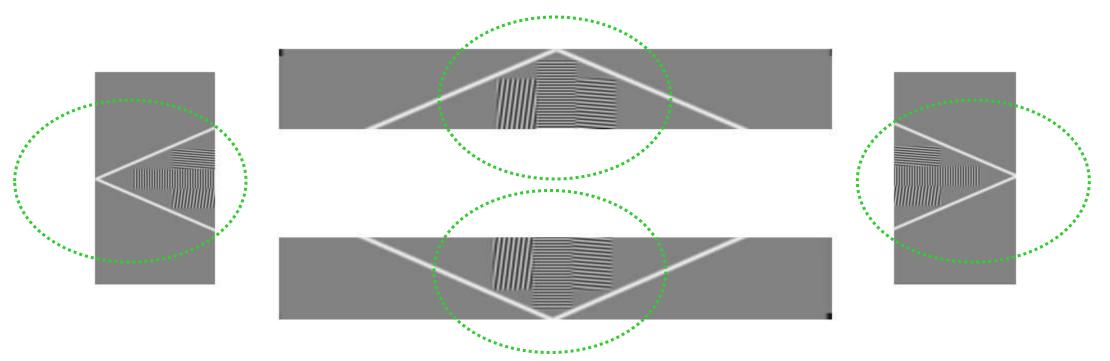
Case 3:

The display is not rendering full valid range; the clipping is at a video level much lower than 940:

- It is **not normal** for any **HLG display**,
- It is **normal** for the **PQ displays** with a **TDMB < 10,000 nit**

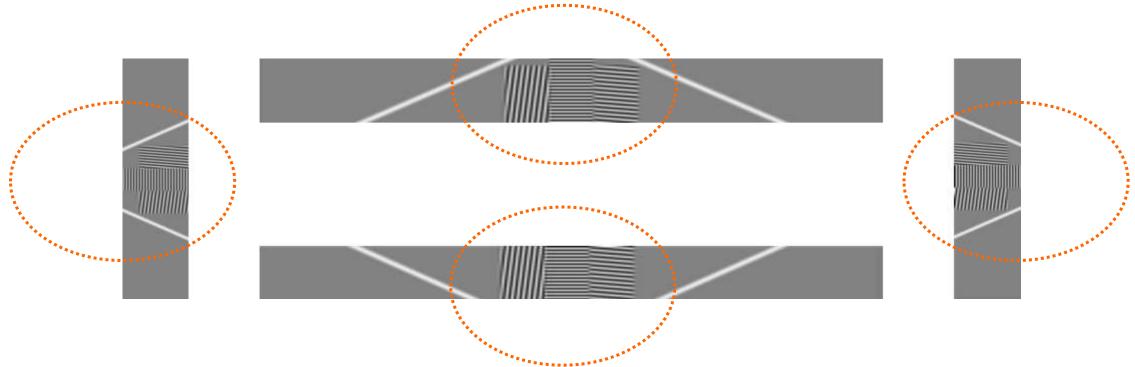
8.2 VQMPC: Diamond Pattern and Crop Markers Usage





Example of correct settings (no cropping):

All picture edges are not cropped and single pixel white markers are visible



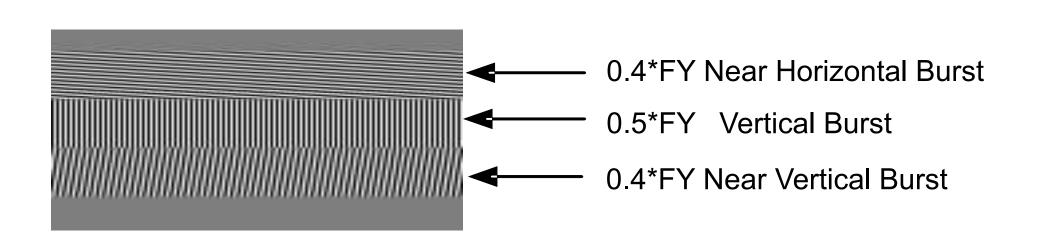
Example of incorrect settings (with cropping):

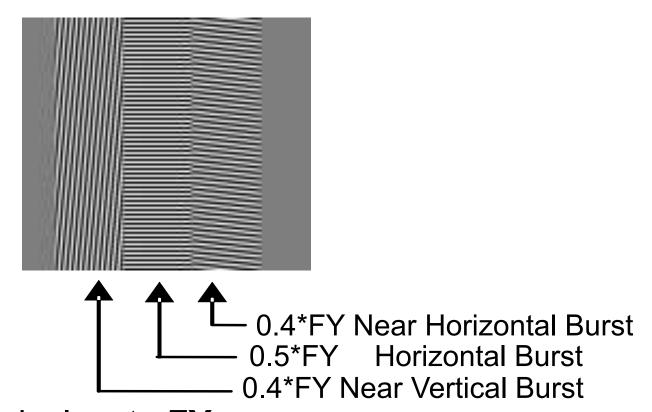
Picture edges are cropped



8.3 VQMPC: Tri-band Bursts Pattern







There are two groups of bursts with frequencies proportional to luma pixels rate **FY**: **full length horizontal** bursts band and **full height vertical** bursts band. Maximum luminance frequency burst of exactly **0.5 FY** is in the middle of each band. Two slightly oblique bands of 0.4 FY surrounds the middle burst.

Two **central 0.5 FY sub-bands** are especially sensitive to any errors in **pixel clock**, **mapping** or **scaling**. Four other sub-bands allow differentiation between horizontal and vertical distortions thru the whole picture area – from left picture edge to the right picture edge and from top to bottom.

