**3GPP TSG SA WG4#119-e S4-220739**

**E-meeting, 11th- 20th May 2022**

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| *CR-Form-v12.0* | | | | | | | | |
| **PSEUDO CHANGE REQUEST** | | | | | | | | |
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|  | **26**.**955** | **CR** |  | **rev** | **-** | **Current version:** | **1.6.0** |  |
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| *For* [***HE******LP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* | | | | | | | | |
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| ***Proposed change affects:*** | UICC apps |  | ME |  | Radio Access Network |  | Core Network |  |

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| ***Title:*** | **[FS\_5G\_Video] Proposed Updates to Clause 6 and 7** | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Source to WG:*** | Tencent | | | | | | | | | |
| ***Source to TSG:*** |  | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Work item code:*** | FS\_5GVideo | | | | |  | ***Date:*** | | | 05/05/2022 |
|  |  | | | |  | |  | | |  |
| ***Category:*** |  |  | | | | | ***Release:*** | | |  |
|  | *Use one of the following categories:* ***F*** *(correction)* ***A*** *(mirror corresponding to a change in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)*  Detailed explanations of the above categories can be found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | | | | | | | | *Use one of the following releases: Rel-8 (Release 8) Rel-9 (Release 9) Rel-10 (Release 10) Rel-11 (Release 11) Rel-12 (Release 12)* *Rel-13 (Release 13) Rel-14 (Release 14) Rel-15 (Release 15) Rel-16 (Release 16)* | |
|  |  | | | | | | | | | |
| ***Reason for change:*** | | Proposed updates to Clause 6 and 7   * Editorial fixes * Typos corrected, links to metrics and results * Empty clauses removed * S3-HM-01 and S3-HM-03 are exactly the same files same for S3-HM-02 and S3-HM-04; S3-SCC-01 and S3-SCC-03; S3-SCC-02 and S3-SCC-04: proposed to simplify the text | | | | | | | | |
|  | |  | | | | | | | | |
| ***Summary of change:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
| ***Consequences if not approved:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
| ***Clauses affected:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
|  | | **Y** | **N** |  | | | |  | | |
| ***Other specs*** | |  |  | Other core specifications | | | | TS/TR ... CR ... | | |
| ***affected:*** | |  |  | Test specifications | | | | TS/TR ... CR ... | | |
| ***(show related CRs)*** | |  |  | O&M Specifications | | | | TS/TR ... CR ... | | |
|  | |  | | | | | | | | |
| ***Other comments:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
| ***This CR's revision history:*** | |  | | | | | | | | |

**===== CHANGE =====**

# 6 Relevant Scenarios

## 6.1 Introduction

This clause collects relevant scenarios based on the template defined in Annex A. It also defines the anchors for each scenario based on the existing 3GPP codecs and profiles defined in clause 4. For each scenario, the following information is provided:

- Motivation: provides a context for the scenario, why it is relevant for 5G video services.

- Description of the Anticipated Application: This provides an overview on how the service may be done technically in a 5G system. It summarizes where encoders and decoders reside, what codecs are in use today and how the end-to-end system is working.

- Source format properties: Provides an overview of relevant video source formats in terms of spatial and temporal resolutions, colour spaces, etc.

- Encoding and Decoding Constraints: provides details on encoder settings and configurations for each of the 3GPP codecs mapped to the scenario.

- Performance Metrics: Documents the relevant performance metrics for this scenario

- Interoperability Considerations: Documents relevant interoperability requirements for a codec when used in the scenario, based on the known applications and protocols.

- Reference Sequences: defines the reference sequences that are selected for this scenario in order to create anchors and anchor metrics. A justification is provided, why this sequence is selected.

- Anchor Definition: provides details on how to generate the anchors for the scenario for each 3GPP codec using the selected reference sequences, the reference software and the codec configuration.

- Anchor Results: provides the results for each anchor.

- Additional information and performance data: provides additional information and performance data available externally.

## 6.2 Scenario 1: Full HD Streaming

### 6.2.1 Motivation

The 2020 Mobile Internet Phenomena Report from Sandvine [9] shows that mobile video downstream traffic accounts for more than 65% of the global application category traffic share.

According to Ericsson mobility report [10], video traffic in mobile networks is forecast to grow by around 30 percent annually through 2025 to account for three-quarters of mobile data traffic, from slightly more than 60 percent in 2019. The video traffic growth is driven by the increase of embedded video in many online applications, growth of video-on-demand (VoD) streaming services in terms of both subscribers and viewing time per subscriber, and the evolution toward higher screen resolutions on smart devices. All of these factors have been influenced by the increasing penetration of video-capable smart devices.

Furthermore, while UHD and 4K are trendy formats, the main application for mobile streaming is Full HD with 1080p at 50 or 60 frames per second and is expected to be the format of choice for mobile streaming at scale. The distribution version may be down-sampled to support adaptive bitrate streaming, possibly with High Dynamic Range (HDR) support. For detailed discussion please refer to the presentation at the DASH-IF Workshop Dec 2019 [11].

In terms of distribution, while in the past, streaming video was delivered primarily via RTMP or RTP, fewer and fewer devices support these aging protocols each year. Instead, the latest web standards support built-in video playback and HTML5 is now by far the preferred method for video playback. And adaptive bitrate protocols dominate the distribution. According to the developer report [12], adaptive bitrate streaming through HLS/DASH, using the CMAF/DASH based segment formats, provide vast majority for streaming video. The distribution is used for On-Demand and Live Streaming.

### 6.2.2 Description of the Anticipated Application

In the context of 3GPP services, 5G Media Streaming [13] as well as the TV Video Profiles [3] are specifications addressing this streaming scenario. Both, 5G Media Streaming [13] and TV Video Profiles [3] builds on CMAF-based Segment formats and DASH distribution. From TS 26.116, the following operation points may be considered in scope of the Full HD Streaming Scenario (pending availability of appropriate test content):

- H.265/HEVC Full HD HDR, see TS26.116 [3] clause 4.5.3.

- H.264/AVC Full HD, see TS26.116 [3] clause 4.4.3.

- H.265/HEVC Full HD, see TS26.116 [3] clause 4.5.5.

- H.265/HEVC Full HD HDR HLG, see TS26.116 [3] clause 4.5.7.

These operation points are further informed by relevant operational experience with commercially available encoders and decoders.

The considered scenario is the distribution of content through DASH/CMAF based streaming. Important aspects that are expected to be considered when evaluating a codec in the context of this:

- Quality and Coding Efficiency:

- High and uninterrupted visual quality, taking into account the service constraints.

- Any savings can provide significant benefits due to the expected large volume of the traffic either in quality or network utilization.

- Adaptive Bitrate streaming:

- Multiple bit rates are provided, typically with a ladder of 30–50% to permit bandwidth adaptation. The use of constant bit rate (CBR) encoding maximises reuse of a common ladder of encoded representations across multiple distribution networks. The use of capped variable bit rate (VBR) encoding allows the bit rate to be varied according to the difficulty of the source material while maintaining the ability to distribute the encoded representations through distribution networks with fixed capacity. This also maximises reuse of a common ladder across multiple distribution networks.

- CMAF Fragments of size typically in the range of 1–6s to permit seamless switching for bit rate adaptation.

- Regular Random Access, typically every 1–2 seconds according to TS 26.116 [3]. To achieve clean switching in both sound and picture when moving between different encoded representations in the ladder, 3.84 seconds enables video segment boundaries to be aligned with an integer number of audio Access Units, if a 50fps video signal and 48kHz audio signal is used.

- Encoding in this scenario is typically done as

- Live and On-Demand distribution and encoding

- Server and Cloud-based Encoding

- No specific encoding latency constraints

### 6.2.3 Source Format Properties

Table 6.2.3-1 provides an overview of the different source signal properties following the information from TS 26.116 [3]. This information is used to select proper test sequences.

Table 6.2.3-1 Source Format Properties for different operation point

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Source Format Properties | H.264/AVC Full HD | H.265/HEVC Full HD | H.265/HEVC Full HD HDR | H.265/HEVC Full HD HLG |
| Spatial resolutions | 1920 × 1080 (Permitted Distribution formats: 1920 × 1080, 1600 × 900, 1280 × 720, 960 × 540, 854 × 480, 640 × 360,426 × 240) | | | |
| Chroma Format | Y'CbCr | | | |
| Chroma Subsampling | 4:2:0 | | | |
| Picture Aspect ratios | 16:9 | | | |
| Frame rates | 24; 25; 30; 50; 60; 24/1.001; 30/1.001; 60/1.001 Hz | | | |
| Bit Depth | 8 | 8, 10 | 10 | 10 |
| Colour space formats | BT.709 [14] | BT.709 [14]; BT.2020 [15] | BT.2020 [15] | BT.2020 [15] |
| Transfer Characteristics | BT.709 [14] | BT.709 [14]; BT.2020 [15] | BT.2100 [16] PQ | BT.2100 [16] HLG |

### 6.2.4 Encoding and Decoding Constraints

Table 6.2.4-1 provides an overview of encoding and decoding constraints for H.264/AVC Full HD and H.265/HEVC Full HD Profiles. This will support the definition of detailed test conditions.

Table 6.2.4-1 Encoding and Decoding Configurations

|  |  |  |
| --- | --- | --- |
| Encoding and Decoding Constraints | H.264/AVC Full HD | H.265/HEVC Full HD |
| Relevant Codec and Codec Profile/Levels according to TS26.116 and TS26.511. | H.264/AVC Progressive High Profile Level 4.2 [7] | HEVC/H.265 Main 10 Profile  Main Tier Level 4.1 [8] |
| Random access frequency | 1 second, 3.84 seconds | 1 second, 3.84 seconds |
| Error resiliency requirements | None | None |
| Bit rate parameters (CBR, VBR, CAE, HRD parameters) | Fixed QP  CBR 8–12 Mbit/s  VBR capped at 12 Mbit/s  others | Fixed QP  CBR 5–8 Mbit/s  VBR capped at 12 Mbit/s  others |
| ABR encoding requirements (switching frequency, etc.) | 1 second  ABR through multiple QPs | 1 second  ABR through multiple QPs |
| Latency requirements and specific encoding settings | No latency requirements beyond RAP so picture reordering is allowed | No latency requirements beyond RAP so picture reordering is allowed |
| Encoding complexity context | real-time encoding, cloud-based encoding, offline encoding, etc. | real-time encoding, cloud-based encoding, offline encoding, etc. |
| Required decoding capabilities | H.264/AVC Progressive High Profile Level 4.2 [7] | HEVC/H.265 Main 10 Profile  Main Tier Level 4.1 [8] |

### 6.2.5 Performance Metrics

All metrics as defined in clause 5.5 are expected to be reported.

For BD-Rate computation and SDR, only the following metrics are expected to be provided:

- Peak-Signal to Noise Ratio *PSNR*(*Y*) of luma component as defined in clause 5.5.3,

- Average colour component PSNR, *PSNR* over all colour components *PSNR* as defined in clause 5.5.3,

- Structural similarity metric *MS-SSIM* as defined in clause 5.5.4.2,

- Video Multimethod Assessment Fusion (VMAF) *VMAF* as defined in clause 5.5.3.

For BD-Rate computation and HDR, only the following metrics are expected to be provided:

- the weighted Peak-Signal-To-Noise Ratio metric for the luma colour components *wPSNR*(*Y*), as specified in clause 5.5.4 and 5.5.8,

- Average colour component weighted PSNR, *wPSNR* over all colour components *wPSNR*(*Y*), as specified in clause 5.5.4 and 5.5.8,

- the *PSNRL100* metric as specified in clause 5.5.4 and 5.5.8,

- *DE100* metric as specified in clause 5.5.4 and 5.5.8.

### 6.2.6 Interoperability Considerations

In order to use a codec in the context of 5G Media Streaming services in TS 26.511 and for TV Video profiles in TS 26.116, the following list provides a set of potentially relevant interoperability aspects for Full HD Streaming:

1. The receiver requirements on elementary stream level, in particular the profile/level and additional considerations.

2. The encapsulation of an elementary stream into an ISO Base Media File Format track

3. The definition of a CMAF media profile.

4. The static mapping of parameters to a DASH MPD, in particular to the MPD parameters, such as @mimeType, @codecs, etc

5. The dynamic mapping of parameters to a DASH MPD from a CMAF Principal Header, in particular to the MPD parameters, such as @width, @height, etc.

6. All MPD-level signalling for the codec to support capability discovery

7. Encryption requirements and recommendations.

8. Capability discovery options, for example mapping to HTML-5, MSE and media capability APIs.

9. Source Buffer Initialization Requirements.

10. Playback Requirements, for example by referencing CTA WAVE Specifications

11. Relation to other specifications, such as in DVB, ATSC, MPEG, ETSI, etc.

For additional details, please refer to TS 26.116 and TS 26.511.

### 6.2.7 Reference Sequences

Table 6.2.7-1 provides the selected SDR reference sequences for this scenario and Table 6.2.7-2 provides the HDR sequences. Keys are defined to refer to the sequences in the context of the scenario. The sequences are named and a reference to the details of the sequence is provided.

The applied sequences are the subsampled versions of selected 4K-TV sequences as defined in clause 6.3.7. Subsampling is done with HDRConvert based on the configuration provided in the attachment.

Table 6.2.7-1 SDR Reference Sequences for FullHD scenario

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Key | Name | Reference | Resolution | Frame rate | Colour Gamut | Number of Frames | Scene Cut |
| S1-R01 | Brest-Sedof-FHD | Annex C.3.1.3.1 | 1920 x 1080 | 60 | BT.709 | 300 | 0 |
| S1-R02 | Rain Fruits-FHD | Annex C.3.1.3.2 | 1920 x 1080 | 50 | BT.709 | 500 | 0 |
| S1-R03 | Park Joy-FHD | Annex C.3.1.3.3 | 1920 x 1080 | 50 | BT.709 | 500 | 0 |
| S1-R04 | Soccer-FHD | Annex C.3.1.3.4 | 1920 x 1080 | 23.98 | BT.709 | 385 | 4 |
| S1-R05 | Tunnel Flag-FHD | Annex C.3.1.3.5 | 2048 x 1080 | 59.94 | BT.709 | 600 | 0 |
| S1-R06 | Boat-FHD | Annex C.3.1.3.6 | 2048 x 1080 | 59.94 | BT.709 | 300 | 0 |
| S1-R07 | Fountain-FHD | Annex C.3.1.3.7 | 2048 x 1080 | 59.94 | BT.709 | 600 | 0 |
| S1-R08 | Riverbank-FHD | Annex C.3.1.3.8 | 1920 x 1080 | 50 | BT.709 | 600 | 0 |

Table 6.2.7-2 HDR Reference Sequences for FullHD scenario

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Key | Name | Reference | Resolution | Frame rate | Colour Gamut | Number of Frames | Scene Cut |
| S1-R11 | Life-Untouched-FHD | Annex C.3.2.3.1 | 1920 x 1080 | 59.94 | BT.2020 | 450 | 0 |
| S1-R12 | Meridian-FHD | Annex C.3.2.3.2 | 1920 x 1080 | 59.94 | BT.2020 | 327 | 0 |
| S1-R13 | Sol-Levante-FHD | Annex C.3.2.3.3 | 1920 x 1080 | 24 | BT.2020 | 145 | 0 |
| S1-R14 | Cosmos-FHD | Annex C.3.2.3.4 | 1920 x 1080 | 24 | BT.2020 | 182 | 0 |
| S1-R15 | Elevator-FHD | Annex C.3.2.3.5 | 2048 x 1080 | 59.94 | BT.2020 | 432 | 0 |
| S1-R16 | Sparks-FHD | Annex C.3.2.3.6 | 2048 x 1080 | 59.94 | BT.2020 | 261 | 0 |
| S1-R17 | Nocturne-FHD | Annex C.3.2.3.7 | 1920 x 1080 | 60 | BT.2020 | 370 | 0 |

### 6.2.8 Anchor Definition

#### 6.2.8.1 Overview

This clause provides details on how to generate the anchors for the Full HD Scenario.

#### 6.2.8.2 H.264/AVC Anchors

##### 6.2.8.2.1 Overview

Table 6.2.8.2.1-1 provides an overview of the H.264/AVC anchor tuples. Keys are identified to refer to the anchors in the context of the scenario.

The details are also provided here: https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario1-FullHD/264/streams.csv.

Table 6.2.8.2.1-1 Anchor Tuple generation with H.264/AVC for Full HD Scenario

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Key | Clause | Reference Sequence | Reference Encoder | Configuration | Variations | Anchor Key |
| S1-A01-264 | 6.2.8.2.2 | S1-R01 | JM19.0 | S1-JM-01 | QP = [22,27,32,37] | S1-A01-264-<QP> |
| S1-A02-264 | 6.2.8.2.2 | S1-R02 | JM19.0 | S1-JM-01 | QP = [22,27,32,37] | S1-A02-264-<QP> |
| S1-A03-264 | 6.2.8.2.2 | S1-R03 | JM19.0 | S1-JM-01 | QP = [22,27,32,37] | S1-A03-264-<QP> |
| S1-A04-264 | 6.2.8.2.2 | S1-R04 | JM19.0 | S1-JM-01 | QP = [22,27,32,37] | S1-A04-264-<QP> |
| S1-A05-264 | 6.2.8.2.2 | S1-R05 | JM19.0 | S1-JM-01 | QP = [22,27,32,37] | S1-A05-264-<QP> |
| S1-A06-264 | 6.2.8.2.2 | S1-R06 | JM19.0 | S1-JM-01 | QP = [22,27,32,37] | S1-A06-264-<QP> |
| S1-A07-264 | 6.2.8.2.2 | S1-R07 | JM19.0 | S1-JM-01 | QP = [22,27,32,37] | S1-A07-264-<QP> |
| S1-A08-264 | 6.2.8.2.2 | S1-R08 | JM19.0 | S1-JM-01 | QP = [22,27,32,37] | S1-A08-264-<QP> |

##### 6.2.8.2.2 S1-JM-01

To generate the anchor bitstreams, JM19.0 is used. However, as the test sequences are 10 bit sequences, 8 bit version of S1 SDR reference sequences are generated with HDRConvert and the attached HDRConvert config HDRConvert\_10bto8b.cfg. These sequences are used to generate the H.264/AVC anchors for S1. To generate the metrics, the 8 bit output is converted to 10 bit using HDRConvert and the attached HDRConvert config HDRConvert\_8bto10b.cfg.

This anchor tuple produces an anchor over 60 seconds with a typical configuration of H.264/AVC:

- Profile H.264/AVC Progressive High-Profile Level 4.2 [7]

- Random access and switching at 1 second interval

- LevelIDC = 50

- NumberBFrames = 15

- BReferencePictures = 2

- Quantization parameters are set as according to Table 6.2.8.2.2-1

- Picture based multipass coding disabled

- IDRPeriod = 0, i.e. open GOP structure are used in case of intra.

Table 6.2.8.2.2-1: Quantization parameters settings for H.264/AVC Anchor definition

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **QP** | **QPISlice** | **QPPSlice** | QPBSlice | ExplicitHierarchyFormat |
| 22 | 19 | 23 | 23 | B7r0B3r3B1r4b0e6b2e6B5r4b4e6b6e6B11r3B9r4b8e6b10e6B13r4b12e6b14e6 |
| 27 | 24 | 28 | 28 | B7r1B3r4B1r6b0e8b2e8B5r6b4e8b6e8B11r4B9r6b8e8b10e8B13r6b12e8b14e8 |
| 32 | 29 | 33 | 33 | B7r2B3r5B1r7b0e8b2e8B5r7b4e8b6e8B11r5B9r7b8e8b10e8B13r7b12e8b14e8 |
| 37 | 34 | 38 | 38 | B7r3B3r6B1r7b0e8b2e8B5r7b4e8b6e8B11r6B9r7b8e8b10e8B13r7b12e8b14e8 |

The settings are defined in the attached configuration file s1-jm-01.cfg.

The source sequence InputFile as well as the FrameRate needs to be set accordingly.

The following parameters need to be adapted for each sequence as follows using the JSON parameters of the reference sequence:

- IntraPeriod: Intra Period aligned with GOPSize such that approximately 1 second is achieved, i.e.

- "frameRate": 23.98 or 24.0 or 25 or 30 => IntraPeriod and IDRPeriod set to 32,

- "frameRate": 50.0 or 59.94 or 60 => IntraPeriod and IDRPeriod set to 64

#### 6.2.8.3 H.265/HEVC Anchors

##### 6.2.8.3.1 Overview

Table 6.2.8.3.1-1 provides an overview of the H.265/HEVC anchor tuples. Keys are identified to refer to the anchors in the context of the scenario.

The details are also provided here: https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario1-FullHD/265/streams.csv.

Table 6.2.8.3.1-1 Anchor Tuple generation with H.265/HEVC for FullHD Scenario

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Key** | **Clause** | **Reference Sequence** | **Reference Encoder** | **Configuration** | **Variations** | **Anchor Key** |
| S1-A01-265 | 6.3.8.3.3 | S1-R01 | HM.16.24 | S1-HM-01 | QP: [22,27,32,37] | S1-A01-265-<QP> |
| S1-A02-265 | 6.3.8.3.3 | S1-R02 | HM.16.24 | S1-HM-01 | QP: [22,27,32,37] | S1-A02-265-<QP> |
| S1-A03-265 | 6.3.8.3.3 | S1-R03 | HM.16.24 | S1-HM-01 | QP: [22,27,32,37] | S1-A03-265-<QP> |
| S1-A04-265 | 6.3.8.3.3 | S1-R04 | HM.16.24 | S1-HM-01 | QP: [22,27,32,37] | S1-A04-265-<QP> |
| S1-A05-265 | 6.3.8.3.3 | S1-R05 | HM.16.24 | S1-HM-01 | QP: [22,27,32,37] | S1-A05-265-<QP> |
| S1-A06-265 | 6.3.8.3.3 | S1-R06 | HM.16.24 | S1-HM-01 | QP: [22,27,32,37] | S1-A06-265-<QP> |
| S1-A07-265 | 6.3.8.3.3 | S1-R07 | HM.16.24 | S1-HM-01 | QP: [22,27,32,37] | S1-A07-265-<QP> |
| S1-A08-265 | 6.3.8.3.3 | S1-R08 | HM.16.24 | S1-HM-01 | QP: [22,27,32,37] | S1-A08-265-<QP> |
| S1-A11-265 | 6.3.8.3.4 | S1-R11 | HM.16.24 | S1-HM-02 | QP: [22,27,32,37] | S1-A11-265-<QP> |
| S1-A12-265 | 6.3.8.3.4 | S1-R12 | HM.16.24 | S1-HM-02 | QP: [22,27,32,37] | S1-A12-265-<QP> |
| S1-A13-265 | 6.3.8.3.4 | S1-R13 | HM.16.24 | S1-HM-02 | QP: [22,27,32,37] | S1-A13-265-<QP> |
| S1-A14-265 | 6.3.8.3.4 | S1-R14 | HM.16.24 | S1-HM-02 | QP: [22,27,32,37] | S1-A14-265-<QP> |
| S1-A15-265 | 6.3.8.3.4 | S1-R15 | HM.16.24 | S1-HM-02 | QP: [22,27,32,37] | S1-A15-265-<QP> |
| S1-A16-265 | 6.3.8.3.4 | S1-R16 | HM.16.24 | S1-HM-02 | QP: [22,27,32,37] | S1-A16-265-<QP> |
| S1-A17-265 | 6.3.8.3.4 | S1-R17 | HM.16.24 | S1-HM-02 | QP: [22,27,32,37] | S1-A17-265-<QP> |

##### 6.2.8.3.2 Common Parameters and Settings

To generate the anchor bitstreams, HM.16.24 is used:

- HM.16.24 https://hevc.hhi.fraunhofer.de/svn/svn\_HEVCSoftware/tags/HM-16.24/

The common parameters are as follows:

* Profile: main10 (Main 10 Profile)
* DecodingRefreshType: 1 (CRA)
* SearchRange: 384
* InternalBitDepth: 10 (codec operating bit-depth where all sequences (including 8 bit sequences) are coded with an internal bitdeph of 10 in accordance with [44] and metrics are calculated in 10 bits)
* SEIMasteringDisplayColourVolumeSEI is not added. If it would be added, then the metadata in the json file may be used.

The following parameters need to be adapted for each sequence as follows using the JSON parameters of the reference sequence:

- IntraPeriod: Intra Period aligned with GOPSize such that approximately 1 second is achieved, i.e.

- "frameRate": 23.98 or 24.0 or 25 or 30 => IntraPeriod set to 32,

- "frameRate": 50.0 or 59.94 or 60 => IntraPeriod set to 64

The following parameters are variables and triggered through updates of the config-file.

* QP: [22,27,32,37]

In cases where the anchor uses temporal filtering and the codec being tested does not, additional results may be included for information to show the comparison with temporal filtering turned off for the anchor. Alternatively, an external document, which details the improvement due to temporal filtering for the anchor, may be referenced.

##### 6.2.8.3.3 S1-HM-01: SDR Settings

The common parameters as defined in 6.2.8.3.2 apply.

In addition, the following parameters apply:

* VuiParametersPresent: 0 (VUI absent)
* SEIDecodedPictureHash: 0 (md5 checksum absent)

The settings are defined in the attached configuration file s1-hm-01.cfg.

##### 6.2.8.3.4 S1-HM-02: HDR PQ Settings

The common parameters as defined in 6.2.8.3.2 apply.

In addition, the following parameters apply:

* VuiParametersPresent: 1 (VUI present)
* ColourPrimaries: 9
* TransferCharacteristics: 16
* MatrixCoefficients: 9
* ChromaLocInfoPresent: 1
* ChromaSampleLocTypeTopField: 2
* ChromaSampleLocTypeBottomField: 2
* SEIDecodedPictureHash: 0 (md5 checksum absent)

The settings are defined in the attached configuration file s1-hm-02.cfg.

### 6.2.9 Anchor Results

#### 6.2.9.1 H.264/AVC Anchors

AVC anchor streams are provided according to the key system here:

* https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-1-FHD/264/

AVC anchor results are provided with the appropriate keys as defined in Table 6.2.8.2.1-1

* in the attached csv files
* <https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-1-FHD/264/Metrics/>

The verification status for the AVC test stream is provided in <https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-1-FHD/264/verification.csv> and Table 6.2.9.1-1 with S for successful and F for failed. Empty cells indicate missing verification.

**Table 6.2.9.1-1 Verification status of H.264/AVC anchors for Full HD Scenario**

Editor’s Note: Table and details to be added

#### 6.2.9.2 H.265/HEVC Anchors

HEVC anchor streams are provided according to the key system here:

* https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-1-FHD/265/

HEVC anchor results are provided with the appropriate keys as defined in Table 6.2.8.3.1-1

* in the attached csv files
* https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-1-FHD/265/Metrics/

The verification status for the HEVC test stream is provided in https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-1-FHD/265/verification.csv and Table 6.2.9.2-1 with S for successful and F for failed. Empty cells indicate missing verification.

**Table 6.2.9.2-1 Verification status of H.265/HEVC anchors for Full HD Scenario**

Editor’s Note: Table and details to be added

## 6.3 Scenario 2: 4K-TV

### 6.3.1 Motivation

Streaming towards mobile devices is undoubtly the first natural use-case expected for 5G-media streaming. However, consumption of video services on fixed receivers (e.g. TV sets) remains a preferable way of experiencing the high-quality content, whether it is for on-demand (e.g., blockbuster movies) or live services (e.g., sport events). Recent reports from largest VOD platforms such as Netflix confirm that assumption and show that the primary way of watching content remains fixed TV screens, covering 70% of devices 6 months after subscription [17]. In the same way, YouTube indicates that service usage on fixed TV set remains an inevitable way of accessing the content, with 250M of hours viewed per day on TV screens [18]. As 5G media streaming targets a wide range of connected devices and is expected to be able to deliver video streams to many compatible high-resolution receivers, (e.g. 5G-HDMI-sticks, 5G-StB/5G-MediaGateway or even 5G-TV sets) the inclusion of 4K TV Scenarios for 5G Video codec evaluation is important.

First, the 4K-TV set is currently the most established way of displaying premium quality services using latest technology improvements for video content, including High-Dynamic-Range (HDR) and Wide-Colour-Gamut (WCG). Latest statistics from the Ultra-HD forum indicate that 148 UHD services are currently on-air, 74% being linear, 45% of those using HDR [19]. In addition, a large number of SVOD operators propose 4K access in their subscription packages (e.g. Netflix™ and Amazon Prime™). All these services may eventually take advantage of 5G-network capabilities to increase the device reach and enlarge audiences. This scenario is also endorsed by strong shipment forecasts, as indicated in the latest IHS 4K-TV UHD bluebook [20].

### 6.3.2 Description of the Anticipated Application

In the context of 3GPP services, 5G Media Streaming [13] as well as the TV Video Profiles [3] are specifications addressing this 4K-TV scenario. Both, 5G Media Streaming [13] and TV Video Profiles [3] build on CMAF-based Segment formats and DASH distribution. From 3GPP TS 26.116, the following operation points may be considered in scope of the 4K-TV Streaming Scenario (pending availability of appropriate test content):

- H.265/HEVC UHD, see 3GPP TS 26.116 [3] clause 4.5.4.

- H.265/HEVC UHD HDR, see 3GPP TS 26.116 [3] clause 4.5.6.

- H.265/HEVC UHD HDR HLG, see 3GPP TS 26.116 [3] clause 4.5.8.

This scenario is based on CMAF (including LL-DASH and HLS-LL) distribution of UHD-TV video services over 5G networks to 5G/non-5G capable devices. This includes 5G-equipped devices (e.g. smartphone, tablets, …) but also other devices gateway (e.g. TV sets, HDMI-Stick…) accessing services through a “5G-gateway” which can be a mobile phone or a home gateway. As multiple linear services will be delivered in parallel (news, sport, talk show…) in a similar manner as traditional TV services in a multiplex (potentially using multicast/broadcast delivery over 5G). In certain environments, High Frame Rate (HFR) beyond 60 fps is considered, e.g. in DVB and ATSC broadcast specifications. 3GPP does not have any HFR TV video profiles yet.

Important aspects that are expected to be considered when evaluating a codec in the context of this 4K-TV scenario are:

- Quality and Coding Efficiency:

- High and uninterrupted visual quality, considering the service constraints.

- Any savings can provide significant benefits due to the expected large volume of the traffic either in quality or network utilization.

- Adaptive Bitrate streaming:

- Multiple bit rates are provided, typically with a ladder of 30–50% to permit bandwidth adaptation. The use of constant bit rate (CBR) encoding maximises reuse of a common ladder of encoded representations across multiple distribution networks. The use of capped variable bit rate (VBR) encoding allows the bit rate to be varied according to the difficulty of the source material while maintaining the ability to distribute the encoded representations through distribution networks with fixed capacity. This also maximises the usage of a common ladder across multiple distribution networks.

- CMAF Fragments of size typically in the range of 1–6s to permit seamless switching for bit rate adaptation.

- Regular Random Access, typically every 1–2 seconds according to 3GPP TS 26.116 [3]. To achieve clean switching in both sound and picture when moving between different encoded representations in the ladder, 3.84 seconds enables video segment boundaries to be aligned with an integer number of audio Access Units, if a 50fps video signal and 48kHz audio signal is used.

- Encoding in this scenario is typically done as

- Live and On-Demand distribution and encoding

- Server and Cloud-based Encoding

- Capable of encoding multiple services at variable bitrate, inside a fixed dedicated resource (statistical multiplexing).

### 6.3.3 Source Format Properties

Table 6.3.3-1 provides an overview of the different source signal properties for 4K-TV. This information is used to select proper test sequences.

Table 6.3.3-1 4K-TV source format properties

|  |  |
| --- | --- |
| Source format properties | 4K-TV |
| Spatial resolution | 3840 x 2160  (Permitted distribution formats: 2560 × 1440, 1920 × 1080, 1600 × 900, 1280 × 720) |
| Chroma format | Y’CbCr |
| Chroma subsampling | 4:2:0 |
| Picture aspec ratio | 16:9 |
| Frame rates | 24; 50; 60; 24/1.001; 60/1.001; [100; 120] Hz |
| Bit depth | 10 |
| Colour space formats | BT.2020 [15] |
| Transfer characteristics | BT.2020 [15], BT.2100 [16] (PQ & HLG) |

NOTE: High Frame Rate (HFR) is not supported by 3GPP TV Video profiles defined in 3GPP TS 26.116 [3] in release 16. However, HFR is introduced in this clause for consideration on the video codec performances.

### 6.3.4 Encoding and Decoding Constraints

Table 6.3.4-1 provides an overview of encoding and decoding constraints for 4K-TV category using legacy codec HEVC. This will support the definition of detailed test conditions. It is noted that no relevant profiles exist in TS26.116 and TS26.511 for HFR 4K-TV content.

Table 6.3.4-1 Encoding and Decoding Configurations for 4K-TV with legacy HEVC codec

|  |  |  |
| --- | --- | --- |
| Encoding and Decoding Constraints | H.265/HEVC 4K-TV | H.265/HEVC 4K-TV HFR |
| Relevant Codec and Codec Profile/Levels according to TS26.116 and TS26.511. | H.265/HEVC Main 10 Profile  Level 5.1 [8] | No relevant 3GPP profiles, should be aligned with H.265/HEVC Main 10 Profile Level 5.2 [8] |
| RAP period | 3.84sec, 1sec | 3.84sec, 1sec |
| Bit rate parameters (CBR, VBR, CAE, HRD parameters) | QPs see below  B = {10,20,30,40} Mbps [49]  CBR and capped-VBR | QP are tbd  B = {10,20,30,40} Mbps [49]  CBR and capped-VBR |
| Latency requirements and specific encoding settings | No latency requirements beyond RAP so picture reordering allowed | No latency requirements beyond RAP so picture reordering allowed |
| Encoding complexity context | real-time encoding, cloud-based encoding, offline encoding, etc. | real-time encoding, cloud-based encoding, offline encoding, etc. |
| Required decoding capabilities | H.265/HEVC Main 10 Profile  Level 5.1 [8] | H.265/HEVC Main 10 Profile  Level 5.2 [8] |

### 6.3.5 Performance Metrics

Performance is assessed using BD-Rate computation, with PSNR, SSIM and VMAF metrics as objective quality criterion. Regarding complexity considerations, encoding/decoding runtime is provided.

All metrics as defined in clause 5.5 are expected to be reported.

For BD-Rate computation and SDR, only the following metrics are expected to be provided:

- Peak-Signal to Noise Ratio *PSNR*(*Y*) of luma component as defined in clause 5.5.3,

- Average colour component PSNR, *PSNR* over all colour components *PSNR(i)* as defined in clause 5.5.3,

- Structural similarity metric *MS-SSIM* as defined in clause 5.5.4.2,

- Video Multimethod Assessment Fusion (VMAF) *VMAF* as defined in clause 5.5.3.

For BD-Rate computation and HDR, only the following metrics are expected to be provided:

- the weighted Peak-Signal-To-Noise Ratio metric for the luma colour components *wPSNR*(*Y*), as specified in clause 5.5.4 and 5.5.8,

- Average colour component weighted PSNR, *wPSNR* over all colour components *wPSNR(i)*, as specified in clause 5.5.4 and 5.5.8,

- the *PSNRL100* metric as specified in clause 5.5.4 and 5.5.8,

- *DE100* metric as specified in clause 5.5.4 and 5.5.8.

### 6.3.6 Interoperability Considerations

In order to use a codec in the context of 5G Media Streaming services in 3GPP TS 26.511 [13] and for TV Video profiles in 3GPP TS 26.116 [3], the same considerations for interoperability as for FullHD according to clause 6.2.6 apply.

For additional details, please refer to 3GPP TS 26.116 [3] and 3GPP TS 26.511 [13].

### 6.3.7 Reference Sequences

Table 6.3.7-1 provides the selected reference sequences for this scenario for SDR and Table 6.3.7-2 provides the selected reference sequences for this scenario for HDR. Keys are defined to refer to the sequences in the context of the scenario. The sequences are named and a reference to the details of the sequence is provided. Annex C.3 describes in detail the selection process conducted to build the test sequences considered for this scenario, the outcome of this process is reported in the table below.

Table 6.3.7-1 SDR Reference Sequences for 4K-TV scenario

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Key | Name | Reference | Resolution | Frame rate | Colour Gamut | Number of Frames | Scene Cut |
| S2-R01 | Brest-Sedof | Annex C.3.1.3.1 | 3840 x 2160 | 60 | BT.709 | 300 | 0 |
| S2-R02 | Rain Fruits | Annex C.3.1.3.2 | 3840 x 2160 | 50 | BT.709 | 500 | 0 |
| S2-R03 | Park Joy | Annex C.3.1.3.3 | 3840 x 2160 | 50 | BT.709 | 500 | 0 |
| S2-R04 | Soccer | Annex C.3.1.3.4 | 3840 x 2160 | 23.98 | BT.709 | 385 | 4 |
| S2-R05 | Tunnel Flag | Annex C.3.1.3.5 | 4096 x 2160 | 59.94 | BT.709 | 600 | 0 |
| S2-R06 | Boat | Annex C.3.1.3.6 | 4096 x 2160 | 59.94 | BT.709 | 300 | 0 |
| S2-R07 | Fountain | Annex C.3.1.3.7 | 4096 x 2160 | 59.94 | BT.709 | 600 | 0 |
| S2-R08 | Riverbank | Annex C.3.1.3.8 | 3840 x 2160 | 50 | BT.709 | 600 | 0 |

Table 6.3.7-2 HDR Reference Sequences for 4K-TV scenario

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Key | Name | Reference | Resolution | Frame rate | Colour Gamut | Number of Frames | Scene Cut |
| S2-R11 | Life-Untouched | Annex C.3.2.3.1 | 3840 x 2160 | 59.94 | BT.2100 PQ | 450 | 0 |
| S2-R12 | Meridian | Annex C.3.2.3.2 | 3840 x 2160 | 59.94 | BT.2100 PQ | 327 | 0 |
| S2-R13 | Sol-Levante | Annex C.3.2.3.3 | 3840 x 2160 | 24 | BT.2100 PQ | 145 | 0 |
| S2-R14 | Cosmos | Annex C.3.2.3.4 | 3840 x 2160 | 24 | BT.2100 PQ | 182 | 0 |
| S2-R15 | Elevator | Annex C.3.2.3.5 | 4096 x 2160 | 59.94 | BT.2100 PQ | 432 | 0 |
| S2-R16 | Sparks | Annex C.3.2.3.6 | 4096 x 2160 | 59.94 | BT.2100 PQ | 261 | 0 |
| S2-R17 | Nocturne | Annex C.3.2.3.7 | 3840 x 2160 | 60 | BT.2100 PQ | 370 | 0 |

### 6.3.8 Anchor Definition

#### 6.3.8.1 Overview

This clause provides details on how to generate the anchors for the 4K-TV scenario.

No H.264/AVC Anchors are defined.

H.265/HEVC Anchors are defined in clause 6.3.8.3.

#### 6.3.8.2 H.264/AVC Anchors

No H.264/AVC Anchors are defined for this scenario.

#### 6.3.8.3 H.265/HEVC Anchors

##### 6.3.8.3.1 Overview

Table 6.3.8.3.1-1 provides an overview of the H.265/HEVC anchor tuples. Keys are identified to refer to the anchors in the context of the scenario.

The details are also provided here: https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-2-4K/265/streams.csv.

Table 6.3.8.3.1-1 Anchor Tuple generation with H.265/HEVC for 4K-TV Scenario

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Key** | **Clause** | **Reference Sequence** | **Reference Encoder** | **Configuration** | **Variations** | **Anchor Key** |
| S2-A01-265 | 6.3.8.3.3 | S2-R01 | HM.16.24 | S2-HM-01 | QP: [22,27,32,37] | S2-A01-265-<QP> |
| S2-A02-265 | 6.3.8.3.3 | S2-R02 | HM.16.24 | S2-HM-01 | QP: [22,27,32,37] | S2-A02-265-<QP> |
| S2-A03-265 | 6.3.8.3.3 | S2-R03 | HM.16.24 | S2-HM-01 | QP: [22,27,32,37] | S2-A03-265-<QP> |
| S2-A04-265 | 6.3.8.3.3 | S2-R04 | HM.16.24 | S2-HM-01 | QP: [22,27,32,37] | S2-A04-265-<QP> |
| S2-A05-265 | 6.3.8.3.3 | S2-R05 | HM.16.24 | S2-HM-01 | QP: [22,27,32,37] | S2-A05-265-<QP> |
| S2-A06-265 | 6.3.8.3.3 | S2-R06 | HM.16.24 | S2-HM-01 | QP: [22,27,32,37] | S2-A06-265-<QP> |
| S2-A07-265 | 6.3.8.3.3 | S2-R07 | HM.16.24 | S2-HM-01 | QP: [22,27,32,37] | S2-A07-265-<QP> |
| S2-A08-265 | 6.3.8.3.3 | S2-R08 | HM.16.24 | S2-HM-01 | QP: [22,27,32,37] | S2-A08-265-<QP> |
| S2-A11-265 | 6.3.8.3.4 | S2-R11 | HM.16.24 | S2-HM-02 | QP: [22,27,32,37] | S2-A11-265-<QP> |
| S2-A12-265 | 6.3.8.3.4 | S2-R12 | HM.16.24 | S2-HM-02 | QP: [22,27,32,37] | S2-A12-265-<QP> |
| S2-A13-265 | 6.3.8.3.4 | S2-R13 | HM.16.24 | S2-HM-02 | QP: [22,27,32,37] | S2-A13-265-<QP> |
| S2-A14-265 | 6.3.8.3.4 | S2-R14 | HM.16.24 | S2-HM-02 | QP: [22,27,32,37] | S2-A14-265-<QP> |
| S2-A15-265 | 6.3.8.3.4 | S2-R15 | HM.16.24 | S2-HM-02 | QP: [22,27,32,37] | S2-A15-265-<QP> |
| S2-A16-265 | 6.3.8.3.4 | S2-R16 | HM.16.24 | S2-HM-02 | QP: [22,27,32,37] | S2-A16-265-<QP> |
| S2-A17-265 | 6.3.8.3.4 | S2-R17 | HM.16.24 | S2-HM-02 | QP: [22,27,32,37] | S2-A17-265-<QP> |

##### 6.3.8.3.2 Common Parameters and Settings

To generate the anchor bitstreams, HM.16.24 is used:

- HM.16.24 https://hevc.hhi.fraunhofer.de/svn/svn\_HEVCSoftware/tags/HM-16.24/

The common parameters are as follows:

* Profile: main10 (Main 10 Profile)
* DecodingRefreshType: 1 (CRA)
* SearchRange: 384
* InternalBitDepth: 10 (codec operating bit-depth where all sequences (including 8 bit sequences) are coded with an internal bitdeph of 10 in accordance with [44] and metrics are calculated in 10 bits)
* SEIMasteringDisplayColourVolumeSEI is not added. If it would be added, then the metadata in the json file may be used.

The following parameters need to be adapted for each sequence as follows using the JSON parameters of the reference sequence:

- IntraPeriod: Intra Period aligned with GOPSize such that approximately 1 second is achieved, i.e.

- "frameRate": 23.98 or 24.0 or 25 or 30 => IntraPeriod set to 32,

- "frameRate": 50.0 or 59.94 or 60 => IntraPeriod set to 64

The following parameters are variables and triggered through updates of the config-file.

* QP: [22,27,32,37]

In cases where the anchor uses temporal filtering and the codec being tested does not, additional results may be included for information to show the comparison with temporal filtering turned off for the anchor. Alternatively, an external document, which details the improvement due to temporal filtering for the anchor, may be referenced.

##### 6.3.8.3.3 S2-HM-01: SDR Settings

The common parameters as defined in 6.3.8.3.2 apply.

In addition, the following parameters apply:

* VuiParametersPresent: 0 (VUI absent)
* SEIDecodedPictureHash: 0 (md5 checksum absent)

The settings are defined in the attached configuration file s2-hm-01.cfg.

##### 6.3.8.3.4 S2-HM-02: HDR PQ Settings

The common parameters as defined in 6.3.8.3.2 apply.

In addition, the following parameters apply:

* VuiParametersPresent: 1 (VUI present)
* ColourPrimaries: 9
* TransferCharacteristics: 16
* MatrixCoefficients: 9
* ChromaLocInfoPresent: 1
* ChromaSampleLocTypeTopField: 2
* ChromaSampleLocTypeBottomField: 2
* SEIDecodedPictureHash: 0 (md5 checksum absent)

The settings are defined in the attached configuration file s2-hm-02.cfg.

### 6.3.9 Anchor Results

#### 6.3.9.1 H.264/AVC Anchors

No H.264/AVC anchors are provided.

#### 6.3.9.2 H.265/HEVC Anchors

HEVC anchor streams are provided according to the key system here:

* https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-2-4K/265/

HEVC anchor results are provided with the appropriate keys as defined in Table 6.3.8.3.1-1

* in the attached csv files
* <https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-2-4K/265/Metrics/>

The verification status for the HEVC test stream is provided in https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-2-4K/265/verification.csv and Table 6.2.9.1-1 with S for successful and F for failed. Empty cells indicate missing verification.

**Table 6.3.9.2-1 Verification status of H.265/HEVC anchors for 4K TV Scenario**

Editor’s Note: Table and details to be added

## 6.4 Scenario 3: Screen Content Scenario

### 6.4.1 Motivation

This scenario mostly motivates cases for which content goes beyond videographic content, and in particular includes computer generated imagery (CGI). Several application spaces rely on screen content types such as videoconferencing and webinars with presentation slides displayed, or remote desktop applications for demos or remote assistance. These services include massive online videoconferencing systems and telepresence systems both being particularly popular with remote collaboration.

For telepresence with screen-sharing applications, some information related to video is collected in the following:

- MS Teams™ [26] as of end of 2019.

o There are several formats supported for video. Two key properties of a video format are its frame size and colour format. Supported frame sizes include 640x360 ("360p"), 1280x720 ("720p"), and 1920x1080 ("1080p"). Supported colour formats include NV12 (12 bits per pixel) and RGB24 (24 bits per pixel).

o A "720p" video frame contains 921,600 pixels (1280 times 720). In the RGB24 colour format, each pixel is represented as 3 bytes (24-bits) comprised of one byte each of red, green, and blue colour components. Therefore, a single 720p RGB24 video frame requires 2,764,800 bytes of data (921,600 pixels times 3 bytes/pixel). At a frame rate of 30fps, sending 720p RGB24 video frames means processing approximately 80 MB/s of content (which is substantially compressed by the H.264 video codec before network transmission).

- Other tools are for further study.

As an example of hardware implementation, the Intel Xe LP™ chipset supports HEVC screen content profile (see slide 101 of [41]).

### 6.4.2 Description of the Anticipated Application

3GPP until now has very restricted set of services but based on the considerations in clause 6.4.1, the following encoding benchmark capabilities are considered for decoding:

- H.264 (AVC) YUV 4:2:0, YUV 4:4:4, 8 bit, Max Resolution 1920x1080

- H.265 (HEVC) YUV 4:2:0, YUV 4:4:4, 10 bit, Max Resolution 4096 x 2048

The considered scenario is low-latency streaming or conversational. Important aspects that are expected to be considered when evaluating a codec in the context of this:

- Quality and Coding Efficiency:

- The ability to compress computer-generated content. Typically, it means the ability to have non perceptible intra refreshes and the ability to maintain stability on low frequency areas (such as uniform backgrounds) as well as maintaining details on high frequencies (particularly for text)

- The ability compress YUV 4:2:0 and 4:4:4 content.

- Considered settings for encoding:

- Low-latency settings

- No specific error resilience mechanisms

- Encoding in this scenario is typically done as

- Real-time encoding

### 6.4.3 Source Format Properties

Table 6.4.3-1 provides an overview of the different source signal properties for Screen Content Sharing. This information is used to select proper test sequences.

Table 6.4.3-1 Screen Content Sharing source properties

|  |  |
| --- | --- |
| Source format properties | Screen Content |
| Spatial resolution | 1920 x 1080, 3840 x 2160 |
| Chroma format | Y’CbCr, RGB |
| Chroma subsampling | 4:2:0, 4:4:4 |
| Picture aspect ratio | 16:9 |
| Frame rates | 25, 30, 50, 60 Hz |
| Bit depth | 8, 10 |
| Colour space formats | BT.709 |
| Transfer characteristics | BT.709 |

### 6.4.4 Encoding and Decoding Constraints

Table 6.4.4-1 provides an overview of the different codec tools per profile that may be suitable for coding screen content sequences for the AVC and HEVC codecs.

Table 6.4.4-1 Screen Content Tools per Profile

|  |  |  |
| --- | --- | --- |
| Screen content tools | AVC | HEVC |
| main profile | Not applicable | Transform skip |
| range extension profile | not applicable | Residual Differential Pulse Code Modulation (RDPCM) (implicit intra/explicit inter), |
| screen content profile | Not applicable | Intra Block Copy (full frame or less), Palette, Adaptive Colour Transform |

Table 6.4.4-2 provides an overview of encoding and decoding constraints for Screen Content scenario

- general constraints

- using H.264/AVC codecs operating points,

- using H.265/HEVC codecs operating points.

These configurations support the definition of detailed test conditions. The configuration files for HEVC are used as the reference configurations for other codecs.

Table 6.4.4-2 Encoding and Decoding Configurations for Screen Content

|  |  |  |  |
| --- | --- | --- | --- |
| Encoding and Decoding Constraints | General | H.264/AVC | H.265/HEVC |
| Relevant Codec and Codec Profile/Levels according to TS26.116 and TS26.511. | Profiles suitable for screen content  Levels to meet the above frame rates | H.264/AVC Progressive High Profile  Level 4.2, 5.2 | H.265/HEVC Main 10 Profile  H.265/HEVC Screen-Extended Main 10 profile  Level 4.1, 5.1, 6.1 |
| Random access frequency | 1 second, No RA | 1 second, No RA | 1 second, No RA |
| Error resiliency tools | none | none | none |
| Bit rate parameters (CBR, VBR, CAE, HRD parameters) | Constant quality | Fixed QP for I and P slices | Fixed QP for I and P slices |
| Bit rates and quality configuration | Covering a range of relevant bitrates and qualities | QP variations between 22 and 42 | QP variations between 22 and 42 |
| Latency requirements and specific encoding settings | Encoding adds no latency | Low-delay P | Low-delay P |
| Encoding complexity context | Real-time encoding is possible | Settings for search ranges, set to 256 | Settings for search ranges, set to 64 |
| Required decoding capabilities | Profiles suitable for screen content  Levels to meet the above frame rates | H.264/AVC Progressive High Profile  Level 4.2, 5.2 | H.265/HEVC Main 10 Profile  H.265/HEVC Screen-extended Main 10 profile  Level 4.1, 5.1, 6.1 |

NOTE: A Random access frequency No RA means only the first frame is intra coded.