Within the burst vertical and almost vertical lines test horizontal frequencies, whilst horizontal and almost horizontal lines test vertical frequencies.



8.4 VQMPC: Tri-band Bursts Pattern Usage

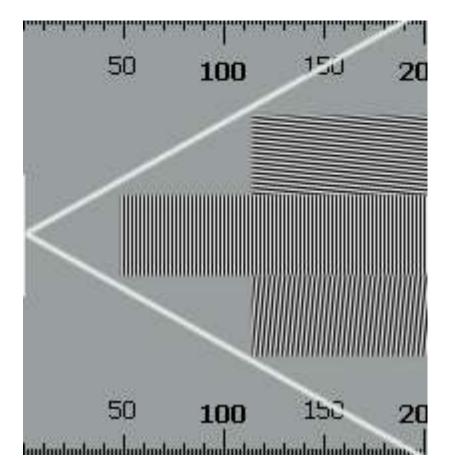


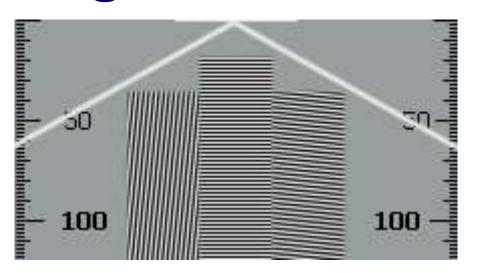
Example of correct settings (no scaling):

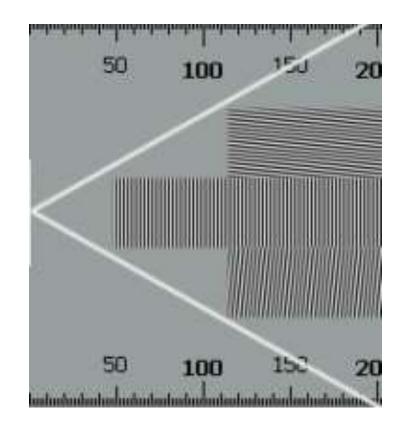
There are no visible beat waves on both horizontal and vertical Tri-band Patterns