### 6.4.5 Performance Metrics

All SDR Metrics as defined in clause 5.5.2 may be reported. However, VMAF and MS-SSIM may not be adequate for screen content sequences and PSNR is the main SDR metric to consider.

Based on this, for BD-Rate computation and SDR, only the following metrics are provided:

- Peak-Signal to Noise Ratio *PSNR*(*Y*) of luma component as defined in clause 5.5.3,

- Average colour component *PSNR*, PSNR over all colour components PSNR as defined in clause 5.5.3.

### 6.4.6 Interoperability Considerations

For screen content, RTP-based communication is expected.

### 6.4.7 Reference Sequences

Table 6.4.7-1 provides the selected reference sequences for this scenario. Keys are defined to refer to the sequences in the context of the scenario. The sequences are named and a reference to the details of the sequence is provided. A justification is provided, why this sequence is selected.

Reference sequences illustrating the screen content scenario are described in Annex C. They contain either synthetic content from a presentation such as a slide deck with text and graphics.

The details are also provided here: https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-3-Screen/reference-sequence.csv.

Table 6.4.7-1 Reference Sequences for Screen Content Scenario

|  |  |  |
| --- | --- | --- |
| Key | Name | Reference |
| S3-R01 | MovingText2-4K-10bit | Annex C.6.2 |
| S3-R02 | MovingText2-4K-8bit | Annex C.6.2 |
| S3-R03 | MovingText2-FullHD-10bit | Annex C.6.2 |
| S3-R04 | MovingText2-FullHD-8bit | Annex C.6.2 |
| S3-R05 | TextMixTransitions-4K-10bit | Annex C.6.3 |
| S3-R06 | TextMixTransitions-4K-8bit | Annex C.6.3 |
| S3-R07 | TextMixTransitions-FullHD-10bit | Annex C.6.3 |
| S3-R08 | TextMixTransitions-FullHD-8bit | Annex C.6.3 |
| S3-R09 | GraphicsMixSimple-4K-10bit | Annex C.6.4 |
| S3-R10 | GraphicsMixSimple-4K-8bit | Annex C.6.4 |
| S3-R11 | GraphicsMixSimple-FullHD-10bit | Annex C.6.4 |
| S3-R12 | GraphicsMixSimple-FullHD-8bit | Annex C.6.4 |
| S3-R13 | GraphicsMixTransitions-4K-10bit | Annex C.6.5 |
| S3-R14 | GraphicsMixTransitions-4K-8bit | Annex C.6.5 |
| S3-R15 | GraphicsMixTransitions-FullHD-10bit | Annex C.6.5 |
| S3-R16 | GraphicsMixTransitions-FullHD-8bit | Annex C.6.5 |
| S3-R17 | Mission-Control | Annex C.6.6 |

### 6.4.8 Anchor Definition

#### 6.4.8.1 Overview

This clause provides details on how to generate the anchors for the Screen Content scenario.

The screen content configuration relies on low delay encoding modes with the optional use of Screen Content encoding tools when possible (for HEVC).

#### 6.4.8.2 H.264/AVC Anchors

##### 6.4.8.2.1 Overview

Table 6.4.8.2.1-1 provides an overview of the H.264/AVC anchor tuples. Keys are identified to refer to the anchors in the context of the scenario. Note that only the 8-bit sequences are used.

The details are also provided here: https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-3-Screen/264/streams.csv.

Table 6.4.8.2.1-1 Anchor Tuple generation with H.264/AVC for Screen Content Scenario

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Key | Clause | Reference Sequence | Reference Encoder | Config | Variations | Anchor Key |
| S3-A02-264 | 6.4.8.2.3 | S3-R02 | JM19.0 | S3-JM-01 | QP=[22,27,32,37,42] | S3-A02-264-<QP> |
| S3-A04-264 | 6.4.8.2.3 | S3-R04 | JM19.0 | S3-JM-01 | QP=[22,27,32,37,42] | S3-A04-264-<QP> |
| S3-A06-264 | 6.4.8.2.3 | S3-R06 | JM19.0 | S3-JM-01 | QP=[22,27,32,37,42] | S3-A06-264-<QP> |
| S3-A08-264 | 6.4.8.2.3 | S3-R08 | JM19.0 | S3-JM-01 | QP=[22,27,32,37,42] | S3-A08-264-<QP> |
| S3-A10-264 | 6.4.8.2.3 | S3-R10 | JM19.0 | S3-JM-01 | QP=[22,27,32,37,42] | S3-A10-264-<QP> |
| S3-A12-264 | 6.4.8.2.3 | S3-R12 | JM19.0 | S3-JM-01 | QP=[22,27,32,37,42] | S3-A12-264-<QP> |
| S3-A14-264 | 6.4.8.2.3 | S3-R14 | JM19.0 | S3-JM-01 | QP=[22,27,32,37,42] | S3-A14-264-<QP> |
| S3-A16-264 | 6.4.8.2.3 | S3-R16 | JM19.0 | S3-JM-01 | QP=[22,27,32,37,42] | S3-A16-264-<QP> |
| S3-A18-264 | 6.4.8.2.3 | S3-R17 | JM19.0 | S3-JM-01 | QP=[22,27,32,37,42] | S3-A18-264-<QP> |
| S3-A20-264 | 6.4.8.2.3 | S3-R02 | JM19.0 | S3-JM-02 | QP=[22,27,32,37,42] | S3-A20-264-<QP> |
| S3-A22-264 | 6.4.8.2.4 | S3-R04 | JM19.0 | S3-JM-02 | QP=[22,27,32,37,42] | S3-A22-264-<QP> |
| S3-A24-264 | 6.4.8.2.4 | S3-R06 | JM19.0 | S3-JM-02 | QP=[22,27,32,37,42] | S3-A24-264-<QP> |
| S3-A26-264 | 6.4.8.2.4 | S3-R08 | JM19.0 | S3-JM-02 | QP=[22,27,32,37,42] | S3-A26-264-<QP> |
| S3-A28-264 | 6.4.8.2.4 | S3-R10 | JM19.0 | S3-JM-02 | QP=[22,27,32,37,42] | S3-A28-264-<QP> |
| S3-A30-264 | 6.4.8.2.4 | S3-R12 | JM19.0 | S3-JM-02 | QP=[22,27,32,37,42] | S3-A30-264-<QP> |
| S3-A32-264 | 6.4.8.2.4 | S3-R14 | JM19.0 | S3-JM-02 | QP=[22,27,32,37,42] | S3-A32-264-<QP> |
| S3-A34-264 | 6.4.8.2.4 | S3-R16 | JM19.0 | S3-JM-02 | QP=[22,27,32,37,42] | S3-A34-264-<QP> |
| S3-A65-264 | 6.4.8.2.4 | S3-R17 | JM19.0 | S3-JM-02 | QP=[22,27,32,37,42] | S3-A65-264-<QP> |

##### 6.4.8.2.2 Common Parameters

To generate the anchor bitstreams, JM19.0 is used.

The common parameters are as follows:

- ProfileIDC = 100 (High Profile)

- IDRPeriod = IntraPeriod

- NumberOfReferenceFrames = 4

- PList0References = 4 (P slice List 0 reference override)

- I16RDOpt = 1 (rd-optimized mode decision for Intra 16x16 MB)

- SearchMode = 3 Enhanced Predictive Zonal Search (EPZS)

- SearchRange = 256;

- Picture based multipass coding disabled

The following parameters are variables and triggered through updates of the config-file.

* QP: [22,27,32,37,42]

Note that the MaxMvsPer2Mb restriction is not matching the used level requirement from H.264/AVC due to use of inter 4x4 subpartitions. While a strictly conforming decoder may fail, this is not considered a limiting factor in today’s implementations.

##### 6.4.8.2.3 S3-JM-01: no random access

The common parameters as defined in 6.4.8.2.2 apply.

In addition, the following parameters apply:

- LevelIDC = 42 or 52 (depending on resolution)

- IntraPeriod = 0 (no random access)

- NumberBFrames = 4

- Quantization parameters are set according to Table 6.4.8.2.3-1.

Table 6.4.8.2.3-1 Quantization Parameters for S3-JM-01

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| QP | QPISlice | QPPSlice | QPBSlice | ExplicitHierarchyFormat |
| 22 | 21 | 24 | N/A | P0r3P1r2P2r3P3r2 |
| 27 | 26 | 29 | N/A | P0r5P1r4P2r5P3r4 |
| 32 | 31 | 34 | N/A | P0r6P1r5P2r6P3r5 |
| 37 | 36 | 39 | N/A | P0r6P1r5P2r6P3r5 |
| 42 | 41 | 44 | N/A | P0r6P1r5P2r6P3r5 |

The settings are defined in the attached configuration file s3-jm-01.cfg.

##### 6.4.8.2.3 S3-JM-02: fixed Intra every second

The common parameters as defined in 6.4.8.2.2 apply.

In addition, the following parameters apply:

- LevelIDC = 42 or 52 (depending on resolution)

- IntraPeriod such that exactly 1 second is achieved (i.e. IntraPeriod value equal to the sequence fps value)

- SearchRange = 256

- QPISlice = QPPSlice = QP

- NumberBFrames = 0

The settings are defined in the attached configuration file s3-jm-02.cfg.

#### 6.4.8.3 H.265/HEVC Anchors

##### 6.4.8.3.1 Overview

Table 6.4.8.3.1-1 provides an overview of the H.265/HEVC anchor tuples. Keys are identified to refer to the anchors in the context of the scenario.

The details are also provided here: https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-3-Screen/265/streams.csv.

Table 6.4.8.3.1-1 Anchor Tuple generation with H.265/HEVC for Screen Content Scenario

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Key | Clause | Reference Sequence | Reference Encoder | Configuration | Variations | Anchor Key |
| S3-A01-265 | 6.4.8.3.3 | S3-R01 | HM16.22 | S3-HM-03 | QP = [22,27,32,37,42] | S3-A01-265-<QP> |
| S3-A02-265 | 6.4.8.3.3 | S3-R02 | HM16.22 | S3-HM-01 | QP = [22,27,32,37,42] | S3-A02-265-<QP> |
| S3-A03-265 | 6.4.8.3.3 | S3-R03 | HM16.22 | S3-HM-03 | QP = [22,27,32,37,42] | S3-A03-265-<QP> |
| S3-A04-265 | 6.4.8.3.3 | S3-R04 | HM16.22 | S3-HM-01 | QP = [22,27,32,37,42] | S3-A04-265-<QP> |
| S3-A05-265 | 6.4.8.3.3 | S3-R05 | HM16.22 | S3-HM-03 | QP = [22,27,32,37,42] | S3-A05-265-<QP> |
| S3-A06-265 | 6.4.8.3.3 | S3-R06 | HM16.22 | S3-HM-01 | QP = [22,27,32,37,42] | S3-A06-265-<QP> |
| S3-A07-265 | 6.4.8.3.3 | S3-R07 | HM16.22 | S3-HM-03 | QP = [22,27,32,37,42] | S3-A07-265-<QP> |
| S3-A08-265 | 6.4.8.3.3 | S3-R08 | HM16.22 | S3-HM-01 | QP = [22,27,32,37,42] | S3-A08-265-<QP> |
| S3-A09-265 | 6.4.8.3.3 | S3-R09 | HM16.22 | S3-HM-03 | QP = [22,27,32,37,42] | S3-A09-265-<QP> |
| S3-A10-265 | 6.4.8.3.3 | S3-R10 | HM16.22 | S3-HM-01 | QP = [22,27,32,37,42] | S3-A10-265-<QP> |
| S3-A11-265 | 6.4.8.3.3 | S3-R11 | HM16.22 | S3-HM-03 | QP = [22,27,32,37,42] | S3-A11-265-<QP> |
| S3-A12-265 | 6.4.8.3.3 | S3-R12 | HM16.22 | S3-HM-01 | QP = [22,27,32,37,42] | S3-A12-265-<QP> |
| S3-A13-265 | 6.4.8.3.3 | S3-R13 | HM16.22 | S3-HM-03 | QP = [22,27,32,37,42] | S3-A13-265-<QP> |
| S3-A14-265 | 6.4.8.3.3 | S3-R14 | HM16.22 | S3-HM-01 | QP = [22,27,32,37,42] | S3-A14-265-<QP> |
| S3-A15-265 | 6.4.8.3.3 | S3-R15 | HM16.22 | S3-HM-03 | QP = [22,27,32,37,42] | S3-A15-265-<QP> |
| S3-A16-265 | 6.4.8.3.3 | S3-R16 | HM16.22 | S3-HM-01 | QP = [22,27,32,37,42] | S3-A16-265-<QP> |
| S3-A17-265 | 6.4.8.3.4 | S3-R01 | HM16.22 | S3-HM-04 | QP = [22,27,32,37,42] | S3-A17-265-<QP> |
| S3-A18-265 | 6.4.8.3.4 | S3-R02 | HM16.22 | S3-HM-02 | QP = [22,27,32,37,42] | S3-A18-265-<QP> |
| S3-A19-265 | 6.4.8.3.4 | S3-R03 | HM16.22 | S3-HM-04 | QP = [22,27,32,37,42] | S3-A19-265-<QP> |
| S3-A20-265 | 6.4.8.3.4 | S3-R04 | HM16.22 | S3-HM-02 | QP = [22,27,32,37,42] | S3-A20-265-<QP> |
| S3-A21-265 | 6.4.8.3.4 | S3-R05 | HM16.22 | S3-HM-04 | QP = [22,27,32,37,42] | S3-A21-265-<QP> |
| S3-A22-265 | 6.4.8.3.4 | S3-R06 | HM16.22 | S3-HM-02 | QP = [22,27,32,37,42] | S3-A22-265-<QP> |
| S3-A23-265 | 6.4.8.3.4 | S3-R07 | HM16.22 | S3-HM-04 | QP = [22,27,32,37,42] | S3-A23-265-<QP> |
| S3-A24-265 | 6.4.8.3.4 | S3-R08 | HM16.22 | S3-HM-02 | QP = [22,27,32,37,42] | S3-A24-265-<QP> |
| S3-A25-265 | 6.4.8.3.4 | S3-R09 | HM16.22 | S3-HM-04 | QP = [22,27,32,37,42] | S3-A25-265-<QP> |
| S3-A26-265 | 6.4.8.3.4 | S3-R10 | HM16.22 | S3-HM-02 | QP = [22,27,32,37,42] | S3-A26-265-<QP> |
| S3-A27-265 | 6.4.8.3.4 | S3-R11 | HM16.22 | S3-HM-04 | QP = [22,27,32,37,42] | S3-A27-265-<QP> |
| S3-A28-265 | 6.4.8.3.4 | S3-R12 | HM16.22 | S3-HM-02 | QP = [22,27,32,37,42] | S3-A28-265-<QP> |
| S3-A29-265 | 6.4.8.3.4 | S3-R13 | HM16.22 | S3-HM-04 | QP = [22,27,32,37,42] | S3-A29-265-<QP> |
| S3-A30-265 | 6.4.8.3.4 | S3-R14 | HM16.22 | S3-HM-02 | QP = [22,27,32,37,42] | S3-A30-265-<QP> |
| S3-A31-265 | 6.4.8.3.4 | S3-R15 | HM16.22 | S3-HM-04 | QP = [22,27,32,37,42] | S3-A31-265-<QP> |
| S3-A32-265 | 6.4.8.3.4 | S3-R16 | HM16.22 | S3-HM-02 | QP = [22,27,32,37,42] | S3-A32-265-<QP> |
| S3-A33-265 | 6.4.8.3.5 | S3-R01 | SCM8.8 | S3-SCC-03 | QP = [22,27,32,37,42] | S3-A33-265-<QP> |
| S3-A34-265 | 6.4.8.3.5 | S3-R02 | SCM8.8 | S3-SCC-01 | QP = [22,27,32,37,42] | S3-A34-265-<QP> |
| S3-A35-265 | 6.4.8.3.5 | S3-R03 | SCM8.8 | S3-SCC-03 | QP = [22,27,32,37,42] | S3-A35-265-<QP> |
| S3-A36-265 | 6.4.8.3.5 | S3-R04 | SCM8.8 | S3-SCC-01 | QP = [22,27,32,37,42] | S3-A36-265-<QP> |
| S3-A37-265 | 6.4.8.3.5 | S3-R05 | SCM8.8 | S3-SCC-03 | QP = [22,27,32,37,42] | S3-A37-265-<QP> |
| S3-A38-265 | 6.4.8.3.5 | S3-R06 | SCM8.8 | S3-SCC-01 | QP = [22,27,32,37,42] | S3-A38-265-<QP> |
| S3-A39-265 | 6.4.8.3.5 | S3-R07 | SCM8.8 | S3-SCC-03 | QP = [22,27,32,37,42] | S3-A39-265-<QP> |
| S3-A40-265 | 6.4.8.3.5 | S3-R08 | SCM8.8 | S3-SCC-01 | QP = [22,27,32,37,42] | S3-A40-265-<QP> |
| S3-A41-265 | 6.4.8.3.5 | S3-R09 | SCM8.8 | S3-SCC-03 | QP = [22,27,32,37,42] | S3-A41-265-<QP> |
| S3-A42-265 | 6.4.8.3.5 | S3-R10 | SCM8.8 | S3-SCC-01 | QP = [22,27,32,37,42] | S3-A42-265-<QP> |
| S3-A43-265 | 6.4.8.3.5 | S3-R11 | SCM8.8 | S3-SCC-03 | QP = [22,27,32,37,42] | S3-A43-265-<QP> |
| S3-A44-265 | 6.4.8.3.5 | S3-R12 | SCM8.8 | S3-SCC-01 | QP = [22,27,32,37,42] | S3-A44-265-<QP> |
| S3-A45-265 | 6.4.8.3.5 | S3-R13 | SCM8.8 | S3-SCC-03 | QP = [22,27,32,37,42] | S3-A45-265-<QP> |
| S3-A46-265 | 6.4.8.3.5 | S3-R14 | SCM8.8 | S3-SCC-01 | QP = [22,27,32,37,42] | S3-A46-265-<QP> |
| S3-A47-265 | 6.4.8.3.5 | S3-R15 | SCM8.8 | S3-SCC-03 | QP = [22,27,32,37,42] | S3-A47-265-<QP> |
| S3-A48-265 | 6.4.8.3.5 | S3-R16 | SCM8.8 | S3-SCC-01 | QP = [22,27,32,37,42] | S3-A48-265-<QP> |
| S3-A49-265 | 6.4.8.3.6 | S3-R01 | SCM8.8 | S3-SCC-04 | QP = [22,27,32,37,42] | S3-A49-265-<QP> |
| S3-A50-265 | 6.4.8.3.6 | S3-R02 | SCM8.8 | S3-SCC-02 | QP = [22,27,32,37,42] | S3-A50-265-<QP> |
| S3-A51-265 | 6.4.8.3.6 | S3-R03 | SCM8.8 | S3-SCC-04 | QP = [22,27,32,37,42] | S3-A51-265-<QP> |
| S3-A52-265 | 6.4.8.3.6 | S3-R04 | SCM8.8 | S3-SCC-02 | QP = [22,27,32,37,42] | S3-A52-265-<QP> |
| S3-A53-265 | 6.4.8.3.6 | S3-R05 | SCM8.8 | S3-SCC-04 | QP = [22,27,32,37,42] | S3-A53-265-<QP> |
| S3-A54-265 | 6.4.8.3.6 | S3-R06 | SCM8.8 | S3-SCC-02 | QP = [22,27,32,37,42] | S3-A54-265-<QP> |
| S3-A55-265 | 6.4.8.3.6 | S3-R07 | SCM8.8 | S3-SCC-04 | QP = [22,27,32,37,42] | S3-A55-265-<QP> |
| S3-A56-265 | 6.4.8.3.6 | S3-R08 | SCM8.8 | S3-SCC-02 | QP = [22,27,32,37,42] | S3-A56-265-<QP> |
| S3-A57-265 | 6.4.8.3.6 | S3-R09 | SCM8.8 | S3-SCC-04 | QP = [22,27,32,37,42] | S3-A57-265-<QP> |
| S3-A58-265 | 6.4.8.3.6 | S3-R10 | SCM8.8 | S3-SCC-02 | QP = [22,27,32,37,42] | S3-A58-265-<QP> |
| S3-A59-265 | 6.4.8.3.6 | S3-R11 | SCM8.8 | S3-SCC-04 | QP = [22,27,32,37,42] | S3-A59-265-<QP> |
| S3-A60-265 | 6.4.8.3.6 | S3-R12 | SCM8.8 | S3-SCC-02 | QP = [22,27,32,37,42] | S3-A60-265-<QP> |
| S3-A61-265 | 6.4.8.3.6 | S3-R13 | SCM8.8 | S3-SCC-04 | QP = [22,27,32,37,42] | S3-A61-265-<QP> |
| S3-A62-265 | 6.4.8.3.6 | S3-R14 | SCM8.8 | S3-SCC-02 | QP = [22,27,32,37,42] | S3-A62-265-<QP> |
| S3-A63-265 | 6.4.8.3.6 | S3-R15 | SCM8.8 | S3-SCC-04 | QP = [22,27,32,37,42] | S3-A63-265-<QP> |
| S3-A64-265 | 6.4.8.3.6 | S3-R16 | SCM8.8 | S3-SCC-02 | QP = [22,27,32,37,42] | S3-A64-265-<QP> |
| S3-A65-265 | 6.4.8.3.3 | S3-R17 | HM16.22 | S3-HM-03 | QP = [22,27,32,37,42] | S3-A65-265-<QP> |
| S3-A66-265 | 6.4.8.3.4 | S3-R17 | HM16.22 | S3-HM-04 | QP = [22,27,32,37,42] | S3-A66-265-<QP> |
| S3-A67-265 | 6.4.8.3.5 | S3-R17 | SCM8.8 | S3-SCC-03 | QP = [22,27,32,37,42] | S3-A67-265-<QP> |
| S3-A68-265 | 6.4.8.3.6 | S3-R17 | SCM8.8 | S3-SCC-04 | QP = [22,27,32,37,42] | S3-A68-265-<QP> |
| S3-A69-265 | 6.4.8.3.3 | S3-R17 | HM16.22 | S3-HM-01 | QP = [22,27,32,37,42] | S3-A69-265-<QP> |
| S3-A70-265 | 6.4.8.3.4 | S3-R17 | HM16.22 | S3-HM-02 | QP = [22,27,32,37,42] | S3-A70-265-<QP> |
| S3-A71-265 | 6.4.8.3.5 | S3-R17 | SCM8.8 | S3-SCC-01 | QP = [22,27,32,37,42] | S3-A71-265-<QP> |
| S3-A72-265 | 6.4.8.3.6 | S3-R17 | SCM8.8 | S3-SCC-02 | QP = [22,27,32,37,42] | S3-A72-265-<QP> |

##### 6.4.8.3.2 Common Settings

Each source sequence is encoded with:

- QP: [22, 27, 32, 37, 42]

- InternalBitDepth is 10 # codec operating bit-depth where all sequences (including 8 bit sequences) are coded with an internal bitdepth of 10 in accordance with [44] and metrics are calculated in 10 bits.

##### 6.4.8.3.3 S3-HM-01 and S3-HM-03: Main 10 Profile with no fixed Intra

To generate the anchor bitstreams, HM16.22 is used.

The settings are defined in the attached configuration file s3-hm-01.cfg and s3-hm-03.cfg.

Each source sequence is encoded with:

- The settings defined in 6.4.8.3.2.

- IntraPeriod with no fix interval

- GOPSize is equal to 8. Each P picture refers to up to 4 preceding pictures in display order

##### 6.4.8.3.4 S3-HM-02 and S3-HM-04: Main 10 Profile with fixed Intra every second

To generate the anchor bitstreams, HM16.22 is used.

The settings are defined in the attached configuration file s3-hm-02.cfg and s3-hm-04.cfg.

Each source sequence is encoded with:

- The settings defined in 6.4.8.3.2.

- IntraPeriod such that exactly 1 second is achieved (i.e. IntraPeriod value equal to the sequence fps value)

- DecodingRefreshType: (2) IDR

- IntraQPOffset and QPoffsets are set equal to 0

- Each P picture refers to immediately preceding pictures in display order.

##### 6.4.8.3.5 S3-SCC-01 and S3-SCC-03: Screen Content Profile with no fixed Intra

To generate the anchor bitstreams SCM-8.8 is used.

The settings are defined in the attached configuration file s3-scc-01.cfg and s3-scc-03.cfg.

Each source sequence is encoded with:

- The settings defined in 6.4.8.3.2.

- IntraPeriod with no fix interval

- GOPSize is equal to 8. Each P picture refers to up to 4 preceding pictures in display order within the GOP

##### 6.4.8.3.6 S3-SCC-02 and S3-SCC-04: Screen Content Profile with fixed Intra every second

To generate the anchor bitstreams SCM-8.8 is used.

The settings are defined in the attached configuration file s3-scc-02.cfg and s3-scc-04.cfg.

Each source sequence is encoded with:

- The settings defined in 6.4.8.3.2.

- IntraPeriod such that exactly 1 second is achieved (i.e. IntraPeriod value equal to the sequence fps value)

- DecodingRefreshType: (2) IDR

- IntraQPOffset and P pictures QPoffsets are set equal to 0

- Each P picture refers to immediately preceding pictures in display order.

### 6.4.9 Anchor Results

#### 6.4.9.1 H.264/AVC Anchors

AVC anchor streams are provided according to the key system here:

* https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-3-Screen/264/

AVC anchor results are provided with the appropriate keys as defined in Table 6.4.8.2.1-1

* in the attached csv files
* https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-3-Screen/264/Metrics/

Editor’s Note:

* The metrics for VMAF and MS\_SSIM still need to be zeroed based on agreement in S4-220484
* Verification is still missing

#### 6.4.9.2 H.265/HEVC Anchors

HEVC anchor streams are provided according to the key system here:

* https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-3-Screen/265/

HEVC anchor results are provided with the appropriate keys as defined in Table 6.4.8.3.1-1

* in the attached csv files
* https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-3-Screen/265/Metrics/

### 6.4.10 Additional information and external performance data

In JCTVC-AA1006 [40], verification test report for HEVC screen content coding extensions, “the coding performance of HEVC screen content model (SCM) reference software with the SCC extensions enabled is compared with that of HEVC test model (HM) without the SCC extensions, as well as with the AVC joint model (JM) reference software in both lossy and mathematically lossless compression modes using All-Intra (AI), Random Access (RA), and Low-delay B (LB) encoding structures and using similar encoding rate-distortion optimization techniques.

BD-rate savings of SCM over JM and SCM-w/o-SCC for RGB, YUV 4:4:4, and YUV 4:2:0 colour sampling formats were calculated by using the actual 648 test points that were used in the subjective testing across 6 JCT-VC sequences.

The document contains details on sequences, test parameters and configuration files, as well as subjective results. In the context of this study, only the objective results for lossy Low-delay B are reported in Table 6.4.10-1.

Table 6.4.10-1: BD-rate savings of SCM over JM and HM for LB coding configuration

Une image contenant table

Description générée automatiquement

## 6.5 Scenario 4: Messaging and Social Sharing

### 6.5.1 Motivation

According to the 2020 Mobile Internet Phenomena Report from Sandvine [9] Video traffic continues to grow worldwide, and the increasing popularity of mobile consumers sharing video has not only caused growth in downstream traffic, but also in upstream traffic as well. Instagram ™ grew in the upstream as more consumers share images and videos. TikTok ™, Snapchat ™ (video), FaceTime ™, and even Facebook ™ Live were all in the top 50 applications worldwide on the upstream that are video-sharing-centric. Messaging applications, especially on the upstream, continue to become a critical part of the mobile experience, replacing old style text messaging, and increasingly are video-based. Four of the top 20 applications on the upstream are messaging apps.

Some typical examples and restrictions in April 2020 are provided in the following:

1. WhatsApp™ [25]

a. The maximum size of the video that you can share is 16 MB.

b. Various container formats that are supported by include MP4, MKV, AVI, 3GP, and MOV. H.264/AVC video codec and AAC audio codec are needed today.

2. YouTube™ [26]

a. H.264/AVC is the recommended codec with the following settings

i. Progressive scan

ii. High Profile

iii. 2 consecutive B frames

iv. Closed GOP. GOP of half the frame rate.

v. CABAC

vi. Variable bitrate. No bitrate limit required, though we offer recommended bit rates below for reference

vii. Chroma subsampling: 4:2:0

b. Resolution Formats: 360p, 480p, 720p, 1080p, 1440p, 2160p

c. Both SDR and HDR are possible

d. The standard aspect ratio is 16:9

3. Facebook Live ™ [27]. To live stream on Facebook™, these video format guidelines are provided:

a. Recommended max bit rate is 4000 Kbps (4 mbps).

b. Max: 1080p (1920x1080) resolution, at 60 frames per second.

c. An I-frame (keyframe) must be sent at least every 2 seconds throughout the stream.

d. H264 encoded video.

4. TikTok™ [28], some video restrictions

a. Upload from Android, up to 72 MB at most. upload videos from iOS up to 287.6 MB.

b. Video dimensions should be 1080 x 1920

c. MP4 or MOV file format. Video should be H.264/AVC encoded

5. Snapchat™ [25][2)], The latest information from 2018

a. Recommended size: 1080 by 1920 pixels (9:16 aspect ratio)

b. Recommended specs: .MP4 or MOV, H.264 encoded, maximum file size 1GB

According to Sandvine's report [9], sharing and uploading content as part of social sharing is predominantly pictures and videos that uploaded directly into a cloud and uploaded to one or many social networks, and then discussed (or shared again) over messaging networks. The relevant quality-of-experience factors include the quality of shared content, the time it takes to upload, the costs associated with the upload and also the processing and battery consumption requirements on the device to prepare the content for upload.

In another activity, three large operators released a 5G messaging white paper [31] to promote enhanced messaging services based on Rich Communication Services (RCS). This also shows the relevance of operator-based messaging services. Generally, uplink resources are even more precious and costly in 5G network operation and hence efficient technologies are vital for mass-scale services. This aspect is also considered by GSMA RCS Universal Profile specification, promoted as the industry standard for RCS Business Messaging, ensuring the telecoms industry remains at the centre of digital communications [34].

### 6.5.2 Description of the Anticipated Application

In the context of 3GPP services, 5G Media Streaming [13] provides the following encoding benchmark capabilities:

- HEVC-FullHD-Enc: the capability to encode a video signal with

- up to 133,693,440 luma samples per second, and

- up to a luma picture size of 2,228,224 samples, and

- up to 240 frames per second, and

- the Chroma format being 4:2:0, and

- the bit depth being either 8 or 10 bit,

to a bitstream that is decodable by a decoder that is HEVC-FullHD-Dec capable as defined in clause 4.2.2.1 of TS26.511 and defined as the capability to decode H.265 (HEVC) Main10 Profile, Main Tier, Level 4.1 [3] bitstreams that have general\_progressive\_source\_flag equal to 1, general interlaced\_source\_flag equal to 0, general\_non\_packed\_constraint\_flag equal to 1, and general\_frame\_only\_constraint\_flag equal to 1.

Based on the considerations in clause 6.5.1, it is also recommended to take into account the AVC-FullHD-Enc capabilities as defined in TS 26.511 [13]:

- AVC-FullHD-Enc: the capability to encode a video signal with

- up to 245,760 macroblocks per second, and

- up to a frame size of 8,192 macroblocks, and

- up to 240 frames per second, and

- the Chroma format being 4:2:0, and

- the bit depth being 8 bit,

to a bitstream that is decodable by a decoder that is AVC-HD-Dec capable as defined in clause 4.2.1.1 of TS26.511 and defined as the capability to decode H.264 (AVC) Progressive High Profile Level 4.0 [2] bitstreams.

Based on future expectations of higher quality uploads, it is also recommended to take into account the HEVC-UHD-Enc capabilities as defined in TS26.511 [13]:

- HEVC-UHD-Enc: the capability to encode a video signal with

- up to 534,773,760 luma samples per second, and

- up to a luma picture size of 8,912,896 samples, and

- up to 480 frames per second, and

- the Chroma format being 4:2:0, and

- the bit depth being either 8 or 10 bit,

to a bitstream that is decodable by a decoder that is HEVC-UHD-Dec capable as defined in clause 4.2.2.1 of TS26.511 and defined as the capability the capability to decode H.265 (HEVC) Main10 Profile, Main Tier, Level 5.1[3] bitstreams that have general\_progressive\_source\_flag equal to 1, general\_ interlaced\_source\_flag equal to 0, general\_non\_packed\_constraint\_flag equal to 1, and general\_frame\_only\_constraint\_flag equal to 1.

The considered scenario is the uploading and uplink streaming into the ISO/BMFF and CMAF container formats. Important aspects that are expected to be considered when evaluating a codec in the context of this:

- Quality and Coding Efficiency:

- The ability to compress a video sequence targeting the maximum file size and maintaining high quality.

- The ability to compress a video stream in real time to the available uplink streaming resources.

- Considered settings for encoding:

- Regular random access at least every 2 seconds, preferably more often

- No specific encoding latency constraints are applicable

- Encoding in this scenario is typically done as

- Real-time encoding for social sharing

- Offline encoding for messaging

- UE-based Encoding

### 6.5.3 Source Format Properties

Table 6.5.3-1 provides an overview of the different source signal properties for Social Sharing and Messaging. This information is used to select proper test sequences.

Table 6.5.3-1 Source Format Properties for Social sharing scenario

|  |  |
| --- | --- |
| Source format properties | Social Sharing |
| Spatial resolution | 3840x2160, 1920 x 1080, 1080x1920 |
| Chroma format | Y’CbCr |
| Chroma subsampling | 4:2:0 |
| Picture aspect ratio | 16:9, 9:16 |
| Frame rates | 24, 25, 30 Hz  50, 60 Hz (Full HD only) |
| Bit depth | 8, 10 |
| Colour space formats | BT.709, BT.2020 |
| Transfer characteristics | BT.709, BT.2100 (HDR) |

### 6.5.4 Encoding and Decoding Constraints

Table 6.5.4-1 provides an overview of encoding and decoding constraints for H.264/AVC Full HD and H.265/HEVC for Social Sharing and Messaging scenario. This information supports the definition of detailed anchor conditions.

Table 6.5.4-1 Encoding and Decoding Configurations

|  |  |  |  |
| --- | --- | --- | --- |
| Encoding and Decoding Constraints | General | H.264/AVC | H.265/HEVC |
| Relevant Codec and Codec Profile/Levels | Profile suitable for messaging content, no specific requirements.  Levels to meet the above formats | H.264/AVC Progressive High Profile  Level 4.2, 5.2 | H.265/HEVC Main 10 Profile  Level 4.1, 5.1 |
| Random access frequency | 1 second and 10 seconds | 1 and 10 seconds | 1 and 10 seconds |
| Bit rates and quality configuration | Capped-VBR (social sharing) and VBR (messaging)  Fixed QP | B = {5, 10,15, 20} Mbps  Capped-VBR (social sharing) and VBR (messaging)  Fixed QP | B = {2.5, 5, 7.5,10} Mbps  Capped-VBR (social sharing) and VBR (messaging)  Fixed QP |
| Bit rate parameters (CBR, VBR, CAE, HRD parameters) | Covering a range of relevant bitrates and qualities | No latency requirements beyond RAP so picture reordering allowed | No latency requirements beyond RAP so picture reordering allowed |
| Latency requirements and specific encoding settings | No latency requirements | No specific requirements | No specific requirements |
| Encoding complexity context | real-time encoding (social sharing), offline encoding (messaging) on mobile device, single path | see General | see General |
| Required decoding capabilities | Profile suitable for messaging content, no specific requirements.  Levels to meet the above formats | H.264/AVC Progressive High Profile  Level 4.2, 5.2 | H.265/HEVC Main 10 Profile  Level 4.1, 5.1 |

### 6.5.5 Performance Metrics

All metrics as defined in clause 5.5 are expected to be reported.

For BD-Rate computation and SDR, only the following metrics are expected to be provided:

- Peak-Signal to Noise Ratio *PSNR*(*Y*) of luma component as defined in clause 5.5.3,

- Average colour component PSNR, *PSNR* over all colour components *PSNR* as defined in clause 5.5.3,

- Structural similarity metric *MS-SSIM* as defined in clause 5.5.4.2,

- Video Multimethod Assessment Fusion (VMAF) *VMAF* as defined in clause 5.5.3.

### 6.5.6 Interoperability Considerations

Social sharing and messaging applications require that the content is included in a packaging and file format.

### 6.5.7 Reference Sequences

Table 6.5.7-1 provides the selected reference sequences for this scenario. Keys are identified to refer to the sequences in the context of the scenario. The sequences are named and a reference to the details of the sequence is provided. A justification is provided, why this sequence is selected.

Table 6.5.7-1 Reference Sequences for Social sharing and messaging

|  |  |  |  |
| --- | --- | --- | --- |
| Key | Name | Reference | Justification/Comment |
| S4-R01 | Vertical-Bees | Annex C.5.2 | Full-HD, portrait Stationary sequence with graphic overlays. Easy. |
| S4-R02 | Vertical-Walking | Annex C.5.3 | Difficult content, Full-HD Portrait. |
| S4-R03 | Neon-4K | Annex C.5.4 | 4K difficult sequence, dark and noisy. |
| S4-R04 | Skater-4K | Annex C.5.5 | 4K Especially good on the face close-up. |

### 6.5.8 Anchor Definition

#### 6.5.8.1 Overview

This clause provides details on how to generate the anchors for the social sharing and messaging scenario.

The Social sharing and messaging scenario relies on relaxed delay encoding modes with limited encoding complexity.

#### 6.5.8.2 H.264/AVC Anchors

##### 6.5.8.2.1 Overview

Table 6.5.8.2.1-1 provides an overview of the H.264/AVC anchor tuples. Keys are identified to refer to the anchors in the context of the scenario.

The details are also provided here: https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-4-Sharing/264/streams.csv.

Table 6.5.8.2.1-1 Anchor Tuple generation with H.264/AVC for social sharing and messaging

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Key | Clause | Reference Sequence | Reference Encoder | Config | Variations | Anchor Key |
| S4-A01-264 | 6.5.8.2.3 | S4-R01 | JM19.0 | S4-JM-01 | QP=[22,27,32,37] | S4-A01-264-<QP> |
| S4-A02-264 | 6.5.8.2.3 | S4-R02 | JM19.0 | S4-JM-01 | QP=[22,27,32,37] | S4-A02-264-<QP> |
| S4-A03-264 | 6.5.8.2.4 | S4-R03 | JM19.0 | S4-JM-01 | QP=[22,27,32,37] | S4-A03-264-<QP> |
| S4-A04-264 | 6.5.8.2.4 | S4-R04 | JM19.0 | S4-JM-01 | QP=[22,27,32,37] | S4-A04-264-<QP> |
| S4-A05-264 | 6.5.8.2.5 | S4-R01 | JM19.0 | S4-JM-02 | QP=[22,27,32,37] | S4-A05-264-<QP> |
| S4-A06-264 | 6.5.8.2.5 | S4-R02 | JM19.0 | S4-JM-02 | QP=[22,27,32,37] | S4-A06-264-<QP> |
| S4-A07-264 | 6.5.8.2.6 | S4-R03 | JM19.0 | S4-JM-02 | QP=[22,27,32,37] | S4-A07-264-<QP> |
| S4-A08-264 | 6.5.8.2.6 | S4-R04 | JM19.0 | S4-JM-02 | QP=[22,27,32,37] | S4-A08-264-<QP> |

##### 6.5.8.2.2 Common Parameters

To generate the anchor bitstreams, JM19.0 is used.

The common parameters are as follows:

- ProfileIDC = 100 (High Profile)

- IDRPeriod = IntraPeriod

- NumberOfReferenceFrames = 4

- PList0References = 4 (P slice List 0 reference override)

- I16RDOpt = 1 (rd-optimized mode decision for Intra 16x16 MB)

- SearchMode = 3 (Enhanced Predictive Zonal Search (EPZS))

- SearchRange = 256;

- Picture based multipass coding disabled

The following variable triggers updates to the config-file depending on the test scenario.

* QP: [22,27,32,37]

Note that the MaxMvsPer2Mb restriction is not matching the used level requirement from H.264/AVC due to use of inter 4x4 subpartitions. While a strictly conforming decoder may fail, this is not considered a limiting factor in today’s implementations.

##### 6.5.8.2.3 S4-JM-01: no random access

In addition, the following parameters apply:

- LevelIDC = 52

- IntraPeriod = 0 (no random access)

- NumberBFrames = 4

- BReferencePictures = 2

- Quantization parameters are set as according to Table 6.5.8.2.3-1

Table 6.5.8.2.3-1 Quantization Parameters for S4-JM-01

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| QP | QPISlice | QPPSlice | QPBSlice | ExplicitHierarchyFormat |
| 22 | 21 | 24 | 24 | B0r3B1r2B2r3B3r2 |
| 27 | 26 | 29 | 29 | B0r5B1r4B2r5B3r4 |
| 32 | 31 | 34 | 34 | B0r6B1r5B2r6B3r5 |
| 37 | 36 | 39 | 39 | B0r6B1r5B2r6B3r5 |

The settings are defined in the attached configuration file s4-jm-01.cfg.

##### 6.5.8.2.4 S4-JM-02: Intra near 1 sec

The common parameters as defined in 6.5.8.2.2 apply.

In addition, the following parameters apply:

- IntraPeriod and IDRPeriod = power of 2 value that is greater than or equal to the frame rate (fps), such that near 1 second is achieved: 32 for 30fps sequences and 64 for 60fps sequences

- NumberBFrames = 0

- BReferencePictures = 2

- QPISlice = QPPSlice = QPBSlice = QP

The settings are defined in the attached configuration file s4-jm-02.cfg.

#### 6.5.8.3 H.265/HEVC Anchors

##### 6.5.8.3.1 Overview

Table 6.5.8.3.1-1 provides an overview of the H.265/HEVC anchor tuples. Keys are identified to refer to the anchors in the context of the scenario.

The details are also provided here: https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-4-Sharing/265/streams.csv.

Table 6.5.8.3.1-1 Anchor Tuple generation with H.265/HEVC for Social sharing and messaging

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Key | Clause | Reference Sequence | Reference Encoder | Config | Variations | Anchor Key |
| S4-A01-265 | 6.5.8.3.3 | S4-R01 | HM16.22 | S4-HM-01 | QP = [22,27,32,37] | S4-A01-265-<QP> |
| S4-A02-265 | 6.5.8.3.3 | S4-R02 | HM16.22 | S4-HM-01 | QP = [22,27,32,37] | S4-A02-265-<QP> |
| S4-A03-265 | 6.5.8.3.4 | S4-R03 | HM16.22 | S4-HM-01 | QP = [22,27,32,37] | S4-A03-265-<QP> |
| S4-A04-265 | 6.5.8.3.4 | S4-R04 | HM16.22 | S4-HM-01 | QP = [22,27,32,37] | S4-A04-265-<QP> |
| S4-A05-265 | 6.5.8.3.5 | S4-R01 | HM16.22 | S4-HM-02 | QP = [22,27,32,37] | S4-A05-265-<QP> |
| S4-A06-265 | 6.5.8.3.5 | S4-R02 | HM16.22 | S4-HM-02 | QP = [22,27,32,37] | S4-A06-265-<QP> |
| S4-A07-265 | 6.5.8.3.6 | S4-R03 | HM16.22 | S4-HM-02 | QP = [22,27,32,37] | S4-A07-265-<QP> |
| S4-A08-265 | 6.5.8.3.6 | S4-R04 | HM16.22 | S4-HM-02 | QP = [22,27,32,37] | S4-A08-265-<QP> |

##### 6.5.8.3.2 Common Parameters

To generate the anchor bitstreams, HM16.22 is used.

Each source sequence is encoded with:

- QP: [22, 27, 32, 37]

- InternalBitDepth is 10 # codec operating bit-depth where all sequences (including 8 bit sequences) are coded with an internal bitdeph of 10 in accordance with [44] and metrics are calculated in 10 bits.

- SEIDecodedPictureHash=1

As the SEIDecodedPictureHash is set to 1, the effective file size (EFS) needs to take into account the removal of this SEI message when computing the bitrate metric as defined in clause 5.5.2.

6.5.8.3.3 S4-HM-01: no random access

The same parameters as for S5-HM-01 as documented in clause 6.6.8.3.3 are used.

Each source sequence is encoded with the following changes:

- The common parameters as defined in clause 6.6.8.3.3

- IntraPeriod with no fix interval

- GOPSize is equal to 8. Each B picture refers to up to 4 preceding pictures in display order within the GOP

- IntraQPOffset is -1. B picture QP offsets are IntraQPOffset is -1. B picture QP offsets are adjusted based on the base QP and on the QPmod, QPoffset, QPOffsetModelScale and QPOffsetModelOff.

The settings are defined in the attached configuration file s4-hm-01.cfg.

##### 6.5.8.3.4 S4-HM-02: Intra

Each source sequence is encoded with the following changes:

- The common parameters as defined in clause 6.6.8.3.3

- IntraPeriod = power of 2 value that is greater than or equal to the frame rate (fps), such that near 1 second is achieved: 32 for 30fps sequences and 64 for 60fps sequences

- DecodingRefreshType: (2) IDR

- IntraQPOffset and B pictures QPoffsets are set equal to 0

- Each B picture refers to immediately preceding pictures in display order.

The settings are defined in the attached configuration file s4-hm-02.cfg.

### 6.5.9 Anchor Results

#### 6.5.9.1 H.264/AVC Anchors

AVC anchor streams are provided according to the key system here:

* https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-4-Sharing/264/

AVC anchor results are provided with the appropriate keys as defined in Table 6.5.8.2.1-1

* in the attached csv files
* https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-4-Sharing/264//Metrics/

Editor’s Note:

* Verification is still needed

#### 6.5.9.2 H.265/HEVC Anchors

HEVC anchor streams are provided according to the key system here:

* https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-4-Sharing/265/

HEVC anchor results are provided with the appropriate keys as defined in Table 6.5.8.3.1-1

* in the attached csv files
* https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-4-Sharing/265/Metrics/

Editor’s Note:

* Verification is still needed

## 6.6 Scenario 5: Online Gaming

### 6.6.1 Motivation

According to the 2020 Mobile Internet Phenomena Report from Sandvine [9] gaming is continuing to grow on mobile network. The improved performance of 4G and the coming promise of 5G will continue to drive at least casual gamers to mobile networks.

For games rendered on 2D displays such as smart phones, typical characteristics of rasterized frames produced by the game engine are:

- Resolution of 720p, 1080p or 4K

- Framerate of 30fps, 60fps or 120 fps

Typical colour bit depth of 8bits (RGB frames) but higher bit depth may be offered for HDR compatible games.

Rasterized frames are directly passed to a video encoder (typically H.264 but H.265 may be used in a few environments) and content is live encoded to fit target quality. As an example, the following quality categorization may be done:

- High Quality: 4k at 60/120fps with an average throughput of 60/100 Mbps

- Main Quality: 1080p at 60/120fps with an average throughput of 30/40 Mbps

- Low Quality: 720p/1080p at 30fps with an average throughput of 10/12 Mbps

Online gaming for HMD-based consumption was discussed and introduced in detail in TR 26.928 [6]. At least the following use cases are in context of Online gaming:

- Use Case 5: Untethered Immersive Online Gaming

- Use Case 6: Immersive Game Spectator Mode

For raster-based split rendering, according to TR 26.928, clause 4.4, rasterized 3D scenes available in frame buffers are provided by the XR engine and need to be encoded, distributed, and decoded. According to clause 4.2.1, relevant formats for frame buffers are 2k by 2k per eye, potentially even higher. Frame rates are expected to be at least 60fps, potentially higher up to 90 fps. The formats of frame buffers are regular texture video signals that are then directly rendered. As the processing is graphics centric, formats beyond commonly used 4:2:0 signals and YUV signals may be considered. It is known from experiments that with H.264/AVC the bitrates are in the order of 50 Mbps per eye buffer. It is expected that this can be reduced to lower bitrates with improved compression tools as for example available for H.265/HEVC. For use case 5 from above and split rendering, encoding is required to be done in low-latency based on the considerations in TR 26.928. For the spectator mode, higher latency may be acceptable.

As an example, a comprehensive set of APIs including high-performance tools, samples and documentation for hardware accelerated video encode and decode on Windows and Linux for NVIDIA™ Video Codec SDK is available [N]. As another example, in a game recording and streaming scenario like streaming to Twitch.tv using Open Broadcaster Software (OBS), encoding being completely offloaded to NVENC makes the graphics engine bandwidth fully available for game rendering. As of May 2020, the following formats are supported for hardware-based encoding as documented on the high-end Turing encoding:

- H.264 (AVCHD) YUV 4:2:0, YUV 4:4:4, and Lossless, all 8 bit, Max Resolution 4096 x 4096;

- H.265 (HEVC) YUV 4:2:0, YUV 4:4:4, and Lossless, all 10 bit, Max Resolution 8192 x 8192;

In typical cloud gaming environments, the game server produces rasterized frames at a fixed resolution, framerate and colour bit depth which are negotiated with the player client. Negotiation takes into account game capabilities, player choices and eventually bandwidth constraints.

### 6.6.2 Description of the Anticipated Application

3GPP until now has very restricted set of services but based on the considerations in clause 6.6.1, the following encoding benchmark capabilities are considered for decoding 2D displays:

- H.264 (AVC) YUV 4:2:0, YUV 4:4:4, 8 bit, Max Resolution 1920x1080 and 4096 x 2048

- H.265 (HEVC) YUV 4:2:0, YUV 4:4:4, 10 bit, Max Resolutions 4096 x 2048, 8192 x 4096

The considered online gaming scenario is low-latency streaming, typically using UDP/IP based distribution to minimize protocol latencies. Important aspects that are expected to be considered when evaluating a codec in the context of this:

- Quality and Coding Efficiency:

- The ability to compress traditional computer-generated content.

- The ability to compress photorealistic computer-generated content.

- The ability to compress YUV 4:2:0 and 4:4:4 content

- Considered settings for encoding:

- Ultra low latency and Low-latency settings

- No specific error resilience mechanisms

- Encoding in this scenario is typically done as

- Real-time encoding

- Cloud-based encoding

### 6.6.3 Source Format Properties

#### 6.6.3.1 Introduction

Video games have different characteristics that are important to take into account when encoding the rasterized frames produced by the game engine. In TR 26.928 [6], clause 4.2.2, a few different types of games and their interaction delay tolerance are documented. However, TR 26.928 [6] does not differentiate the characteristics of the content. This aspect is addressed in the following.

In particular, the following characteristics are important:

- Dynamicity of content: how frequent rasterized frames change when compared to previous frame

- Complexity of content: how much content changes between frames and how complex such changes are

- Type of content: traditional CGI, photo-realistic CGI or natural images/video

Depending on these characteristics as well as the interaction delay tolerance, video games can be organized into different categories as document in the remainder of this clause.