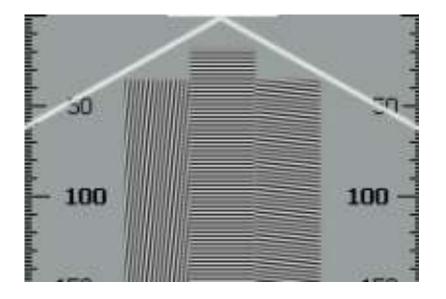


Scaling causes beat waves on both horizontal and vertical Tri-band Patterns





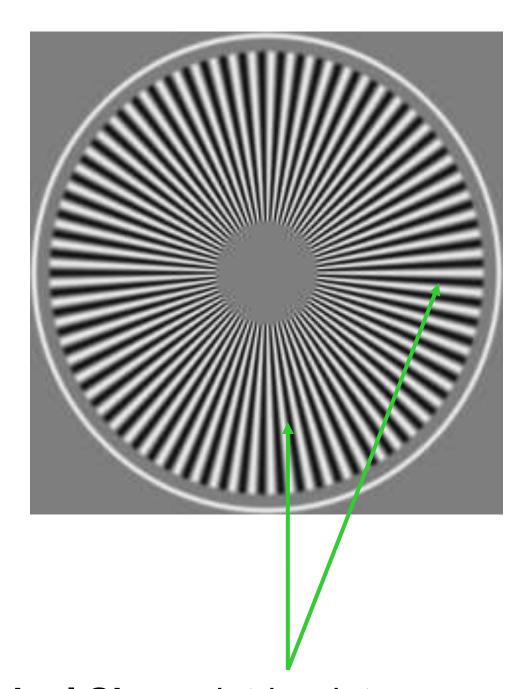




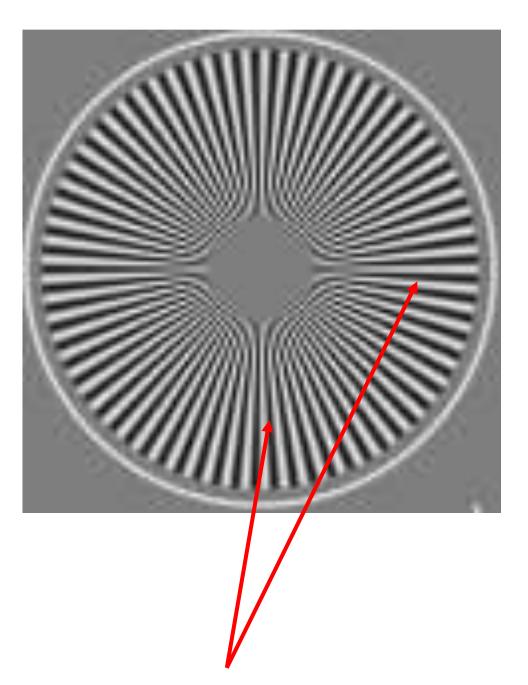


8.5 VQMPC: Radial Plates Usage





Original Size – dot-by-dot:
Full contrast of fine details in all directions



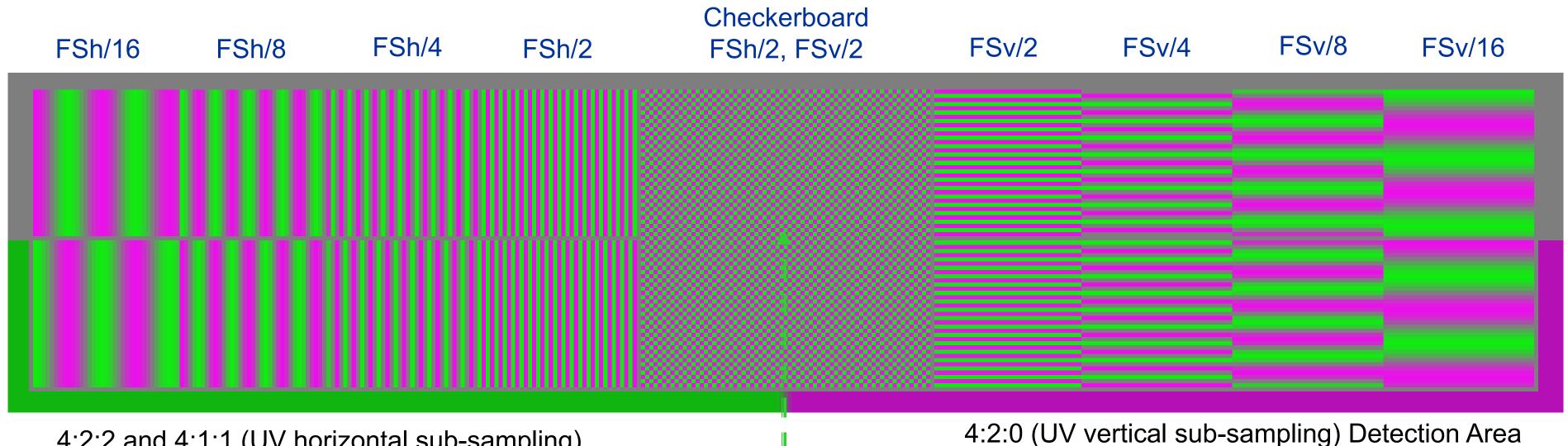
Scaled (Up or Down) Picture, or Sharpness Correction sub-optimal settings: Loss and/or distortion of fine details

8.6 VQMPC: Chroma Sampling Test Details



FSh: Original Horizontal Sampling Rate

FSv: Original Vertical Sampling Rate



4:2:2 and 4:1:1 (UV horizontal sub-sampling)

Detection Area

H & V Scaling Detector Area looks like checkerboard only in absence of any conversion vs. pristine 4:4:4 YUV/RGB



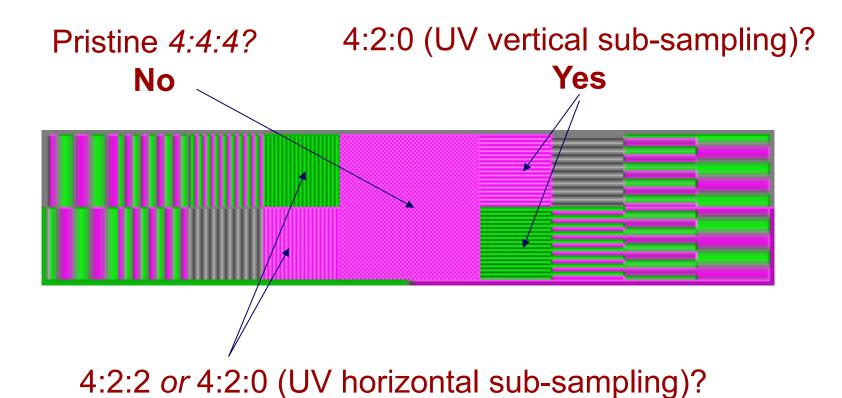
8.7 VQMPC: Chroma Sampling Test Usage Example



Test appearance after UV sub-sampling without pre-filtering

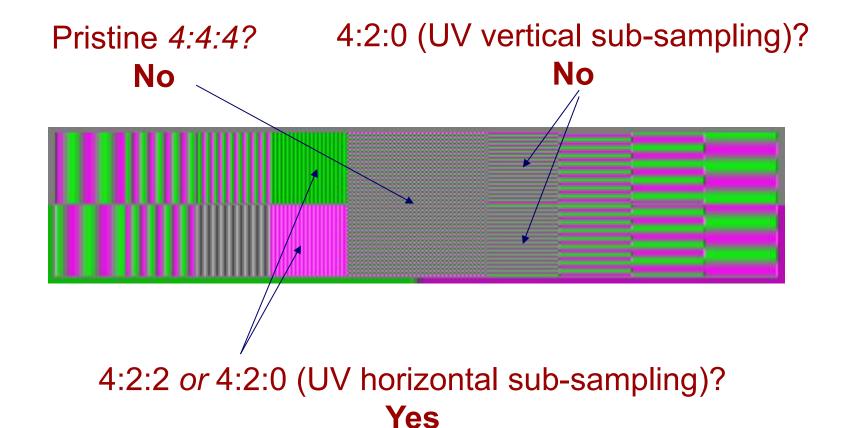
Case #1 Case #2

Dedicated areas indicate different sub-sampling issues:



Sampling Conversion Test Result: **4:2:0** sub-sampling mode detected

Yes



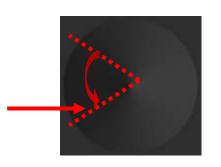
Sampling Conversion Test Result: 4:2:2 sub-sampling mode detected

8.8 VQMPC: Black PLUGE & Black SPLUGE Usage

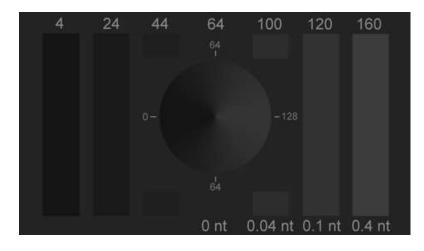


Fine Tuning (SPLUGE)

Clipped sector (with no shades of gray) is much less than 180 degrees



Brightness is too high



Coarse Tuning (PLUGE)

All rectangles on the right and some rectangles on the left are visible

Brightness is too low

Clipped sector (with no shades of gray) is much more than 180 degrees

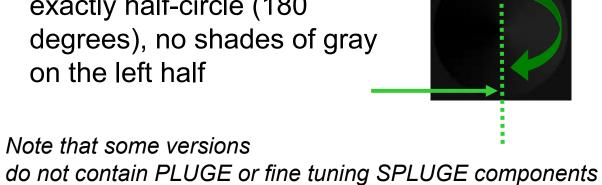


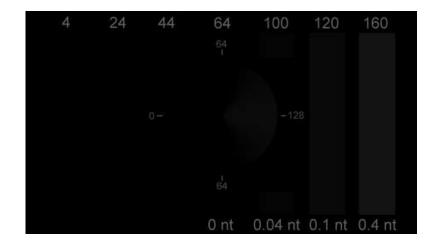
0 nt 0.04 nt 0.1 nt 0.4 nt

Not all rectangles on the right are visible

Brightness is correct

Conical grayscale is clipped exactly half-circle (180 on the left half





All rectangles on the right are visible and all rectangles on the left are not visible

8.9 VQMPC: OETF Test Details and Usage Example

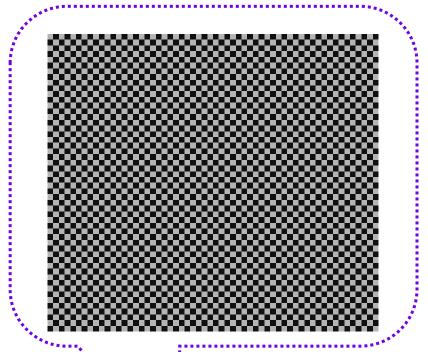


All 3 Checkerboards have the **sampling limit** frequencies: FSh/2, FSv/2

FSh: Original Horizontal Sampling Rate

FSv: Original Vertical Sampling Rate

Note that this test can be used only for full **native** resolution displays and all sharpness correction and gamma curve controls should be switched **off**.



Checking that the selected display mode matches the test file PQ metadata:

Case #1:

SDR and **HLG** patches show much higher contrast than the **PQ** patch.

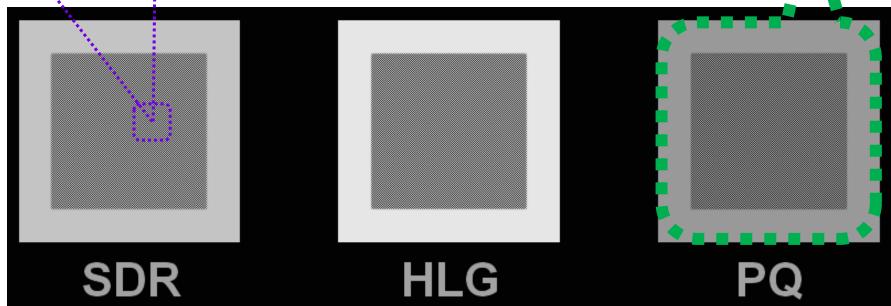
Test result: Correct OETF Mode (PQ)

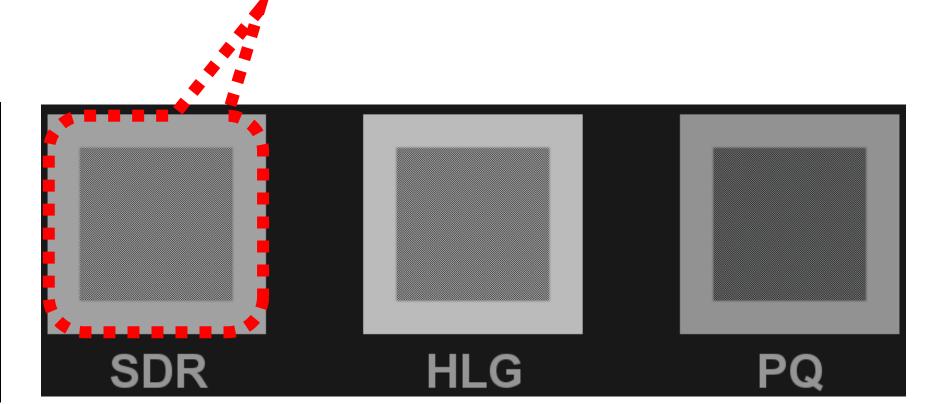
Case #2:

PQ and **HLG** patches show much higher contrast than the **SDR** patch.

Thus, the display under test is in **SDR** mode, **not matching** the **PQ** file metadata

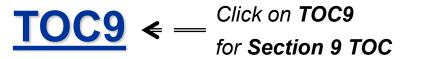
Test result: **Wrong OETF Mode (SDR)**





For an average human observer, the high frequency checkerboard textures are visible only from a very small viewing distance. From a normal viewing distance all central squares look like shades of solid gray.

If the display OETF complies with the standard curve, then the corresponding checkerboard average gray level should match the appropriate square background level, i.e. the contrast of this central square vs. the background is minimal.