#### 6.6.3.2 Category A: Low/medium dynamicity with low/medium complexity.

This category includes games such as board games, turn-by-turn strategy games, management/simulation games or non-realtime role-playing games (RPG) in which content may not change over several consecutive frames and changes are typically limited.

This category also includes games such as adventure games, casual games, or platform games in which although content may change at every single frame, changes are limited to animation of sprites or simple global movements of the content.

The common characteristics of the games in this category is that their playability can support longer interaction delay tolerance (500 – 1000ms according to TR 26.928 [6]) and their content is typically considered to video encode.

#### 6.6.3.3 Category B: games with high dynamicity and low/medium complexity.

This category includes games such as fighting games, racing games, real-time strategy (RTS) games or real-time RPGs in which content is very dynamic but changes are either limited or simple transforms.

The common characteristics of the games in this category is that their playability requires shorter interaction delay tolerances (100ms according to TR 26.928 [6]) while their content is still considered simple to video encode (with high benefits from prediction coding).

#### 6.6.3.4 Category C: games with high dynamicity and high complexity.

This category includes games such as first-person shooters (FPS), Massive Multiplayer Online (MMO) games and racing games in which content is very dynamic with possibly very significant changes regularly in the content.

The common characteristics of the games in this category is that their playability requires shorter interaction delay tolerances (100ms according to TR 26.928) and their content is typically considered as complex content to video encode.

#### 6.6.3.5 Category D: photo-realistic games or games based on natural images/video.

The main characteristics of the games in this category is that their content is typically considered as more complex content to video encode.

#### 6.6.3.6 Category E: XR game content

For a detailed analysis, please refer to clause 6.6.1 and TR 26.928, clause 4.4.

#### 6.6.3.7 Summary

Table 6.6.3.7-1 provides an overview of the different source signal properties for Online Gaming. This information is used to select proper test sequences.

Table 6.6.3.7-1 Online Gaming source properties

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Source format properties | Category A  low/med dynamicity & low/med complexity games | Category B  high dynamicity & low/med complexity games | Category C  high dynamicity & high complexity games | Category D  photo-realistic or natural video games | Category E  XR games |
| Spatial resolution | 1280x720, 1920x1080, 3840x2160 | 1280x720, 1920x1080, 3840x2160 | 1280x720, 1920x1080, 3840x2160 | 1280x720, 1920x1080, 3840x2160 | 1920x1080, 2048x1024, 3840x2160, 4096x2048, 8192x4096 |
| Chroma format | Y’CbCr | Y’CbCr | Y’CbCr | Y’CbCr | Y’CbCr |
| Chroma subsampling | 4:2:0, 4:4:4 | 4:2:0, 4:4:4 | 4:2:0, 4:4:4 | 4:2:0, 4:4:4 | 4:2:0, 4:4:4 |
| Picture aspect ratio | 16:9 | 16:9 | 16:9 | 16:9 | 16:9; 2:1 |
| Frame Buffers | 1 | 1 | 1 | 1 | 2 (1 per eye) |
| Frame rates | 30, 50, 60 Hz | 30, 50, 60, 90, 120 Hz | 30, 50, 60, 90, 120 Hz | 30, 50, 60, 90, 120 Hz | 30, 50, 60, 90, 120 Hz |
| Bit depth | 8 | 8 | 8, 10 | 8, 10 | 8, 10 |
| Colour space formats | BT.709, BT.2020 | BT.709, BT.2020 | BT.709, BT.2020 | BT.709, BT.2020 | BT.709, BT.2020 |
| Transfer characteristics | N/A | N/A | BT.709 (SDR) BT.2100 (HDR) | BT.709 (SDR) BT.2100 (HDR) | BT.709 (SDR)  BT.2100 (HDR) |

### 6.6.4 Encoding and Decoding Constraints

For photo-realistic games (Category D), certain "screen content" tools may not provide much benefits for this type of game content and would need to be tested.

Table 6.6.4-2 provides an overview of encoding and decoding constraints for H.264/AVC Full HD and H.265/HEVC for online gaming. This information supports the definition of detailed anchor conditions. The configuration files for HEVC are used as the reference configurations for other codecs.

Table 6.6.4-2 Encoding and Decoding Configurations for Online Gaming

|  |  |  |
| --- | --- | --- |
| Encoding and Decoding Constraints | AVC | HEVC |
| Relevant Codec and Codec Profile/Levels according to TS26.116 and TS26.511. | H.264/AVC Progressive High Profile Level 4.0 [7] | H.265/HEVC Main 10 Profile  H.265/HEVC Screen-Extended Main 10 profile  Level 4.1, Level 5.1, Level 6.1 |
| RAP period | Near 1 second, infinite | Near 1 second, infinite |
| Bit rate parameters (CBR, VBR, CAE, HRD parameters) | Similar to HEVC configurations. | See configuration files in section 6.6.8.3 |
| Latency requirements and specific encoding settings | Low-latency requirements  Low-delay B configuration  without use of future reference frames | Low-latency requirements,  Low-delay-B configuration  without use of future reference frames. |
| Encoding complexity context | real-time encoding | real-time encoding. |
| Required decoding capabilities | H.264/AVC Main Profile  Level 4.0 [7] | H.265/HEVC Main 10 Profile  H.265/HEVC Screen-Extended Main 10 profile  Level 4.1, 5.1, 6.1 [8] |
| NOTE: Depending on the type of game (First person, Massive Multi-Player Online Role Play Game, Strategy) the latency requirements differs, usually ranging from less than 50ms to more than 200ms, thus leading to different encoding constraints and configuration. | | |

Table 6.6.5-2 provides an overview of latency constraints for each game category and identifies which coding tools are applicable and potentially useful for each category.

Table 6.6.5-2 Latency constraints tools for different game categories

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Latency Constraints | Category A | Category B | Category C | Category D | Category E |
| Low latency requirement | optional | Yes | Yes | Yes/No | Yes |
| Low delay P | optional | required | required | optional | required |
| Low delay B | optional | required | required | optional | required |
| Use of future reference frames | optional | No | No | optional | No |

### 6.6.5 Performance Metrics

All SDR Metrics as defined in clause 5.5.2 may be reported. However, VMAF and MS-SSIM may not be adequate for online gaming sequences and PSNR should be the main SDR metric to consider.

Based on this, for BD-Rate computation and SDR, only the following metrics are expected to be provided:

- Peak-Signal to Noise Ratio *PSNR*(*Y*) of luma component as defined in clause 5.5.3,

- Average colour component PSNR, *PSNR* over all colour components *PSNR* as defined in clause 5.5.3.

### 6.6.6 Interoperability Considerations

For online gamine, RTP-based communication is expected.

### 6.6.7 Reference Sequences

Reference sequences illustrating the Online Gaming scenario should ideally contain synthetic content with detailed textures and realistic movements. This should include FPS, RPG and Strategy games. For candidate test sequences, please refer to Annex C.2.

Table 6.6.7-1 provides the selected reference sequences for this scenario. Keys are identified to refer to the sequences in the context of the scenario. The sequences are named and a reference to the details of the sequence is provided. A justification is provided, why this sequence is selected.

The details are also provided here: https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-5-Gaming/reference-sequence.csv.

Table 6.6.7-1 Reference Sequences for Online Gaming

|  |  |  |  |
| --- | --- | --- | --- |
| Key | Name | Reference | Justification/Comment |
| S5-R01 | AOV | Annex C.2.2 | FullHD Sequence at 60fps |
| S5-R02 | Baolei-Man | Annex C.2.3 | FullHD Sequence at 60fps |
| S5-R03 | Baolei-Woman | Annex C.2.4 | FullHD Sequence at 60fps |
| S5-R04 | Baolei-Balloon | Annex C.2.5 | 4K Sequence at 60fps |
| S5-R05 | Baolei-Yard | Annex C.2.6 | 4K Sequence at 60fps |
| S5-R06 | Jianling-Temple | Annex C.2.7 | FullHD Sequence at 60fps |
| S5-R07 | Jianling-Beach | Annex C.2.8 | FullHD Sequence at 60fps |
| S5-R08 | Heroes-of-the-Storm | Annex C.2.9 | FullHD Sequence at 30fps |
| S5-R09 | Project-CARS | Annex C.2.10 | FullHD Sequence at 30fps |
| S5-R10 | World-of-WarCraft | Annex C.2.11 | FullHD Sequence at 30fps |
| S5-R11 | MineCraft | Annex C.2.12 | FullHD Sequence at 60fps |
| S5-R12 | CS-GO | Annex C.2.13 | FullHD Sequence at 60fps |
| S5-R13 | StarCraft | Annex C.2.14 | FullHD Sequence at 60fps |

### 6.6.8 Anchor Definition

#### 6.6.8.1 Overview

This clause provides details on how to generate the anchors for the Online gaming scenario.

#### 6.6.8.2 H.264/AVC Anchors

##### 6.6.8.2.1 Overview

Table 6.6.8.2.1-1 provides an overview of the H.264/AVC anchor tuples. Keys are identified to refer to the anchors in the context of the scenario.

The details are also provided here: https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-5-Gaming/264/streams.csv.

Table 6.6.8.2.1-1 Anchor Tuple generation with H.264/AVC for Online Gaming Scenario

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Key** | **Clause** | **Reference Sequence** | **Reference Encoder** | **Configuration** | **Variations** | **Anchor Key** |
| **S5-A01-264** | 6.6.8.2.3 | S5-R01 | JM19.0 | S5-JM-01 | [22,27,32,37] | S5-A01-264-<QP> |
| **S5-A02-264** | 6.6.8.2.3 | S5-R02 | JM19.0 | S5-JM-01 | [22,27,32,37] | S5-A02-264-<QP> |
| **S5-A03-264** | 6.6.8.2.3 | S5-R03 | JM19.0 | S5-JM-01 | [22,27,32,37] | S5-A03-264-<QP> |
| **S5-A04-264** | 6.6.8.2.3 | S5-R04 | JM19.0 | S5-JM-01 | [22,27,32,37] | S5-A04-264-<QP> |
| **S5-A05-264** | 6.6.8.2.3 | S5-R05 | JM19.0 | S5-JM-01 | [22,27,32,37] | S5-A05-264-<QP> |
| **S5-A06-264** | 6.6.8.2.3 | S5-R06 | JM19.0 | S5-JM-01 | [22,27,32,37] | S5-A06-264-<QP> |
| **S5-A07-264** | 6.6.8.2.3 | S5-R07 | JM19.0 | S5-JM-01 | [22,27,32,37] | S5-A07-264-<QP> |
| **S5-A08-264** | 6.6.8.2.3 | S5-R08 | JM19.0 | S5-JM-01 | [22,27,32,37] | S5-A08-264-<QP> |
| **S5-A09-264** | 6.6.8.2.3 | S5-R09 | JM19.0 | S5-JM-01 | [22,27,32,37] | S5-A09-264-<QP> |
| **S5-A10-264** | 6.6.8.2.3 | S5-R10 | JM19.0 | S5-JM-01 | [22,27,32,37] | S5-A10-264-<QP> |
| **S5-A11-264** | 6.6.8.2.3 | S5-R11 | JM19.0 | S5-JM-01 | [22,27,32,37] | S5-A11-264-<QP> |
| **S5-A12-264** | 6.6.8.2.3 | S5-R12 | JM19.0 | S5-JM-01 | [22,27,32,37] | S5-A12-264-<QP> |
| **S5-A13-264** | 6.6.8.2.3 | S5-R13 | JM19.0 | S5-JM-01 | [22,27,32,37] | S5-A13-264-<QP> |
| **S5-A14-264** | 6.6.8.2.4 | S5-R01 | JM19.0 | S5-JM-02 | [22,27,32,37] | S5-A14-264-<QP> |
| **S5-A15-264** | 6.6.8.2.4 | S5-R02 | JM19.0 | S5-JM-02 | [22,27,32,37] | S5-A15-264-<QP> |
| **S5-A16-264** | 6.6.8.2.4 | S5-R03 | JM19.0 | S5-JM-02 | [22,27,32,37] | S5-A16-264-<QP> |
| **S5-A17-264** | 6.6.8.2.4 | S5-R04 | JM19.0 | S5-JM-02 | [22,27,32,37] | S5-A17-264-<QP> |
| **S5-A18-264** | 6.6.8.2.4 | S5-R05 | JM19.0 | S5-JM-02 | [22,27,32,37] | S5-A18-264-<QP> |
| **S5-A19-264** | 6.6.8.2.4 | S5-R06 | JM19.0 | S5-JM-02 | [22,27,32,37] | S5-A19-264-<QP> |
| **S5-A20-264** | 6.6.8.2.4 | S5-R07 | JM19.0 | S5-JM-02 | [22,27,32,37] | S5-A20-264-<QP> |
| **S5-A21-264** | 6.6.8.2.4 | S5-R08 | JM19.0 | S5-JM-02 | [22,27,32,37] | S5-A21-264-<QP> |
| **S5-A22-264** | 6.6.8.2.4 | S5-R09 | JM19.0 | S5-JM-02 | [22,27,32,37] | S5-A22-264-<QP> |
| **S5-A23-264** | 6.6.8.2.4 | S5-R10 | JM19.0 | S5-JM-02 | [22,27,32,37] | S5-A23-264-<QP> |
| **S5-A24-264** | 6.6.8.2.4 | S5-R11 | JM19.0 | S5-JM-02 | [22,27,32,37] | S5-A24-264-<QP> |
| **S5-A25-264** | 6.6.8.2.4 | S5-R12 | JM19.0 | S5-JM-02 | [22,27,32,37] | S5-A25-264-<QP> |
| **S5-A26-264** | 6.6.8.2.4 | S5-R13 | JM19.0 | S5-JM-02 | [22,27,32,37] | S5-A26-264-<QP> |

##### 6.6.8.2.2 Common Parameters

To generate the anchor bitstreams, JM19.0 is used.

The common parameters are as follows:

- ProfileIDC = 100 (High Profile)

- IDRPeriod = IntraPeriod

- NumberOfReferenceFrames = 4

- PList0References = 4 (P slice List 0 reference override)

- I16RDOpt = 1 (rd-optimized mode decision for Intra 16x16 MB)

- SearchMode = 3 (Enhanced Predictive Zonal Search (EPZS))

- SearchRange = 256;

- Picture based multipass coding disabled

The following variable triggers updates to the config-file depending on the test scenario.

* QP: [22,27,32,37]

Note that the MaxMvsPer2Mb restriction is not matching the used level requirement from H.264/AVC due to use of inter 4x4 subpartitions. While a strictly conforming decoder may fail, this is not considered a limiting factor in today’s implementations.

##### 6.6.8.2.3 S5-JM-01: no random access

The common parameters as defined in 6.6.8.2.2 apply.

In addition, the following parameters apply:

- LevelIDC = 52

- IntraPeriod = 0 (no random access)

- NumberBFrames = 4

- BReferencePictures = 2

- Quantization parameters are set as according to Table 6.6.8.2.3-1

Table 6.6.8.2.3-1 Quantization Parameters for S5-JM-01

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| QP | QPISlice | QPPSlice | QPBSlice | ExplicitHierarchyFormat |
| 22 | 21 | 24 | 24 | B0r3B1r2B2r3B3r2 |
| 27 | 26 | 29 | 29 | B0r5B1r4B2r5B3r4 |
| 32 | 31 | 34 | 34 | B0r6B1r5B2r6B3r5 |
| 37 | 36 | 39 | 39 | B0r6B1r5B2r6B3r5 |

The settings are defined in the attached configuration file s5-jm-01.cfg.

##### 6.6.8.2.4 S5-JM-02: Intra near 1 sec

The common parameters as defined in 6.6.8.2.2 apply.

In addition, the following parameters apply:

- IntraPeriod and IDRPeriod = power of 2 value that is greater than or equal to the frame rate (fps), such that near 1 second is achieved: 32 for 30fps sequences and 64 for 60fps sequences

- NumberBFrames = 0

- BReferencePictures = 2

- QPISlice = QPPSlice = QPBSlice = QP

The settings are defined in the attached configuration file s5-jm-02.cfg.

#### 6.6.8.3 H.265/HEVC Anchors

##### 6.6.8.3.1 Overview

Table 6.6.8.3.1-1 provides an overview of the H.265/HEVC anchor tuples. Keys are identified to refer to the anchors in the context of the scenario.

The details are also provided here: https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-5-Gaming/265/streams.csv.

Table 6.5.8.3.1-1 Anchor Tuple generation with H.265/HEVC for Online Gaming Scenario

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Key | Clause | Reference Sequence | Reference Encoder | Configuration | Variations | Anchor Key |
| S5-A01-265 | 6.6.8.3.3 | S5-R01 | HM16.22 | S5-HM-01 | [22, 27, 32, 37] | S5-A01-265-<QP> |
| S5-A02-265 | 6.6.8.3.3 | S5-R02 | HM16.22 | S5-HM-01 | [22, 27, 32, 37] | S5-A02-265-<QP> |
| S5-A03-265 | 6.6.8.3.3 | S5-R03 | HM16.22 | S5-HM-01 | [22, 27, 32, 37] | S5-A03-265-<QP> |
| S5-A04-265 | 6.6.8.3.3 | S5-R04 | HM16.22 | S5-HM-01 | [22, 27, 32, 37] | S5-A04-265-<QP> |
| S5-A05-265 | 6.6.8.3.3 | S5-R05 | HM16.22 | S5-HM-01 | [22, 27, 32, 37] | S5-A05-265-<QP> |
| S5-A06-265 | 6.6.8.3.3 | S5-R06 | HM16.22 | S5-HM-01 | [22, 27, 32, 37] | S5-A06-265-<QP> |
| S5-A07-265 | 6.6.8.3.3 | S5-R07 | HM16.22 | S5-HM-01 | [22, 27, 32, 37] | S5-A07-265-<QP> |
| S5-A08-265 | 6.6.8.3.3 | S5-R08 | HM16.22 | S5-HM-01 | [22, 27, 32, 37] | S5-A08-265-<QP> |
| S5-A09-265 | 6.6.8.3.3 | S5-R09 | HM16.22 | S5-HM-01 | [22, 27, 32, 37] | S5-A09-265-<QP> |
| S5-A10-265 | 6.6.8.3.3 | S5-R10 | HM16.22 | S5-HM-01 | [22, 27, 32, 37] | S5-A10-265-<QP> |
| S5-A11-265 | 6.6.8.3.3 | S5-R11 | HM16.22 | S5-HM-01 | [22, 27, 32, 37] | S5-A11-265-<QP> |
| S5-A12-265 | 6.6.8.3.3 | S5-R12 | HM16.22 | S5-HM-01 | [22, 27, 32, 37] | S5-A12-265-<QP> |
| S5-A13-265 | 6.6.8.3.3 | S5-R13 | HM16.22 | S5-HM-01 | [22, 27, 32, 37] | S5-A13-265-<QP> |
| S5-A14-265 | 6.6.8.3.4 | S5-R01 | HM16.22 | S5-HM-02 | [22, 27, 32, 37] | S5-A14-265-<QP> |
| S5-A15-265 | 6.6.8.3.4 | S5-R02 | HM16.22 | S5-HM-02 | [22, 27, 32, 37] | S5-A15-265-<QP> |
| S5-A16-265 | 6.6.8.3.4 | S5-R03 | HM16.22 | S5-HM-02 | [22, 27, 32, 37] | S5-A16-265-<QP> |
| S5-A17-265 | 6.6.8.3.4 | S5-R04 | HM16.22 | S5-HM-02 | [22, 27, 32, 37] | S5-A17-265-<QP> |
| S5-A18-265 | 6.6.8.3.4 | S5-R05 | HM16.22 | S5-HM-02 | [22, 27, 32, 37] | S5-A18-265-<QP> |
| S5-A19-265 | 6.6.8.3.4 | S5-R06 | HM16.22 | S5-HM-02 | [22, 27, 32, 37] | S5-A19-265-<QP> |
| S5-A20-265 | 6.6.8.3.4 | S5-R07 | HM16.22 | S5-HM-02 | [22, 27, 32, 37] | S5-A20-265-<QP> |
| S5-A21-265 | 6.6.8.3.4 | S5-R08 | HM16.22 | S5-HM-02 | [22, 27, 32, 37] | S5-A21-265-<QP> |
| S5-A22-265 | 6.6.8.3.4 | S5-R09 | HM16.22 | S5-HM-02 | [22, 27, 32, 37] | S5-A22-265-<QP> |
| S5-A23-265 | 6.6.8.3.4 | S5-R10 | HM16.22 | S5-HM-02 | [22, 27, 32, 37] | S5-A23-265-<QP> |
| S5-A24-265 | 6.6.8.3.4 | S5-R11 | HM16.22 | S5-HM-02 | [22, 27, 32, 37] | S5-A24-265-<QP> |
| S5-A25-265 | 6.6.8.3.4 | S5-R12 | HM16.22 | S5-HM-02 | [22, 27, 32, 37] | S5-A25-265-<QP> |
| S5-A26-265 | 6.6.8.3.4 | S5-R13 | HM16.22 | S5-HM-02 | [22, 27, 32, 37] | S5-A26-265-<QP> |
| S5-A27-265 | 6.6.8.3.5 | S5-R01 | SCC8.8 | S5-SCC-01 | [22, 27, 32, 37] | S5-A27-265-<QP> |
| S5-A28-265 | 6.6.8.3.5 | S5-R02 | SCC8.8 | S5-SCC-01 | [22, 27, 32, 37] | S5-A28-265-<QP> |
| S5-A29-265 | 6.6.8.3.5 | S5-R03 | SCC8.8 | S5-SCC-01 | [22, 27, 32, 37] | S5-A29-265-<QP> |
| S5-A30-265 | 6.6.8.3.5 | S5-R04 | SCC8.8 | S5-SCC-01 | [22, 27, 32, 37] | S5-A30-265-<QP> |
| S5-A31-265 | 6.6.8.3.5 | S5-R05 | SCC8.8 | S5-SCC-01 | [22, 27, 32, 37] | S5-A31-265-<QP> |
| S5-A32-265 | 6.6.8.3.5 | S5-R06 | SCC8.8 | S5-SCC-01 | [22, 27, 32, 37] | S5-A32-265-<QP> |
| S5-A33-265 | 6.6.8.3.5 | S5-R07 | SCC8.8 | S5-SCC-01 | [22, 27, 32, 37] | S5-A33-265-<QP> |
| S5-A34-265 | 6.6.8.3.5 | S5-R08 | SCC8.8 | S5-SCC-01 | [22, 27, 32, 37] | S5-A34-265-<QP> |
| S5-A35-265 | 6.6.8.3.5 | S5-R09 | SCC8.8 | S5-SCC-01 | [22, 27, 32, 37] | S5-A35-265-<QP> |
| S5-A36-265 | 6.6.8.3.5 | S5-R10 | SCC8.8 | S5-SCC-01 | [22, 27, 32, 37] | S5-A36-265-<QP> |
| S5-A37-265 | 6.6.8.3.5 | S5-R11 | SCC8.8 | S5-SCC-01 | [22, 27, 32, 37] | S5-A37-265-<QP> |
| S5-A38-265 | 6.6.8.3.5 | S5-R12 | SCC8.8 | S5-SCC-01 | [22, 27, 32, 37] | S5-A38-265-<QP> |
| S5-A39-265 | 6.6.8.3.5 | S5-R13 | SCC8.8 | S5-SCC-01 | [22, 27, 32, 37] | S5-A39-265-<QP> |
| S5-A40-265 | 6.6.8.3.6 | S5-R01 | SCC8.8 | S5-SCC-02 | [22, 27, 32, 37] | S5-A40-265-<QP> |
| S5-A41-265 | 6.6.8.3.6 | S5-R02 | SCC8.8 | S5-SCC-02 | [22, 27, 32, 37] | S5-A41-265-<QP> |
| S5-A42-265 | 6.6.8.3.6 | S5-R03 | SCC8.8 | S5-SCC-02 | [22, 27, 32, 37] | S5-A42-265-<QP> |
| S5-A43-265 | 6.6.8.3.6 | S5-R04 | SCC8.8 | S5-SCC-02 | [22, 27, 32, 37] | S5-A43-265-<QP> |
| S5-A44-265 | 6.6.8.3.6 | S5-R05 | SCC8.8 | S5-SCC-02 | [22, 27, 32, 37] | S5-A44-265-<QP> |
| S5-A45-265 | 6.6.8.3.6 | S5-R06 | SCC8.8 | S5-SCC-02 | [22, 27, 32, 37] | S5-A45-265-<QP> |
| S5-A46-265 | 6.6.8.3.6 | S5-R07 | SCC8.8 | S5-SCC-02 | [22, 27, 32, 37] | S5-A46-265-<QP> |
| S5-A47-265 | 6.6.8.3.6 | S5-R08 | SCC8.8 | S5-SCC-02 | [22, 27, 32, 37] | S5-A47-265-<QP> |
| S5-A48-265 | 6.6.8.3.6 | S5-R09 | SCC8.8 | S5-SCC-02 | [22, 27, 32, 37] | S5-A48-265-<QP> |
| S5-A49-265 | 6.6.8.3.6 | S5-R10 | SCC8.8 | S5-SCC-02 | [22, 27, 32, 37] | S5-A49-265-<QP> |
| S5-A50-265 | 6.6.8.3.6 | S5-R11 | SCC8.8 | S5-SCC-02 | [22, 27, 32, 37] | S5-A50-265-<QP> |
| S5-A51-265 | 6.6.8.3.6 | S5-R12 | SCC8.8 | S5-SCC-02 | [22, 27, 32, 37] | S5-A51-265-<QP> |
| S5-A52-265 | 6.6.8.3.6 | S5-R13 | SCC8.8 | S5-SCC-02 | [22, 27, 32, 37] | S5-A52-265-<QP> |

##### 6.6.8.3.2 Common Parameters

Each source sequence is encoded with:

- QP: [22, 27, 32, 37]

- InternalBitDepth is 10 # codec operating bit-depth where all sequences (including 8 bit sequences) are coded with an internal bitdeph of 10 in accordance with [44] and metrics are calculated in 10 bits.