9. Appendix B: Additional Tools



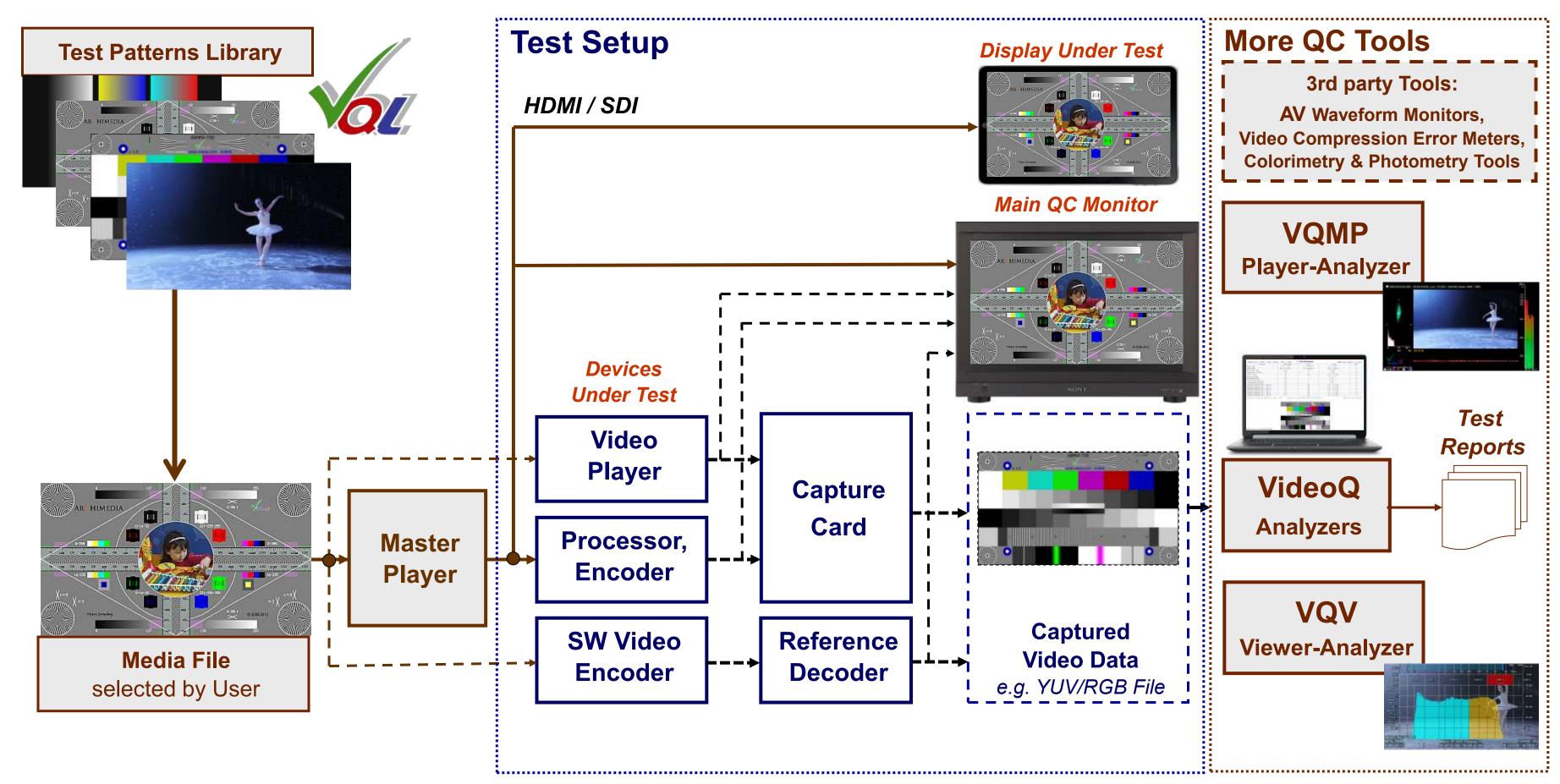
- 9.1 VideoQ Tools Workflow Variants
- 9.2 VQV Viewer-Analyzer and VQMP Player-Analyzer
- 9.3 VQMA Matrix Test Pattern for Automated Analysis
- 9.4 VQCSE Color Space Explorer Dynamic Test
- 9.5 VQCST Dynamic Test Pattern for Compression Codecs
- 9.6 VQFCT Frames Continuity and Packet Loss Test

The following slides contain the description of VideoQ Test Patterns and tools recommended for pre-testing prior to the full HDR test procedures.



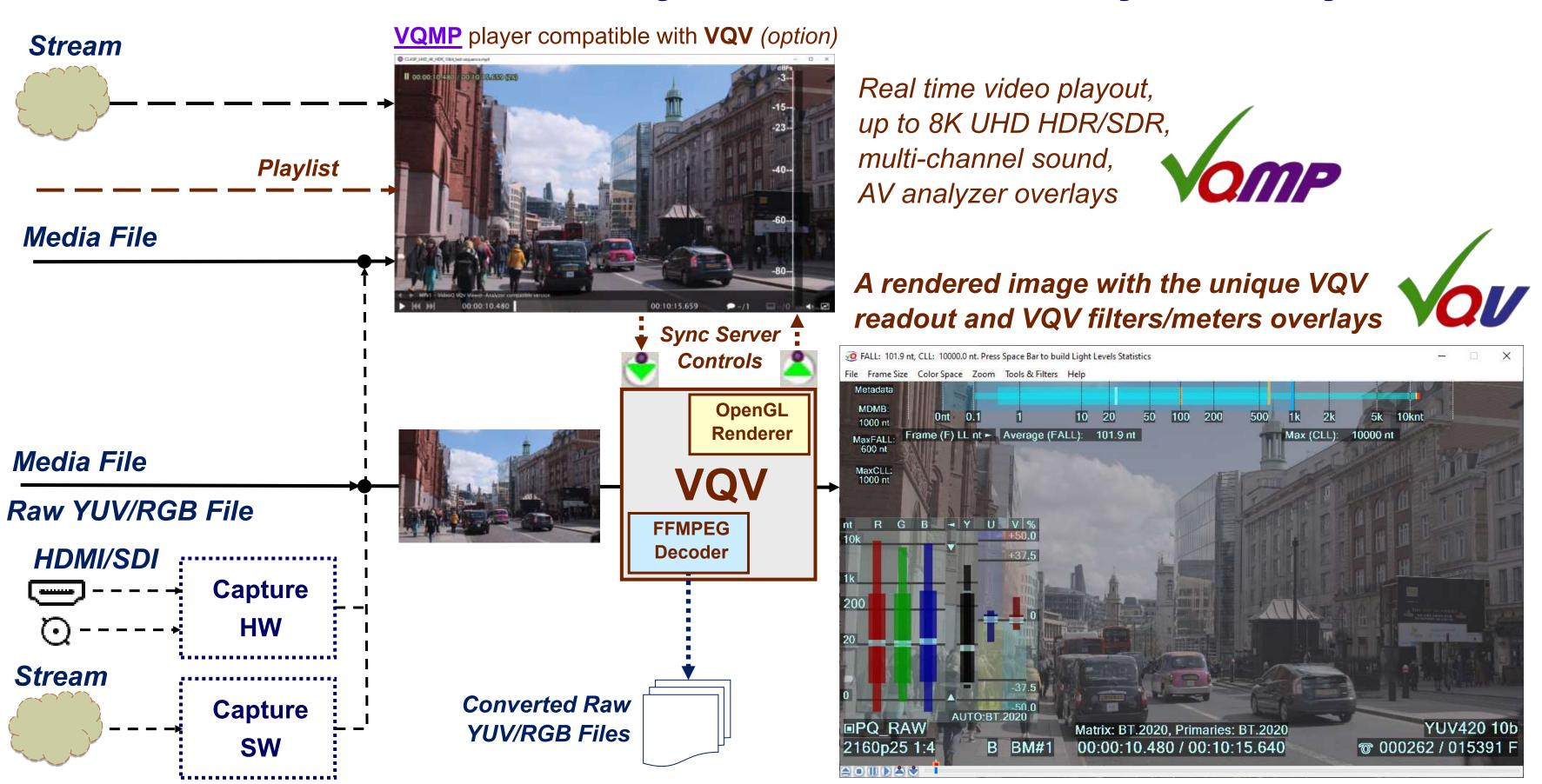
9.1 VideoQ Tools Workflow Variants





9.2 VQV Viewer-Analyzer and VQMP Player-Analyzer

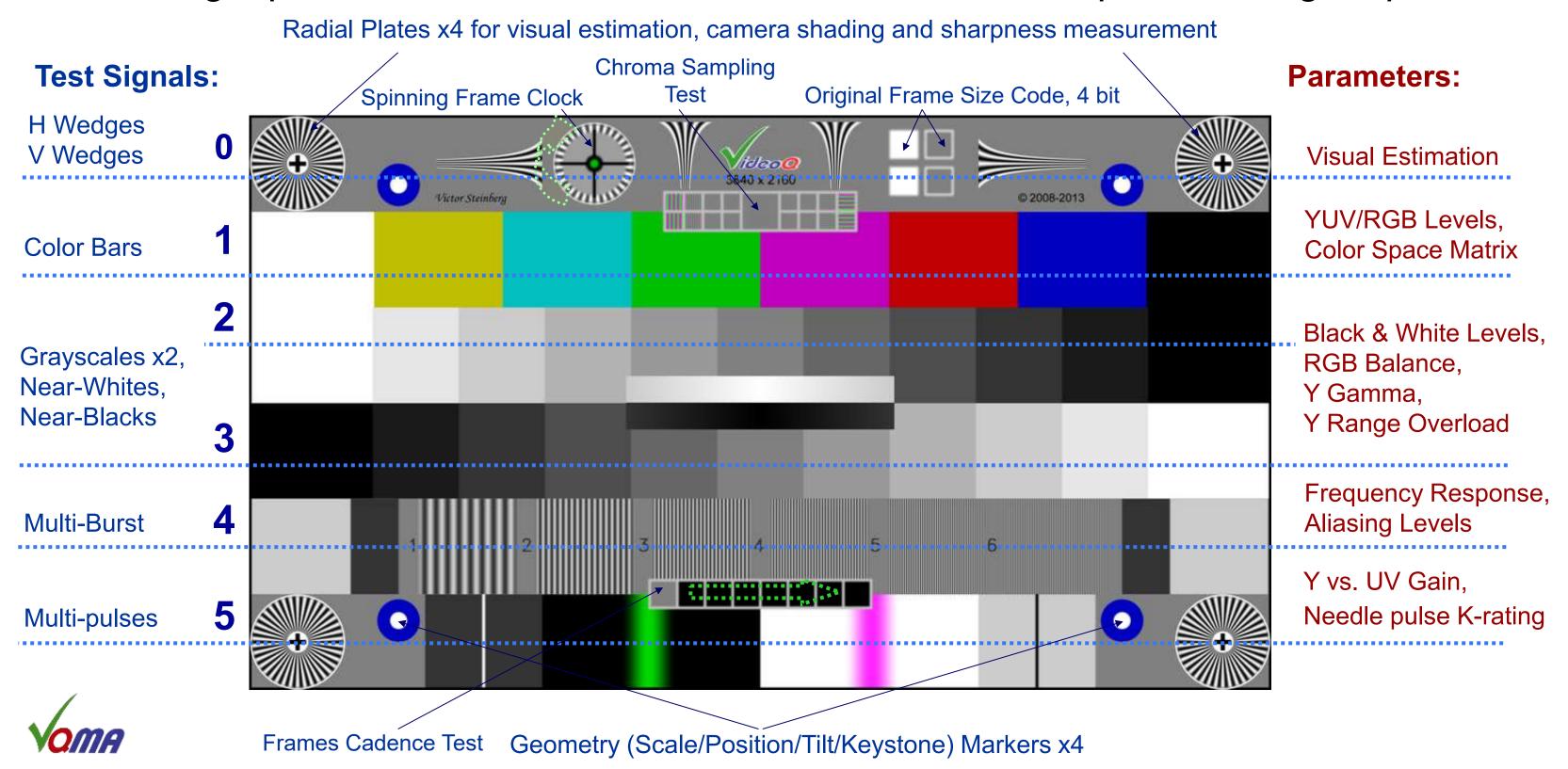




9.3 VQMA – Matrix Test Pattern for Automated Analysis