- SEIDecodedPictureHash=1

As the SEIDecodedPictureHash is set to 1, the effective file size (EFS) needs to take into account the removal of this SEI message when computing the bitrate metric as defined in clause 5.5.2.

##### 6.6.8.3.3 S5-HM-01: Main 10 Profile with no fixed Intra

The common parameters as defined in 6.6.8.3.2 apply.

To generate the anchor bitstreams, HM16.22 is used.

Each source sequence is encoded with the following changes:

- IntraPeriod with no fix interval

- GOPSize is equal to 8. Each B picture refers to up to 4 preceding pictures in display order within the GOP

- IntraQPOffset is -1. B picture QP offsets are IntraQPOffset is -1. B picture QP offsets are adjusted based on the base QP and on the QPmod, QPoffset, QPOffsetModelScale and QPOffsetModelOff.

The settings are defined in the attached configuration file s5-hm-01.cfg.

##### 6.6.8.3.4 S5-HM-02: Main 10 Profile with fixed Intra near 1 sec

The common parameters as defined in 6.6.8.3.2 apply.

To generate the anchor bitstreams, HM16.22 is used.

Each source sequence is encoded with the following changes:

- IntraPeriod = power of 2 value that is greater than or equal to the frame rate (fps), such that near 1 second is achieved: 32 for 30fps sequences and 64 for 60fps sequences

- DecodingRefreshType: (2) IDR

- IntraQPOffset and B pictures QPoffsets are set equal to 0

- Each B picture refers to immediately preceding pictures in display order.

The settings are defined in the attached configuration file s5-hm-02.cfg.

##### 6.6.8.3.5 S5-SCC-01: Screen Content Profile with no fixed Intra

The common parameters as defined in 6.6.8.3.2 apply.

To generate the anchor bitstreams SCM-8.8 is used.

Each source sequence is encoded with the following changes:

- IntraPeriod with no fix interval

- GOPSize is equal to 8. Each P picture refers to up to 4 preceding pictures in display order within the GOP

- IntraQPOffset is -1. B picture QP offsets are IntraQPOffset is -1. B picture QP offsets are adjusted based on the base QP and on the QPmod, QPoffset, QPOffsetModelScale and QPOffsetModelOff.

##### 6.6.8.3.6 S5-SCC-02: Screen Content Profile with Intra near 1 sec

The common parameters as defined in 6.6.8.3.2 apply.

To generate the anchor bitstreams SCM-8.8 is used.

Each source sequence is encoded with the following changes:

- IntraPeriod = power of 2 value that is greater than or equal to the frame rate (fps), such that near 1 second is achieved: 32 for 30fps sequences and 64 for 60fps sequences

- DecodingRefreshType: (2) IDR

- IntraQPOffset and B pictures QPoffsets are set equal to 0

- Each B picture refers to immediately preceding pictures in display order.

### 6.6.9 Anchor Results

#### 6.6.9.1 H.264/AVC Anchors

AVC anchor streams are provided according to the key system here:

* https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-5-Gaming/264/

AVC anchor results are provided with the appropriate keys as defined in Table 6.6.8.2.1-1

* in the attached csv files
* https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/ Scenario-5-Gaming/264/Metrics/

Editor’s Note:

* The metrics for VMAF and MS\_SSIM still need to be zeroed based on agreement in S4-220484
* Verification is still missing

#### 6.6.9.2 H.265/HEVC Anchors

HEVC anchor streams are provided according to the key system here:

* https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-5-Gaming/265/

HEVC anchor results are provided with the appropriate keys as defined in Table 6.4.8.3.1-1

* in the attached csv files
* https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-5-Gaming/265/Metrics/

# 7 Characterization Framework

## 7.1 Introduction

This clause provides a characterization of existing codecs. This serves pre-dominantly as an example to introduce the characterization framework.

## 7.2 Characterization against 3GPP Anchor Codecs

7.2.1 Characterization against H.264/AVC

For a codec to be fully characterized against H.264/AVC, the following information should be provided:

1. For scenario 1:

a) *BD-Rate Gain* table as defined in clause 5.8 for all H.264/AVC reference sequences and configuration S1-JM-01 as defined in clause 6.2.8.2 with a comparable configuration and all SDR metrics defined clause 6.2.5.

2. For scenario 2 no characterization possible.

3. For scenario 3:

a) *BD-Rate Gain* table as defined in clause 5.8 for all H.264/AVC reference sequences and configuration S3-JM-01 and S3-JM-02 as defined in clause 6.4.8.2 with a comparable configuration and all SDR metrics defined clause 6.4.5.

b) *BD-Rate Gain* table as defined in clause 5.8 for all H.264/AVC reference sequences and configuration S3-JM-03 and S3-JM-04 as defined in clause 6.4.8.2 with a comparable configuration and all SDR metrics defined clause 6.4.5.

4. For scenario 4:

a) *BD-Rate Gain* table as defined in clause 5.8 for all H.264/AVC reference sequences and configuration S4-JM-01 as defined in clause 6.5.8.2 with a comparable configuration and all SDR metrics defined clause 6.5.5.

b) *BD-Rate Gain* table as defined in clause 5.8 for all H.264/AVC reference sequences and configuration S4-JM-02 as defined in clause 6.5.8.2 with a comparable configuration and all SDR metrics defined clause 6.5.5.

5. For scenario 5:

a) *BD-Rate Gain* table as defined in clause 5.8 for all H.264/AVC reference sequences and configuration S5-JM-01 as defined in clause 6.6.8.2 with a comparable configuration and all SDR metrics defined clause 6.6.5.

b) *BD-Rate Gain* table as defined in clause 5.8 for all H.264/AVC reference sequences and configuration S5-JM-02 as defined in clause 6.6.8.2 with a comparable configuration and all SDR metrics defined clause 6.6.5.

Additional information such as Rate-Quality plots may be provided if considered insightful.

Partial characterization may be conducted as well.

7.2.2 Characterization against H.265/HEVC HM

For a codec to be fully characterized against H.265/HEVC HM (Main 10 profile), the following information should be provided:

1. For scenario 1:

a) *BD-Rate Gain* table as defined in clause 5.8 for all H.265/HEVC reference sequences and configuration S1-HM-01 as defined in clause 6.2.8.3 with a comparable configuration and all SDR metrics defined clause 6.2.5.

b) *BD-Rate Gain* table as defined in clause 5.8 for all H.265/HEVC reference sequences and configuration S1-HM-02 as defined in clause 6.2.8.3 with a comparable configuration and all HDR metrics defined clause 6.2.5.

2. For scenario 2:

a) *BD-Rate Gain* table as defined in clause 5.8 for all H.265/HEVC reference sequences and configuration S2-HM-01 as defined in clause 6.3.8.3 with a comparable configuration and all SDR metrics defined clause 6.3.5.

b) *BD-Rate Gain* table as defined in clause 5.8 for all H.265/HEVC reference sequences and configuration S2-HM-02 as defined in clause 6.3.8.3 with a comparable configuration and all HDR metrics defined clause 6.3.5.

3. For scenario 3:

a) *BD-Rate Gain* table as defined in clause 5.8 for all H.265/HEVC reference sequences and configuration S3-HM-01 as defined in clause 6.4.8.3 with a comparable configuration and all SDR metrics defined clause 6.4.5.

b) *BD-Rate Gain* table as defined in clause 5.8 for all H.265/HEVC reference sequences and configuration S3-HM-02 as defined in clause 6.4.8.3 with a comparable configuration and all SDR metrics defined clause 6.4.5.

c) *BD-Rate Gain* table as defined in clause 5.8 for all H.265/HEVC reference sequences and configuration S3-HM-03 as defined in clause 6.4.8.3 with a comparable configuration and all SDR metrics defined clause 6.4.5.

d) *BD-Rate Gain* table as defined in clause 5.8 for all H.265/HEVC reference sequences and configuration S3-HM-04 as defined in clause 6.4.8.3 with a comparable configuration and all SDR metrics defined clause 6.4.5.

4. For scenario 4:

a) *BD-Rate Gain* table as defined in clause 5.8 for all H.265/HEVC reference sequences and configuration S4-HM-01 as defined in clause 6.5.8.3 with a comparable configuration and all SDR metrics defined clause 6.5.5.

b) *BD-Rate Gain* table as defined in clause 5.8 for all H.265/HEVC reference sequences and configuration S4-HM-02 as defined in clause 6.5.8.3 with a comparable configuration and all SDR metrics defined clause 6.5.5.

5. For scenario 5:

a) *BD-Rate Gain* table as defined in clause 5.8 for all H.265/HEVC reference sequences and configuration S5-HM-01 as defined in clause 6.6.8.3 with a comparable configuration and all SDR metrics defined clause 6.6.5.

b) *BD-Rate Gain* table as defined in clause 5.8 for all H.265/HEVC reference sequences and configuration S5-HM-02 as defined in clause 6.6.8.3 with a comparable configuration and all SDR metrics defined clause 6.6.5.

Additional information such as Rate-Quality plots may be provided if considered insightful.

Partial characterization may be conducted as well.

7.2.3 Characterization against H.265/HEVC SCC

For a codec to be fully characterized against H.265/HEVC SCC (Screen-Extended Main 10 profile), the following information should be provided:

1. For scenario 1 no characterization possible.

2. For scenario 2 no characterization possible.

3. For scenario 3:

a) *BD-Rate Gain* table as defined in clause 5.8 for all H.265/HEVC reference sequences and configuration S3-SCC-01 as defined in clause 6.4.8.3 with a comparable configuration and all SDR metrics defined clause 6.4.5.

b) *BD-Rate Gain* table as defined in clause 5.8 for all H.265/HEVC reference sequences and configuration S3-SCC-02 as defined in clause 6.4.8.3 with a comparable configuration and all SDR metrics defined clause 6.4.5.

c) *BD-Rate Gain* table as defined in clause 5.8 for all H.265/HEVC reference sequences and configuration S3-SCC-03 as defined in clause 6.4.8.3 with a comparable configuration and all SDR metrics defined clause 6.4.5.

d) *BD-Rate Gain* table as defined in clause 5.8 for all H.265/HEVC reference sequences and configuration S3-SCC-04 as defined in clause 6.4.8.3 with a comparable configuration and all SDR metrics defined clause 6.4.5.

4. For scenario 4 no characterization possible.

5. For scenario 5:

a) *BD-Rate Gain* table as defined in clause 5.8 for all H.265/HEVC reference sequences and configuration S5-HM-01 as defined in clause 6.6.8.3 with a comparable configuration and all SDR metrics defined clause 6.6.5.

b) *BD-Rate Gain* table as defined in clause 5.8 for all H.265/HEVC reference sequences and configuration S5-HM-02 as defined in clause 6.6.8.3 with a comparable configuration and all SDR metrics defined clause 6.6.5.

Additional information such as Rate-Quality plots may be provided if considered insightful.

Partial characterization may be conducted as well.

## 7.3 H.265/HEVC Characterization against H.264/AVC

### 7.3.1 Introduction

This clause provides characterization results for H.265/HEVC against H.264/AVC for different scenarios and metrics.

The clause 7.3.2 provides the results for H.265/HEVC Main 10 profile (referred as H.265/HEVC HM) and clause 7.3.3 provides the results for H.265/HEVC Screen-Extended Main 10 profile (referred as H.265/HEVC SCC) compared to H.264/AVC.

[

Editor’s Note: the results provided for characterization are based on intermediate non-verified numbers and primarily provide verification of the process. The numbers will be updated accordingly

### 7.3.2 H.265/HEVC HM against H.264/AVC

#### 7.3.2.1 Overview

This clause provides a full characterization of H.265/HEVC HM against H.264/AVC according to clause 7.2.1. The results provided in clause 6 are used for the characterization.

#### 7.3.2.2 Scenario 1: Full HD

This clause provides characterization of H.265/HEVC HM mode configurations against H.264/AVC for Scenario 1 Full HD. In particular, Table 7.3.2.2-1 provides the BD rate gain of H.265/HEVC HM with S1-HM-01 against H.264/AVC with configuration S1-HM-01, i.e. with the Full HD SDR scenario reference sequences.

Table 7.3.2.2-1 BD rate gain of H.265/HEVC HM with S1-HM-01 against H.264/AVC with configuration S1-JM-01, i.e. with the Full HD SDR scenario reference sequences

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Reference sequence | Name | psnr | y\_psnr | vmaf | ms\_ssim |
| S1-R01 | Brest-Sedof-FHD | 69.321 | 71.563 | 58.558 | 47.572 |
| S1-R02 | Rain Fruits-FHD | 49.23 | 50.551 | 48.296 | 47.333 |
| S1-R03 | Park Joy-FHD | 24.71 | 23.276 | 30.356 | 27.548 |
| S1-R04 | Soccer-FHD | 59.224 | 59.115 | 58.083 | 57.541 |
| S1-R05 | Tunnel Flag-FHD | 47.436 | 46.246 | 48.282 | 49.485 |
| S1-R06 | Boat-FHD | 34.567 | 34.581 | 37.455 | 34.468 |
| S1-R07 | Fountain-FHD | 21.739 | 21.674 | 28.414 | 21.563 |
| S1-R08 | Riverbank-FHD | 39.923 | 37.04 | 38.456 | 32.952 |
| Minimum |  | 21.739 | 21.674 | 28.414 | 21.563 |
| Maximum |  | 69.321 | 71.563 | 58.558 | 57.541 |
| Average |  | 43.269 | 43.006 | 43.487 | 39.808 |

As an example, Figure 7.3.2.2-1 provides Rate-Quality curves and BD rate gain for psnr of H.265/HEVC HM with S1-JM-01 against H.264/AVC HM with configuration S1-JM-01 for reference sequence S1-R01.

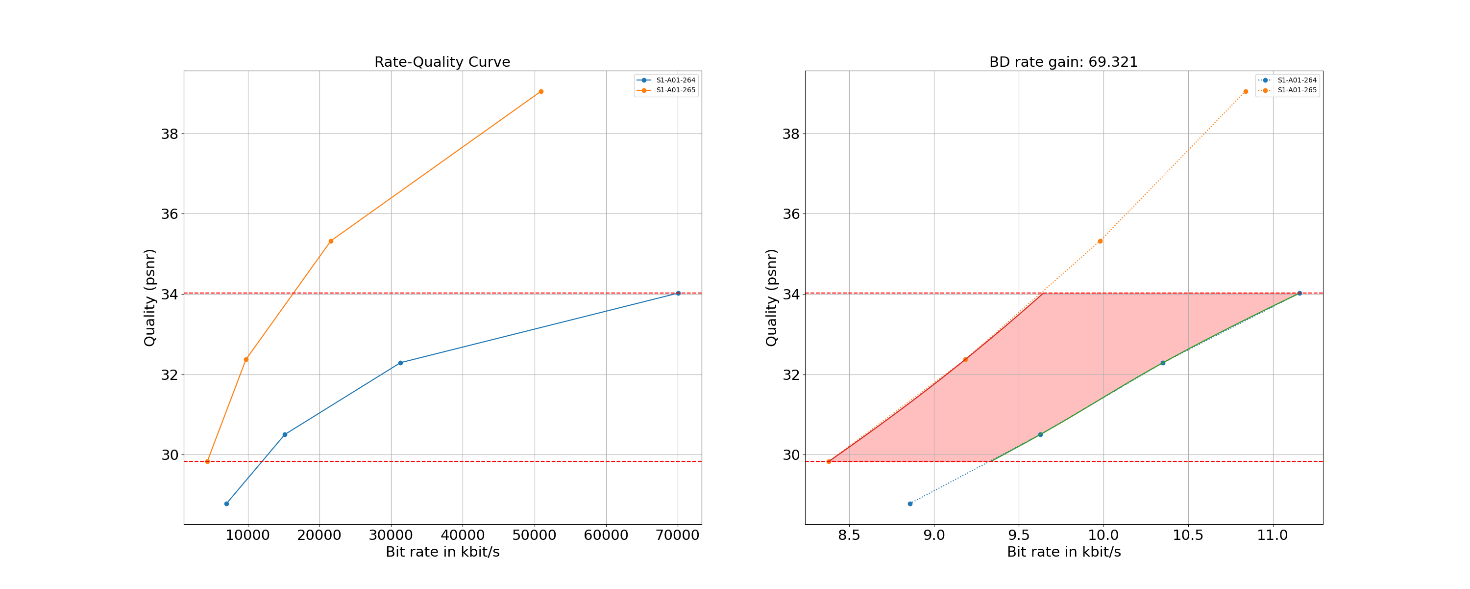


Figure 7.3.2.2-1 Rate-Quality curves and BD rate gain for psnr of H.265/HEVC HM with S1-HM-01 against H.264/AVC with configuration S1-JM-01 for reference sequence S1-R01

All Rate-Quality curves and BD rate gain plots are provided in the attachment as well as online here https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-1-FHD/265/Characterization/.

#### 7.3.2.3 Scenario 3: Screen Content

This clause provides characterization of H.265/HEVC HM mode configurations against H.264/AVC for Scenario 3 Screen Content. In particular,

* Table 7.3.2.3-1 provides the BD rate gain of H.265/HEVC HM with S3-HM-01 against H.264/AVC with configuration S3-JM-01, i.e. with the screen content scenario reference sequences and no fixed intra.
* Table 7.3.2.3-2 provides the BD rate gain of H.265/HEVC HM with S3-HM-02 against H.264/AVC with configuration S3-JM-02, i.e. with the screen content scenario reference sequences with fixed Intra every second.

Table 7.3.2.3-1 BD rate gain of H.265/HEVC HM with S3-HM-01 against H.264/AVC with configuration S3-JM-01, i.e. with the screen content scenario reference sequences and no fixed intra

|  |  |  |  |
| --- | --- | --- | --- |
| Reference sequence | Name | psnr | y\_psnr |
| S3-R02 | MovingText2-4K-8bit | 61.17 | 60.887 |
| S3-R04 | MovingText2-FullHD-8bit | 62.334 | 63.038 |
| S3-R06 | TextMixTransitions-4K-8bit | 55.034 | 50.946 |
| S3-R08 | TextMixTransitions-FullHD-8bit | 39.536 | 36.983 |
| S3-R10 | GraphicsMixSimple-4K-8bit | 51.15 | 50.049 |
| S3-R12 | GraphicsMixSimple-FullHD-8bit | 21.172 | 19.675 |
| S3-R14 | GraphicsMixTransitions-4K-8bit | 60.933 | 59.657 |
| S3-R16 | GraphicsMixTransitions-FullHD-8bit | 49.452 | 47.949 |
| S3-R17 | Mission-Control | 29.562 | 28.624 |
| Minimum |  | 21.172 | 19.675 |
| Maximum |  | 62.334 | 63.038 |
| Average |  | 47.816 | 46.423 |

Table 7.3.2.3-2 BD rate gain of H.265/HEVC HM with S3-HM-02 against H.264/AVC with configuration S3-JM-02, i.e. with the screen content scenario reference sequences with fixed Intra every second

|  |  |  |  |
| --- | --- | --- | --- |
| Reference sequence | Name | psnr | y\_psnr |
| S3-R02 | MovingText2-4K-8bit | 52.647 | 51.492 |
| S3-R04 | MovingText2-FullHD-8bit | 50.507 | 50.702 |
| S3-R06 | TextMixTransitions-4K-8bit | 48.709 | 43.646 |
| S3-R08 | TextMixTransitions-FullHD-8bit | 31.683 | 29.716 |
| S3-R10 | GraphicsMixSimple-4K-8bit | 45.556 | 44.046 |
| S3-R12 | GraphicsMixSimple-FullHD-8bit | 29.01 | 27.587 |
| S3-R14 | GraphicsMixTransitions-4K-8bit | 54.391 | 53.029 |
| S3-R16 | GraphicsMixTransitions-FullHD-8bit | 44.093 | 42.747 |
| S3-R17 | Mission-Control | 25.66 | 25.324 |
| Minimum |  | 25.66 | 25.324 |
| Maximum |  | 54.391 | 53.029 |
| Average |  | 42.473 | 40.921 |

As an example, Figure 7.3.2.3-1 provides Rate-Quality curves and BD rate gain for psnr of H.265/HEVC HM with S3-HM-01 against H.264/AVC HM with configuration S3-JM-01 for reference sequence S3-R02.

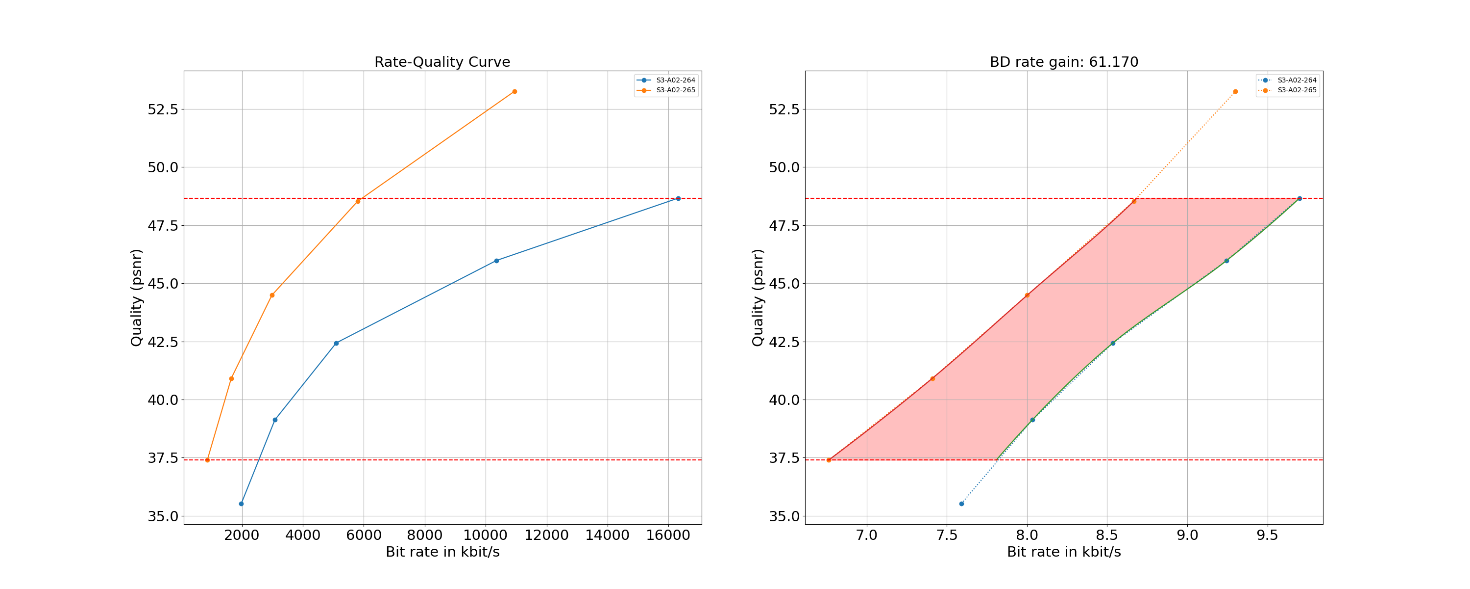


Figure 7.3.2.3-1 Rate-Quality curves and BD rate gain for psnr of H.265/HEVC HM with S3-HM-01 against H.264/AVC with configuration S3-JM-01 for reference sequence S3-R02

All Rate-Quality curves and BD rate gain plots are provided in the attachment as well as online here https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-3-Screen/265/Characterization/.

#### 7.3.2.4 Scenario 4: Messaging and Social Sharing

This clause provides characterization of H.265/HEVC HM mode configurations against H.264/AVC for Scenario 4 Messaging and Social Sharing. In particular,

* Table 7.3.2.4-1 provides the BD rate gain of H.265/HEVC HM with S4-HM-01 against H.264/AVC with configuration S4-JM-01, i.e. with the messaging and social sharing scenario reference sequences and no fixed intra.
* Table 7.3.2.4-2 provides the BD rate gain of H.265/HEVC HM with S4-HM-02 against H.264/AVC with configuration S4-JM-02, i.e. with the messaging and social sharing scenario reference sequences with fixed Intra every second.

Table 7.3.2.4-1 BD rate gain of H.265/HEVC HM with S4-HM-01 against H.264/AVC with configuration S4-JM-01, i.e. with the messaging and social sharing scenario reference sequences and no fixed intra

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Reference sequence | Name | psnr | y\_psnr | vmaf | ms\_ssim |
| S4-R01 | Vertical-Bees | 60.076 | 60.044 | 62.218 | 64.245 |
| S4-R02 | Vertical-Walking | 21.67 | 20.392 | 30.372 | 25.972 |
| S4-R03 | Neon-4K | 33.438 | 31.7 | 38.009 | 34.273 |
| S4-R04 | Skater-4K | 71.455 | 70.634 | 68.399 | 71.119 |
| Minimum |  | 21.67 | 20.392 | 30.372 | 25.972 |
| Maximum |  | 71.455 | 70.634 | 68.399 | 71.119 |
| Average |  | 46.66 | 45.692 | 49.749 | 48.902 |

Table 7.3.2.4-2 BD rate gain of H.265/HEVC HM with S4-HM-02 against H.264/AVC with configuration S4-JM-02, i.e. with the messaging and social sharing scenario reference sequences and fixed Intra every second

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Reference sequence | Name | psnr | y\_psnr | vmaf | ms\_ssim |
| S4-R01 | Vertical-Bees | 41.962 | 43.618 | 47.354 | 47.661 |
| S4-R02 | Vertical-Walking | 15.854 | 14.521 | 23.221 | 18.352 |
| S4-R03 | Neon-4K | 23.866 | 22.64 | 34.791 | 26.499 |
| S4-R04 | Skater-4K | 63.23 | 63.622 | 60.847 | 62.967 |
| Minimum |  | 15.854 | 14.521 | 23.221 | 18.352 |
| Maximum |  | 63.23 | 63.622 | 60.847 | 62.967 |
| Average |  | 36.228 | 36.1 | 41.553 | 38.87 |

As an example, Figure 7.3.2.4-1 provides Rate-Quality curves and BD rate gain for vmaf of H.265/HEVC HM with S4-HM-01 against H.264/AVC HM with configuration S4-JM-01 for reference sequence S4-R01.