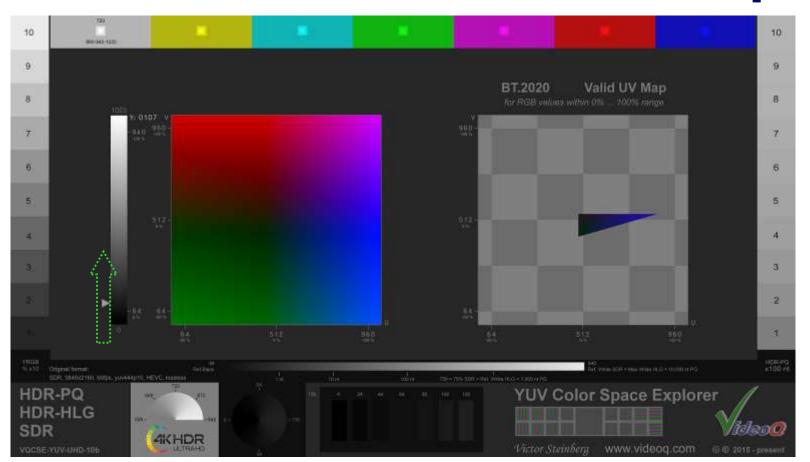


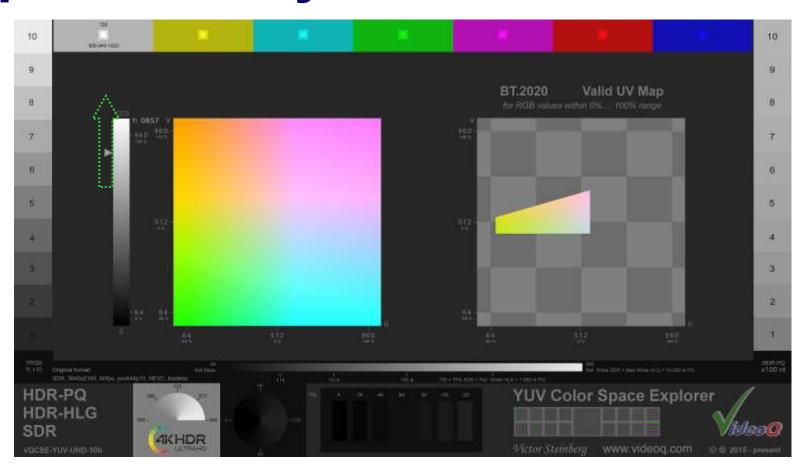
All-In-One: Single pattern allows automatic measurement of multiple video signal parameters