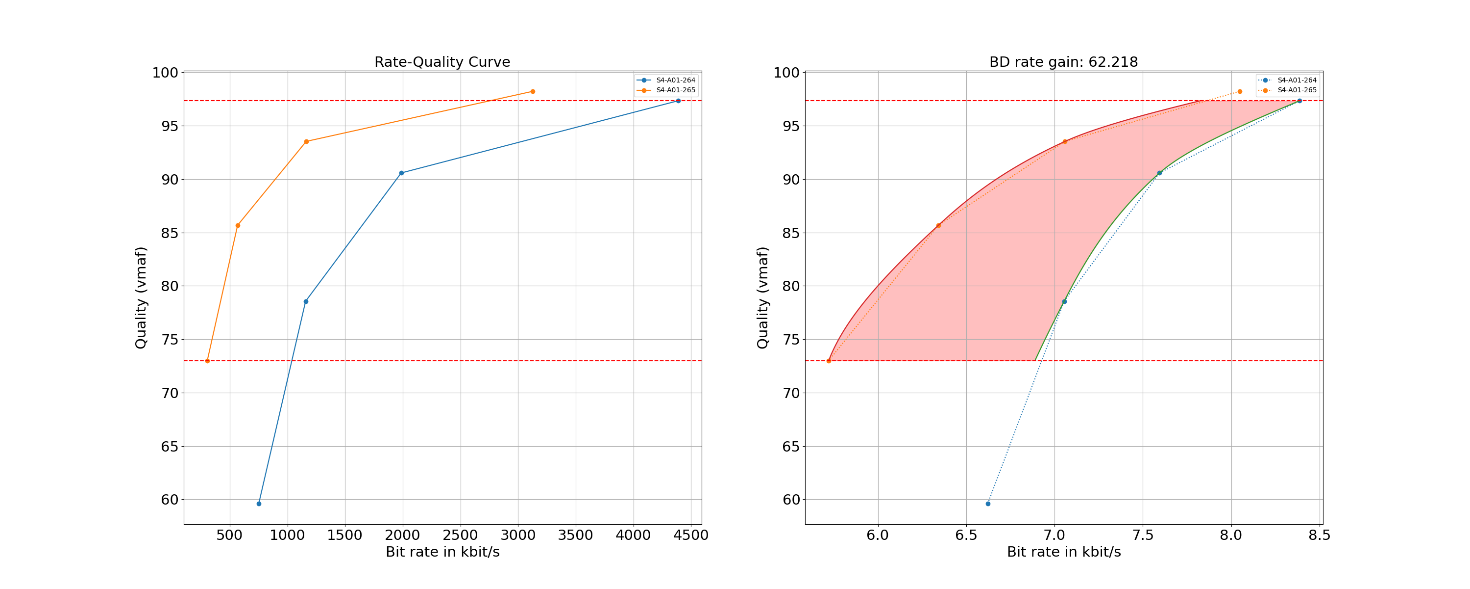


Figure 7.3.2.4-1 Rate-Quality curves and BD rate gain for vmaf of H.265/HEVC HM with S4-HM-01 against H.264/AVC with configuration S4-JM-01 for reference sequence S4-R01

As another example, Figure 7.3.2.4-2 provides Rate-Quality curves and BD rate gain for vmaf of H.265/HEVC HM with S4-HM-02 against H.264/AVC HM with configuration S4-JM-02 for reference sequence S4-R01.

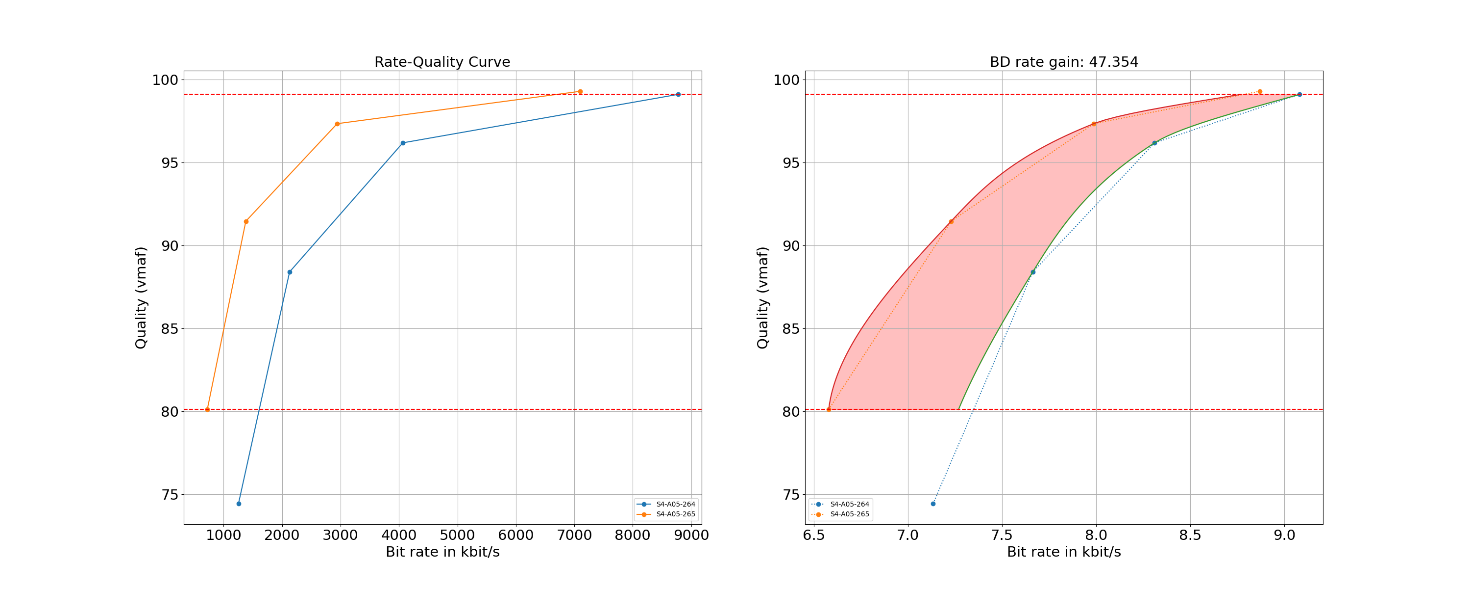


Figure 7.3.2.4-2 Rate-Quality curves and BD rate gain for vmaf of H.265/HEVC HM with S4-HM-02 against H.264/AVC with configuration S4-JM-02 for reference sequence S4-R01

All Rate-Quality curves and BD rate gain plots are provided in the attachment as well as online here https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-4-Sharing/265/Characterization/.

#### 7.3.2.5 Scenario 5: Online Gaming

This clause provides characterization of H.265/HEVC HM mode configurations against H.264/AVC for Scenario 5 Online Gaming. In particular,

* Table 7.3.2.5-1 provides the BD rate gain of H.265/HEVC HM with S5-HM-01 against H.264/AVC with configuration S5-JM-01, i.e. with the online gaming scenario reference sequences and no fixed intra.
* Table 7.3.2.5-2 provides the BD rate gain of H.265/HEVC HM with S5-HM-02 against H.264/AVC with configuration S5-JM-02, i.e. with the online gaming scenario reference sequences with fixed Intra every second.

Table 7.3.2.5-1 BD rate gain of H.265/HEVC HM with S5-HM-01 against H.264/AVC with configuration S5-JM-01, i.e. with the online gaming scenario reference sequences and no fixed intra

|  |  |  |  |
| --- | --- | --- | --- |
| Reference sequence | Name | psnr | y\_psnr |
| S5-R01 | AOV | 44.713 | 44.258 |
| S5-R02 | Baolei-Man | 36.198 | 35.033 |
| S5-R03 | Baolei-Woman | 44.335 | 43.635 |
| S5-R04 | Baolei-Balloon | 52.155 | 52.201 |
| S5-R05 | Baolei-Yard | 48.084 | 47.988 |
| S5-R06 | Jianling-Temple | 23.318 | 22.91 |
| S5-R07 | Jianling-Beach | 36.417 | 34.245 |
| S5-R08 | Heroes-of-the-Storm | 31.132 | 31.021 |
| S5-R09 | Project-CARS | 40.139 | 37.499 |
| S5-R10 | World-of-WarCraft | 47.916 | 47.238 |
| S5-R11 | MineCraft | 28.093 | 25.659 |
| S5-R12 | CS-GO | 52.026 | 48.757 |
| S5-R13 | StarCraft | 43.823 | 42.264 |
| Minimum |  | 23.318 | 22.91 |
| Maximum |  | 52.155 | 52.201 |
| Average |  | 40.642 | 39.439 |

Table 7.3.2.5-2 BD rate gain of H.265/HEVC HM with S5-HM-02 against H.264/AVC with configuration S5-JM-02, i.e. with the online gaming scenario reference sequences and fixed intra every second

|  |  |  |  |
| --- | --- | --- | --- |
| Reference sequence | Name | psnr | y\_psnr |
| S5-R01 | AOV | 32.165 | 32.486 |
| S5-R02 | Baolei-Man | 26.863 | 26.619 |
| S5-R03 | Baolei-Woman | 33.532 | 33.735 |
| S5-R04 | Baolei-Balloon | 42.495 | 43.401 |
| S5-R05 | Baolei-Yard | 41.187 | 42.017 |
| S5-R06 | Jianling-Temple | 20.787 | 20.864 |
| S5-R07 | Jianling-Beach | 23.332 | 23.024 |
| S5-R08 | Heroes-of-the-Storm | 20.606 | 20.977 |
| S5-R09 | Project-CARS | 31.043 | 31.639 |
| S5-R10 | World-of-WarCraft | 36.458 | 35.769 |
| S5-R11 | MineCraft | 25.775 | 24.771 |
| S5-R12 | CS-GO | 35.996 | 35.304 |
| S5-R13 | StarCraft | 29.439 | 28.815 |
| Minimum |  | 20.606 | 20.864 |
| Maximum |  | 42.495 | 43.401 |
| Average |  | 30.744 | 30.725 |

As an example,

* Figure 7.3.2.5-1 provides Rate-Quality curves and BD rate gain for psnr of H.265/HEVC HM with S5-HM-01 against H.264/AVC HM with configuration S5-JM-01 for reference sequence S5-R01
* Figure 7.3.2.5-2 provides Rate-Quality curves and BD rate gain for psnr of H.265/HEVC HM with S5-HM-02 against H.264/AVC HM with configuration S5-JM-02 for reference sequence S5-R01

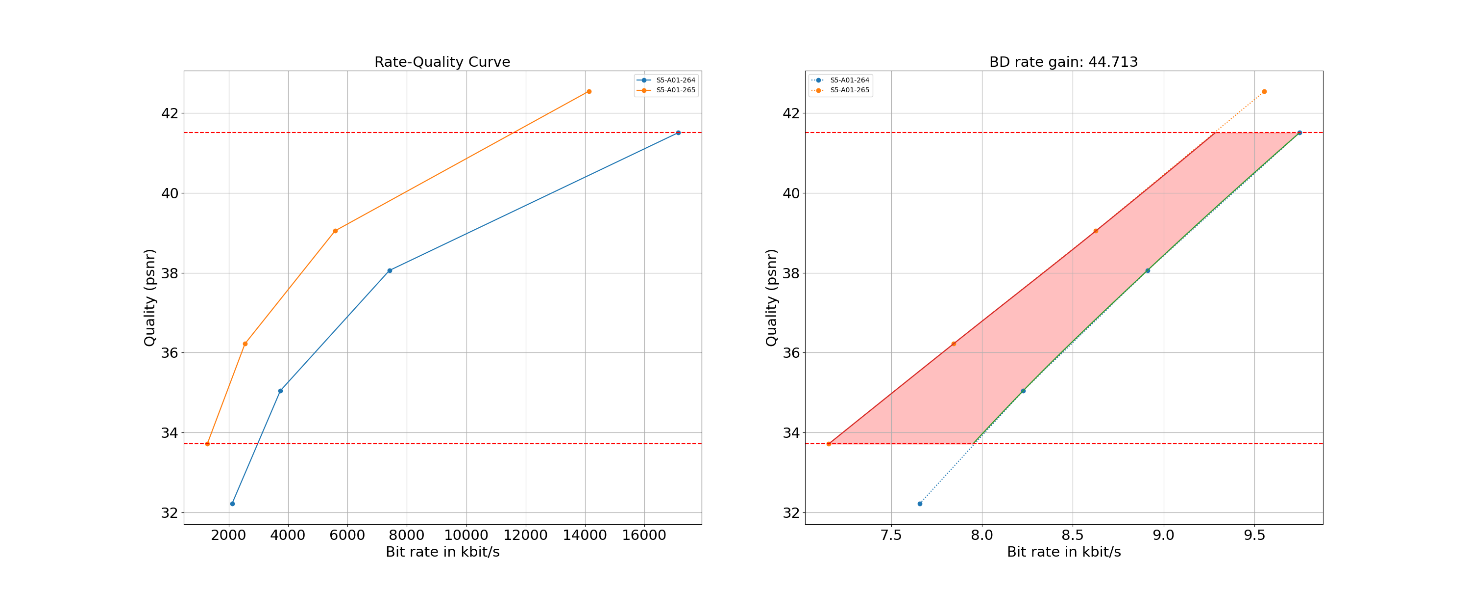


Figure 7.3.2.5-1 Rate-Quality curves and BD rate gain for psnr of H.265/HEVC HM with S5-HM-01 against H.264/AVC with configuration S5-JM-01 for reference sequence S5-R01

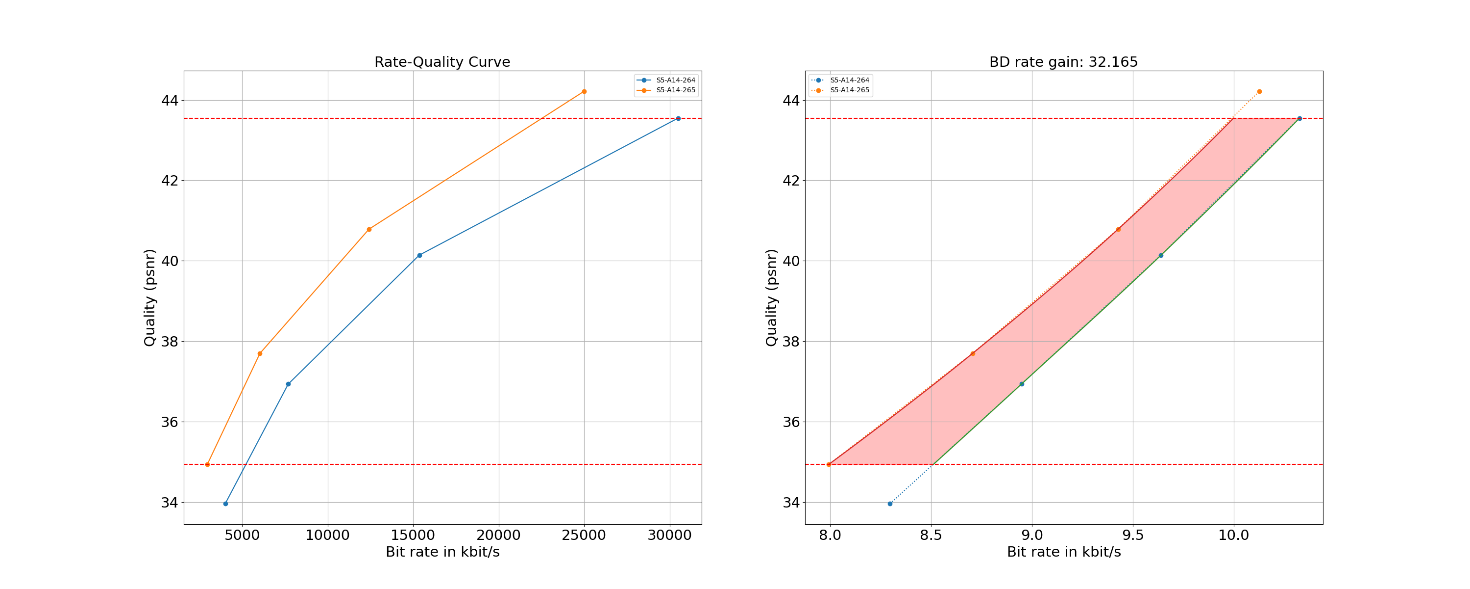


Figure 7.3.2.5-2 Rate-Quality curves and BD rate gain for psnr of H.265/HEVC HM with S5-HM-02 against H.264/AVC with configuration S5-JM-02 for reference sequence S5-R01

All Rate-Quality curves and BD rate gain plots are provided in the attachment as well as online here: https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-5-Gaming/265/Characterization/.

#### 7.3.2.6 Summary

Table 7.3.2.6-1 provides a summary of BD rate gain in psnr and vmaf of H.265/HEVC HM against H.264/AVC for different scenarios and configurations.

Table 7.3.2.6-1 Summary of BD rate gain in psnr and vmaf of H.265/HEVC HM against H.264/AVC for different scenarios and configurations

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Scenario | average psnr | min psnr | max psnr | average vmaf | min vmaf | max vmaf |
| S1 | 43.269 | 21.739 | 43.269 | 43.487 | 28.414 | 58.558 |
| S3 no intra | 47.816 | 21.172 | 62.334 | n/a | n/a | n/a |
| S3 intra | 42.473 | 25.66 | 54.391 | n/a | n/a | n/a |
| S4 no intra | 46.660 | 21.670 | 71.455 | 48.902 | 25.972 | 71.119 |
| S4 intra | 36.288 | 15.854 | 63.230 | 38.870 | 18.352 | 62.967 |
| S5 no intra | 40.642 | 23.318 | 52.155 | n/a | n/a | n/a |
| S5 intra | 30.744 | 20.606 | 42.495 | n/a | n/a | n/a |
| Minimum | 30.744 | 15.854 | 42.495 | 38.870 | 18.352 | 58.558 |
| Maximum | 47.816 | 25.66 | 71.455 | 48.902 | 28.414 | 71.119 |

### 7.3.3 H.265/HEVC SCC against H.264/AVC

#### 7.3.3.1 Overview

This clause provides a partial characterization of H.265/HEVC SCC against H.264/AVC according to clause 7.2.1. The results provided in clause 6 are used for the characterization.

#### 7.3.3.2 Scenario 3: Screen Content

This clause provides characterization of H.265/HEVC SCC mode configurations against H.264/AVC for Scenario 3 Screen Content. In particular,

* Table 7.3.3.2-1 provides the BD rate gain of H.265/HEVC SCC with S3-SCC-01 against H.264/AVC with configuration S3-JM-01, i.e. with the screen content scenario reference sequences and no fixed intra.
* Table 7.3.3.2-2 provides the BD rate gain of H.265/HEVC SCC with S3-SCC-02 against H.264/AVC with configuration S3-JM-02, i.e. with the screen content scenario reference sequences with fixed Intra every second.

Table 7.3.3.2-1 BD rate gain of H.265/HEVC SCC with S3-SCC-01 against H.264/AVC with configuration S3-JM-01, i.e. with the screen content scenario reference sequences and no fixed intra

|  |  |  |  |
| --- | --- | --- | --- |
| Reference sequence | Name | psnr | y\_psnr |
| S3-R02 | MovingText2-4K-8bit | 68.48 | 67.291 |
| S3-R04 | MovingText2-FullHD-8bit | 65.973 | 66.148 |
| S3-R06 | TextMixTransitions-4K-8bit | 71.623 | 67.469 |
| S3-R08 | TextMixTransitions-FullHD-8bit | 53.482 | 48.881 |
| S3-R10 | GraphicsMixSimple-4K-8bit | 69.851 | 68.598 |
| S3-R12 | GraphicsMixSimple-FullHD-8bit | 37.63 | 35.377 |
| S3-R14 | GraphicsMixTransitions-4K-8bit | 66.68 | 65.055 |
| S3-R16 | GraphicsMixTransitions-FullHD-8bit | 53.281 | 50.966 |
| S3-R17 | Mission-Control | 52.538 | 52.036 |
| Minimum |  | 37.63 | 35.377 |
| Maximum |  | 71.623 | 68.598 |
| Average |  | 59.949 | 57.98 |

Table 7.3.3.2-2 BD rate gain of H.265/HEVC SCC with S3-SCC-02 against H.264/AVC with configuration S3-JM-02, i.e. with the screen content scenario reference sequences with fixed Intra every second

|  |  |  |  |
| --- | --- | --- | --- |
| Reference sequence | Name | psnr | y\_psnr |
| S3-R02 | MovingText2-4K-8bit | 61.933 | 60.302 |
| S3-R04 | MovingText2-FullHD-8bit | 56.302 | 55.934 |
| S3-R06 | TextMixTransitions-4K-8bit | 71.961 | 67.969 |
| S3-R08 | TextMixTransitions-FullHD-8bit | 52.877 | 49.414 |
| S3-R10 | GraphicsMixSimple-4K-8bit | 70.68 | 69.339 |
| S3-R12 | GraphicsMixSimple-FullHD-8bit | 49.614 | 47.503 |
| S3-R14 | GraphicsMixTransitions-4K-8bit | 66.498 | 65.005 |
| S3-R16 | GraphicsMixTransitions-FullHD-8bit | 53.298 | 51.092 |
| S3-R17 | Mission-Control | 52.515 | 52.447 |
| Minimum |  | 49.614 | 47.503 |
| Maximum |  | 71.961 | 69.339 |
| Average |  | 59.52 | 57.667 |

As an example,

* Figure 7.3.3.2-1 provides Rate-Quality curves and BD rate gain for psnr of H.265/HEVC SCC with S3-SCC-01 against H.264/AVC HM with configuration S3-JM-01 for reference sequence S3-R02
* Figure 7.3.3.2-2 provides Rate-Quality curves and BD rate gain for psnr of H.265/HEVC SCC with S3-SCC-02 against H.264/AVC HM with configuration S3-JM-02 for reference sequence S3-R02

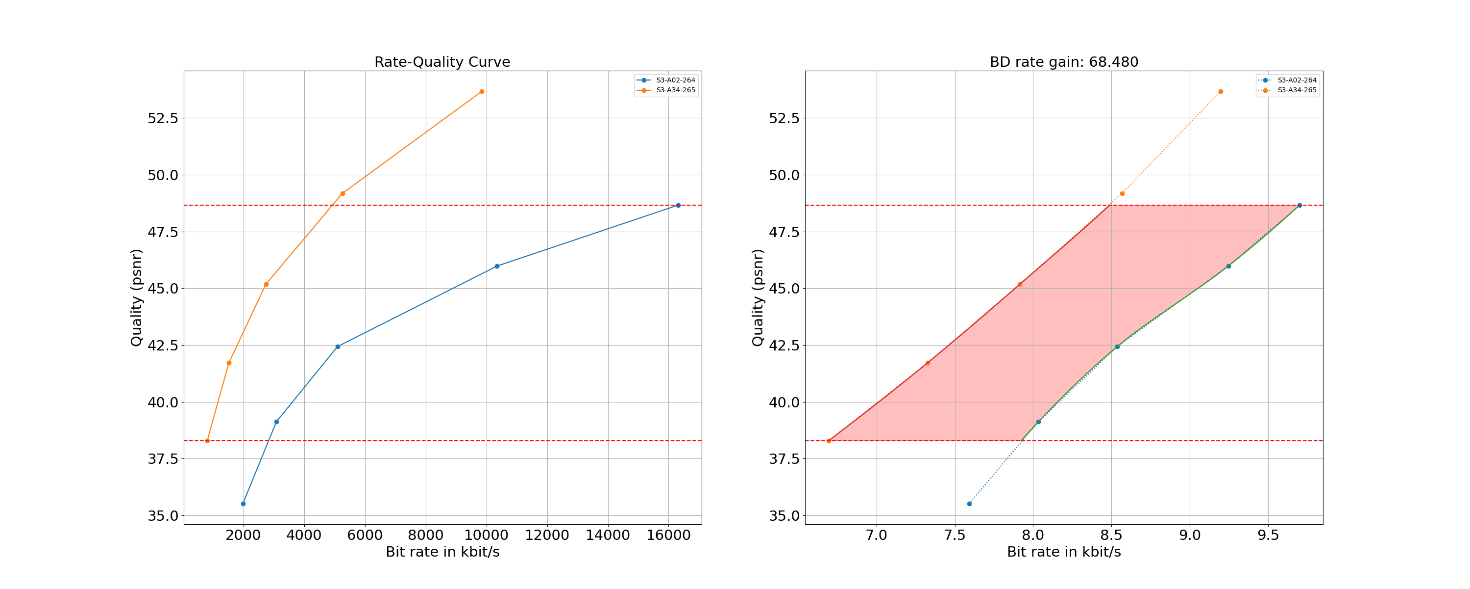
****

Figure 7.3.3.2-1 Rate-Quality curves and BD rate gain for psnr of H.265/HEVC SCC with S3-SCC-01 against H.264/AVC HM with configuration S3-JM-01 for reference sequence S3-R02

Chart, line chart, scatter chart

Description automatically generated

Figure 7.3.3.2-2 Rate-Quality curves and BD rate gain for psnr of H.265/HEVC SCC with S3-SCC-02 against H.264/AVC HM with configuration S3-JM-02 for reference sequence S3-R02

All Rate-Quality curves and BD rate gain plots are provided in the attachment as well as online here https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-3-Screen/265/Characterization/.