9.4 VQCSE – Color Space Explorer TM Dynamic Test





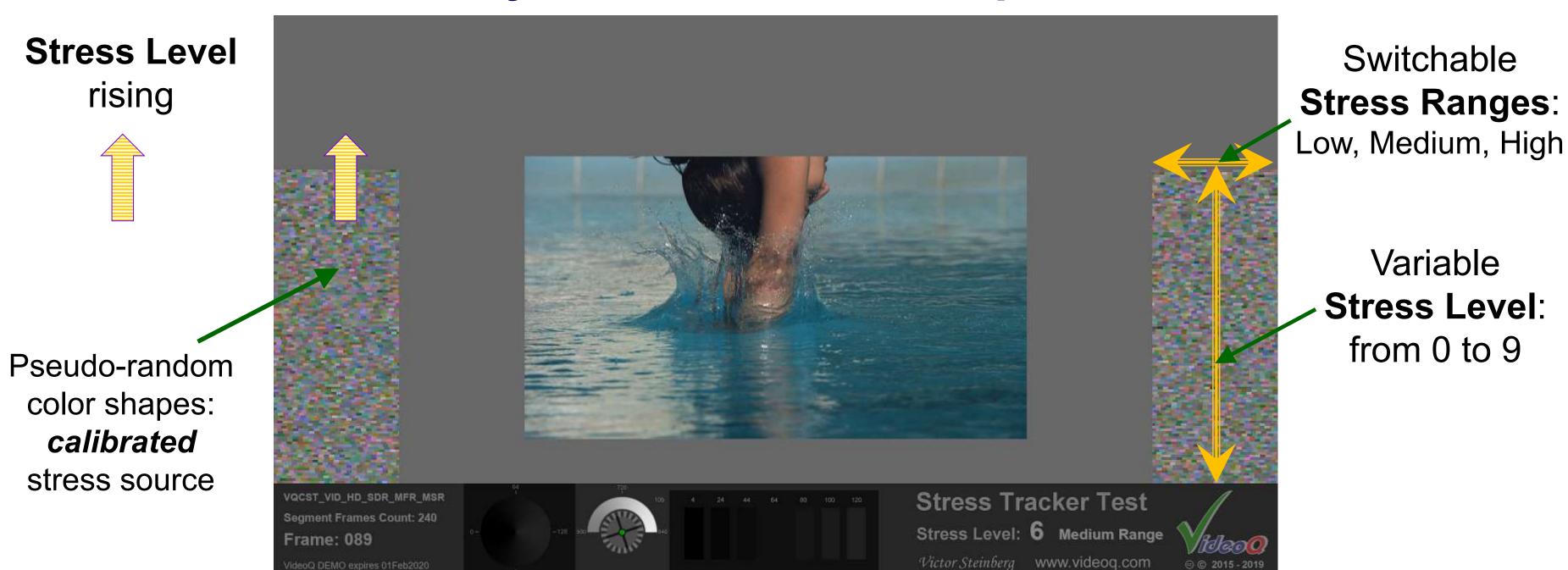


In few seconds this sophisticated dynamic UHD test checks more than one billion (1024³) colors of the **10bit YUV** or **10bit RGB** color space. For example, the VQCSE_YUV variant covers all combinations of Y, U and V values – from 0 to 1023, including all "illegal" colors. For any given Y 10b value "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.

9.5 VQCST – Dynamic Test for Compression Codecs





VQCST is a sequence of **10 Segments** (**10 Stress Levels**), each segment duration: 4.0, 4.8 or 5.0 seconds. Total sequence duration is 40, 48 or 50 seconds, depending on the selected frame rate.

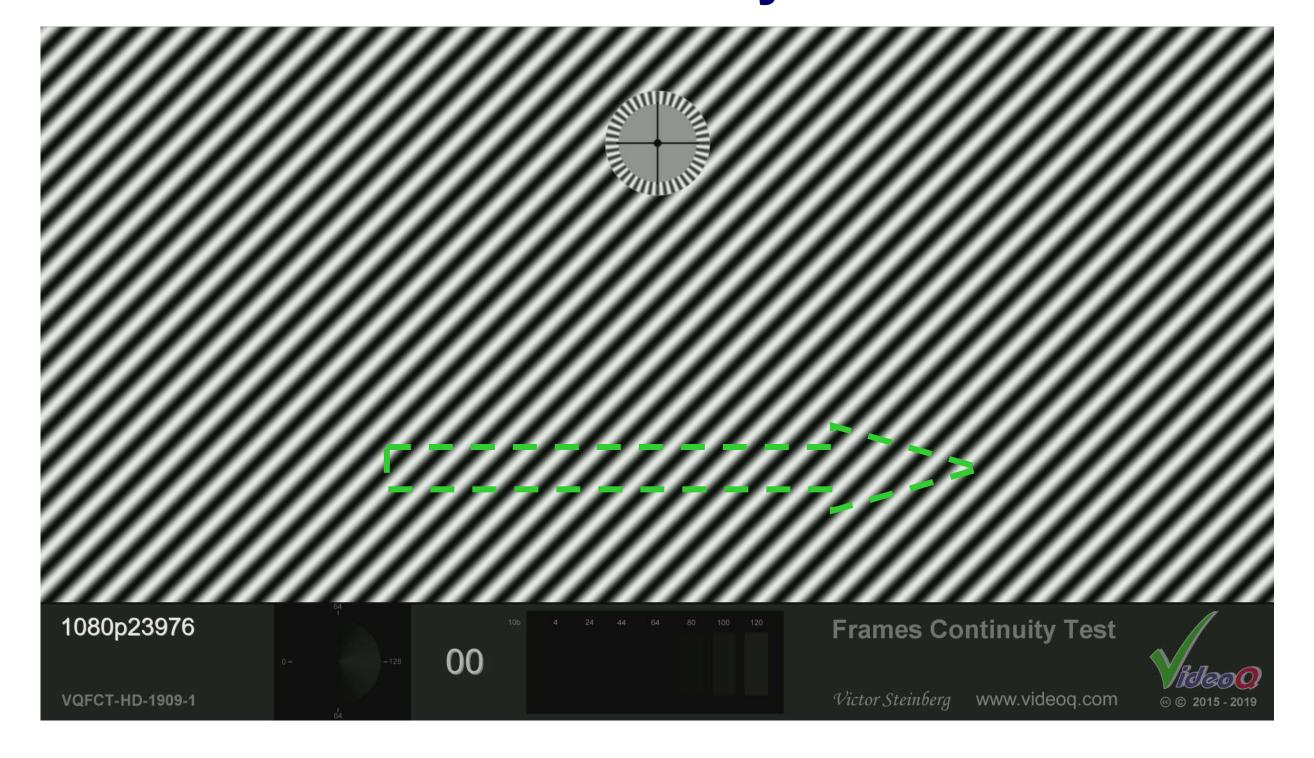
Stress Tracker TM test is suitable for subjective image quality estimation in real time and for automated measurement of Stress Response Profile.

It is possible to play infinite loop of each segment or infinite loop of the full sequence.



9.6 VQFCT – Frames Continuity and Packet Loss Test





VQFCT test features rotating wheel clock, scrolling medium frequency diagonal sinusoidal pattern and frame counter display.

This simple test provides for checking the video communication systems performance in the congested network conditions. Even intermittent or partial disruptions of the smooth timeline progress, e.g. frozen image slices due to the network packets loss, are easily noticeable. It is equally suitable for visual estimation and automated monitoring (watchdog functionality).