#### 7.3.3.3 Scenario 5: Online Gaming

This clause provides characterization of H.265/HEVC SCC mode configurations against H.264/AVC for Scenario 5 Online Gaming. In particular,

* Table 7.3.3.3-1 provides the BD rate gain of H.265/HEVC SCC with S5-SCC-01 against H.264/AVC with configuration S5-JM-01, i.e. with the online gaming scenario reference sequences and no fixed intra.
* Table 7.3.3.3-2 provides the BD rate gain of H.265/HEVC SCC with S5-SCC-02 against H.264/AVC with configuration S5-JM-02, i.e. with the online gaming scenario reference sequences with fixed Intra every second.

Table 7.3.3.3-1 BD rate gain of H.265/HEVC SCC with S5-SCC-01 against H.264/AVC with configuration S5-JM-01, i.e. with the online gaming scenario reference sequences and no fixed intra

|  |  |  |  |
| --- | --- | --- | --- |
| Reference sequence | Name | psnr | y\_psnr |
| S5-R01 | AOV | 45.222 | 44.655 |
| S5-R02 | Baolei-Man | 36.657 | 35.223 |
| S5-R03 | Baolei-Woman | 45.215 | 44.39 |
| S5-R04 | Baolei-Balloon | 52.686 | 52.667 |
| S5-R05 | Baolei-Yard | 48.304 | 48.138 |
| S5-R06 | Jianling-Temple | 25.351 | 24.617 |
| S5-R07 | Jianling-Beach | 39.339 | 36.708 |
| S5-R08 | Heroes-of-the-Storm | 33.534 | 33.181 |
| S5-R09 | Project-CARS | 42.174 | 39.129 |
| S5-R10 | World-of-WarCraft | 49.79 | 48.668 |
| S5-R11 | MineCraft | 39.332 | 34.232 |
| S5-R12 | CS-GO | 56.487 | 52.441 |
| S5-R13 | StarCraft | 46.825 | 44.493 |
| Minimum |  | 25.351 | 24.617 |
| Maximum |  | 56.487 | 52.667 |
| Average |  | 43.147 | 41.426 |

Table 7.3.3.3-2 BD rate gain of H.265/HEVC SCC with S5-SCC-02 against H.264/AVC with configuration S5-JM-02, i.e. with the online gaming scenario reference sequences and fixed intra every second

|  |  |  |  |
| --- | --- | --- | --- |
| Reference sequence | Name | psnr | y\_psnr |
| S5-R01 | AOV | 33.155 | 33.278 |
| S5-R02 | Baolei-Man | 28.04 | 27.483 |
| S5-R03 | Baolei-Woman | 35.415 | 35.378 |
| S5-R04 | Baolei-Balloon | 43.122 | 43.947 |
| S5-R05 | Baolei-Yard | 41.41 | 42.143 |
| S5-R06 | Jianling-Temple | 22.924 | 22.677 |
| S5-R07 | Jianling-Beach | 28.823 | 27.816 |
| S5-R08 | Heroes-of-the-Storm | 24.409 | 24.569 |
| S5-R09 | Project-CARS | 33.842 | 33.73 |
| S5-R10 | World-of-WarCraft | 40.435 | 39.436 |
| S5-R11 | MineCraft | 38.293 | 35.004 |
| S5-R12 | CS-GO | 43.537 | 41.488 |
| S5-R13 | StarCraft | 34.476 | 32.945 |
| Minimum |  | 22.924 | 22.677 |
| Maximum |  | 43.537 | 43.947 |
| Average |  | 34.452 | 33.838 |

As an example,

* Figure 7.3.3.3-1 provides Rate-Quality curves and BD rate gain for psnr of H.265/HEVC SCC with S5-SCC-01 against H.264/AVC HM with configuration S5-JM-01 for reference sequence S5-R01
* Figure 7.3.3.3-2 provides Rate-Quality curves and BD rate gain for psnr of H.265/HEVC SCC with S5-SCC-02 against H.264/AVC HM with configuration S5-JM-02 for reference sequence S5-R01

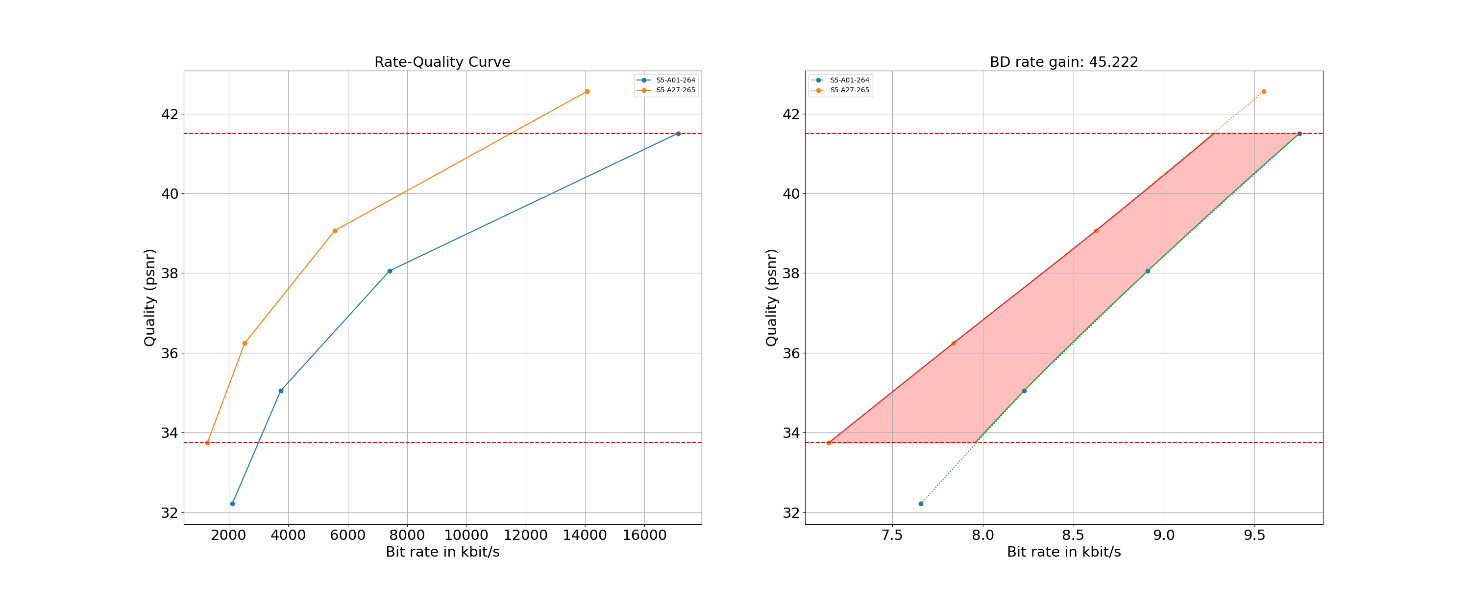
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Figure 7.3.3.3-1 Rate-Quality curves and BD rate gain for psnr of H.265/HEVC SCC with S5-SCC-01 against H.264/AVC HM with configuration S5-JM-01 for reference sequence S5-R01

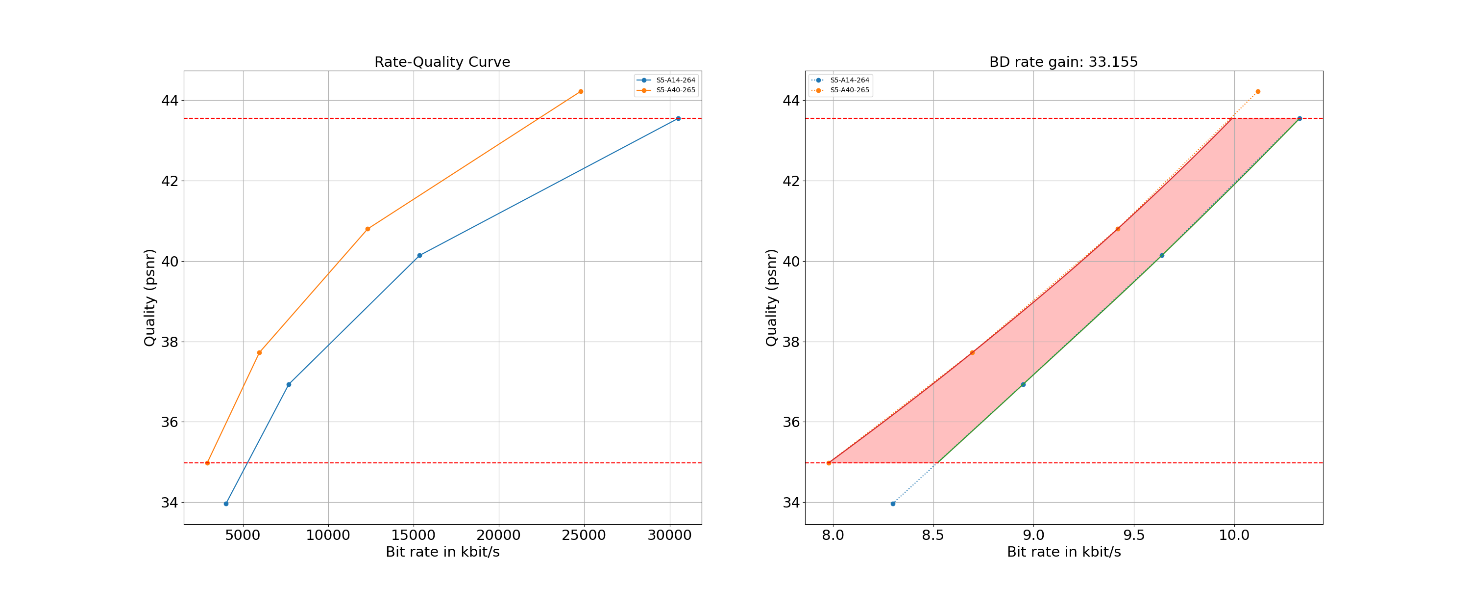


Figure 7.3.3.3-2 Rate-Quality curves and BD rate gain for psnr of H.265/HEVC SCC with S5-SCC-02 against H.264/AVC HM with configuration S5-JM-02 for reference sequence S5-R01

All Rate-Quality curves and BD rate gain plots are provided in the attachment as well as online here: https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-5-Gaming/265/Characterization/.

#### 7.3.3.4 Summary

Table 7.3.3.4-1 provides a summary of BD rate gain in psnr and vmaf of H.265/HEVC SCC against H.264/AVC for different scenarios and configurations.

Table 7.3.3.4-1 Summary of BD rate gain in psnr of H.265/HEVC SCC against H.264/AVC for different scenarios and configurations

|  |  |  |  |
| --- | --- | --- | --- |
| Scenario | average psnr | min psnr | max psnr |
| S3 no intra | 59.949 | 37.63 | 71.623 |
| S3 intra | 59.52 | 49.614 | 71.961 |
| S5 no intra | 43.147 | 25.351 | 56.487 |
| S5 intra | 34.452 | 22.924 | 43.537 |
| Minimum | 34.452 | 22.924 | 43.537 |
| Maximum | 59.949 | 49.614 | 72.961 |

## 7.4 Characterization of different HEVC modes

### 7.4.1 Introduction

This clause provides characterization results H.265/HEVC Screen-Extended Main 10 profile (referred as H.265/HEVC SCC) against H.265/HEVC Main 10 profile (referred as H.265/HEVC HM) for different scenarios and metrics.

### 7.4.2 H.265/HEVC SCC against H.265/HEVC HM

#### 7.4.2.1 Introduction

This clause provides a partial characterization of H.265/HEVC SCC against H.265/HEVC HM according to clause 7.2.1. The results provided in clause 6 are used for the characterization.

#### 7.4.2.2 Scenario 3: Screen Content

This clause provides characterization of H.265/HEVC SCC mode configurations against H.265/HEVC HM for Scenario 3 Screen Content. In particular,

* Table 7.4.2.2-1 provides the BD rate gain of H.265/HEVC SCC with S3-SCC-01/03 against H.265/HEVC HM with configuration S3-HM-01/03, i.e. with the screen content scenario reference sequences and no fixed intra.
* Table 7.4.2.2-2 provides the BD rate gain of H.265/HEVC SCC with S3-SCC-02/04 against H.265/HEVC HM with configuration S3-HM-02/04, i.e. with the screen content scenario reference sequences fixed Intra every second.

Table 7.4.2.2-1 BD rate gain of H.265/HEVC SCC with S3-SCC-01/03 against H.265/HEVC HM with configuration S3-HM-01/03, i.e. with the screen content scenario reference sequences and no fixed intra

|  |  |  |  |
| --- | --- | --- | --- |
| Reference sequence | Name | psnr | y\_psnr |
| S3-R01 | MovingText2-4K-10bit | 18.75 | 16.334 |
| S3-R02 | MovingText2-4K-8bit | 18.458 | 16.037 |
| S3-R03 | MovingText2-FullHD-10bit | 9.606 | 8.278 |
| S3-R04 | MovingText2-FullHD-8bit | 9.988 | 8.598 |
| S3-R05 | TextMixTransitions-4K-10bit | 36.167 | 33.487 |
| S3-R06 | TextMixTransitions-4K-8bit | 36.963 | 33.61 |
| S3-R07 | TextMixTransitions-FullHD-10bit | 21.62 | 18.192 |
| S3-R08 | TextMixTransitions-FullHD-8bit | 22.24 | 18.43 |
| S3-R09 | GraphicsMixSimple-4K-10bit | 38.917 | 38.001 |
| S3-R10 | GraphicsMixSimple-4K-8bit | 38.915 | 37.939 |
| S3-R11 | GraphicsMixSimple-FullHD-10bit | 21.228 | 20.088 |
| S3-R12 | GraphicsMixSimple-FullHD-8bit | 21.428 | 20.288 |
| S3-R13 | GraphicsMixTransitions-4K-10bit | 14.048 | 12.99 |
| S3-R14 | GraphicsMixTransitions-4K-8bit | 14.121 | 12.879 |
| S3-R15 | GraphicsMixTransitions-FullHD-10bit | 6.643 | 5.197 |
| S3-R16 | GraphicsMixTransitions-FullHD-8bit | 7.368 | 5.76 |
| S3-R17 | Mission-Control | 31.436 | 31.535 |
| Minimum |  | 6.643 | 5.197 |
| Maximum |  | 38.917 | 38.001 |
| Average |  | 21.641 | 19.861 |

Table 7.4.2.2-2 BD rate gain of H.265/HEVC SCC with S3-SCC-02/04 against H.265/HEVC HM with configuration S3-HM-02/04, i.e. with the screen content scenario reference sequences fixed Intra every second

|  |  |  |  |
| --- | --- | --- | --- |
| Reference sequence | Name | psnr | y\_psnr |
| S3-R01 | MovingText2-4K-10bit | 17.494 | 15.589 |
| S3-R02 | MovingText2-4K-8bit | 17.434 | 15.449 |
| S3-R03 | MovingText2-FullHD-10bit | 11.41 | 10.37 |
| S3-R04 | MovingText2-FullHD-8bit | 11.527 | 10.324 |
| S3-R05 | TextMixTransitions-4K-10bit | 45.513 | 43.613 |
| S3-R06 | TextMixTransitions-4K-8bit | 45.863 | 43.67 |
| S3-R07 | TextMixTransitions-FullHD-10bit | 30.804 | 27.888 |
| S3-R08 | TextMixTransitions-FullHD-8bit | 30.841 | 28.003 |
| S3-R09 | GraphicsMixSimple-4K-10bit | 46.169 | 45.544 |
| S3-R10 | GraphicsMixSimple-4K-8bit | 46.079 | 45.171 |
| S3-R11 | GraphicsMixSimple-FullHD-10bit | 29.294 | 28.141 |
| S3-R12 | GraphicsMixSimple-FullHD-8bit | 29.259 | 27.928 |
| S3-R13 | GraphicsMixTransitions-4K-10bit | 25.854 | 25.033 |
| S3-R14 | GraphicsMixTransitions-4K-8bit | 25.854 | 24.698 |
| S3-R15 | GraphicsMixTransitions-FullHD-10bit | 15.918 | 14.468 |
| S3-R16 | GraphicsMixTransitions-FullHD-8bit | 16.282 | 14.596 |
| S3-R17 | Mission-Control | 35.03 | 35.067 |
| Minimum |  | 11.41 | 10.324 |
| Maximum |  | 46.169 | 45.544 |
| Average |  | 28.272 | 26.797 |

As an example,

* Figure 7.4.2.2-1 provides Rate-Quality curves and BD rate gain for psnr of H.265/HEVC HM with S3-SCC-03 against H.265/HEVC HM with configuration S3-HM-03 for reference sequence S3-R01
* Figure 7.4.2.2-2 provides Rate-Quality curves and BD rate gain for psnr of H.265/HEVC SCC with S3-SCC-04 against H.265/HEVC HM with configuration S3-HM-04 for reference sequence S3-R01

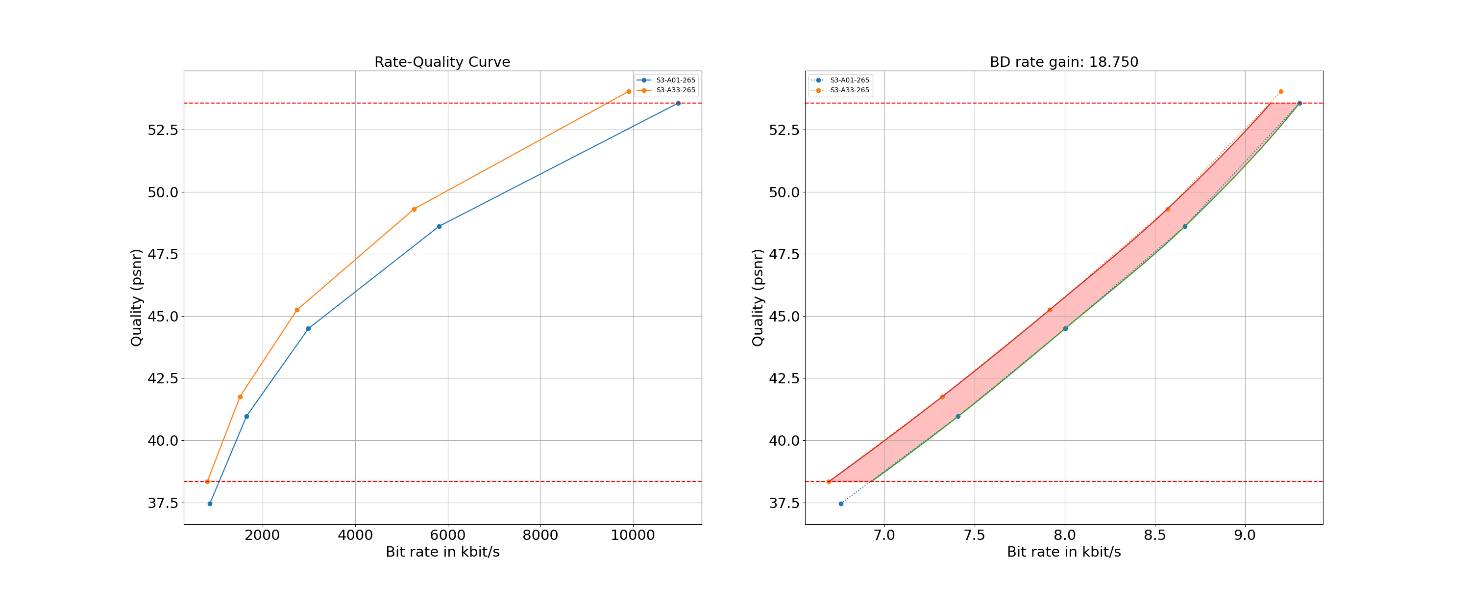
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Figure 7.4.2.2-1 Rate-Quality curves and BD rate gain for psnr of H.265/HEVC SCC with S3-SCC-03 against H.265/HEVC HM with configuration S3-HM-03 for reference sequence S3-R01

Chart, line chart

Description automatically generated

Figure 7.4.2.2-2 Rate-Quality curves and BD rate gain for psnr of H.265/HEVC SCC with S3-SCC-04 against H.265/HEVC HM with configuration S3-HM-04 for reference sequence S3-R01

All Rate-Quality curves and BD rate gain plots are provided in the attachment as well as online here https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-3-Screen/265/Characterization/.

#### 7.4.2.3 Scenario 5: Online Gaming

This clause provides characterization of H.265/HEVC SCC mode configurations against H.265/HEVC HM for Scenario 5 Online Gaming. In particular,

* Table 7.4.2.3-1 provides the BD rate gain of H.265/HEVC SCC with S5-SCC-01 against H.265/HEVC HM with configuration S5-HM-01, i.e. with the online gaming scenario reference sequences and no fixed intra.
* Table 7.4.2.3-2 provides the BD rate gain of H.265/HEVC SCC with S5-SCC-02 against H.265/HEVC HM with configuration S5-HM-02, i.e. with the online gaming scenario reference sequences and fixed intra every second.

Table 7.4.2.3-1 BD rate gain of H.265/HEVC SCC with S5-SCC-01 against H.265/HEVC HM with configuration S5-HM-01, i.e. with the online gaming scenario reference sequences and no fixed intra

|  |  |  |  |
| --- | --- | --- | --- |
| Reference sequence | Name | psnr | y\_psnr |
| S5-R01 | AOV | 0.969 | 0.742 |
| S5-R02 | Baolei-Man | 0.810 | 0.347 |
| S5-R03 | Baolei-Woman | 1.681 | 1.410 |
| S5-R04 | Baolei-Balloon | 1.037 | 0.885 |
| S5-R05 | Baolei-Yard | 0.396 | 0.245 |
| S5-R06 | Jianling-Temple | 2.768 | 2.305 |
| S5-R07 | Jianling-Beach | 4.926 | 3.967 |
| S5-R08 | Heroes-of-the-Storm | 3.485 | 3.093 |
| S5-R09 | Project-CARS | 3.603 | 2.718 |
| S5-R10 | World-of-WarCraft | 3.845 | 2.863 |
| S5-R11 | MineCraft | 16.644 | 12.514 |
| S5-R12 | CS-GO | 9.478 | 7.322 |
| S5-R13 | StarCraft | 5.461 | 3.908 |
| Minimum |  | 0.396 | 0.245 |
| Maximum |  | 16.644 | 12.514 |
| Average |  | 4.239 | 3.255 |

Table 7.4.2.3-2 BD rate gain of H.265/HEVC SCC with S5-SCC-02 against H.265/HEVC HM with configuration S5-HM-02, i.e. with the online gaming scenario reference sequences and fixed intra every second

|  |  |  |  |
| --- | --- | --- | --- |
| Reference sequence | Name | psnr | y\_psnr |
| S5-R01 | AOV | 1.487 | 1.178 |
| S5-R02 | Baolei-Man | 1.639 | 1.174 |
| S5-R03 | Baolei-Woman | 2.881 | 2.462 |
| S5-R04 | Baolei-Balloon | 1.051 | 0.918 |
| S5-R05 | Baolei-Yard | 0.347 | 0.179 |
| S5-R06 | Jianling-Temple | 2.672 | 2.272 |
| S5-R07 | Jianling-Beach | 7.148 | 6.072 |
| S5-R08 | Heroes-of-the-Storm | 4.734 | 4.452 |
| S5-R09 | Project-CARS | 4.152 | 3.105 |
| S5-R10 | World-of-WarCraft | 6.407 | 5.778 |
| S5-R11 | MineCraft | 17.150 | 13.958 |
| S5-R12 | CS-GO | 11.815 | 9.486 |
| S5-R13 | StarCraft | 7.159 | 5.729 |
| Minimum |  | 0.347 | 0.179 |
| Maximum |  | 17.150 | 13.958 |
| Average |  | 5.280 | 4.366 |

As an example,

* Figure 7.4.2.3-1 provides Rate-Quality curves and BD rate gain for psnr of H.265/HEVC SCC with S5-SCC-01 against H.265/HEVC HM with configuration S5-HM-01 for reference sequence S5-R11
* Figure 7.4.2.3-2 provides Rate-Quality curves and BD rate gain for psnr of H.265/HEVC SCC with S5-SCC-02 against H.265/HEVC HM with configuration S5-HM-02 for reference sequence S5-R11

Chart, line chart

Description automatically generated

Figure 7.4.2.3-1 Rate-Quality curves and BD rate gain for psnr of H.265/HEVC SCC with S5-SCC-01 against H.265/HEVC HM with configuration S5-HM-01 for reference sequence S5-R11

Chart, line chart

Description automatically generated

Figure 7.4.2.3-2 Rate-Quality curves and BD rate gain for psnr of H.265/HEVC SCC with S5-SCC-02 against H.265/HEVC HM with configuration S5-HM-02 for reference sequence S5-R11

All Rate-Quality curves and BD rate gain plots are provided in the attachment as well as online here: https://dash-large-files.akamaized.net/WAVE/3GPP/5GVideo/Bitstreams/Scenario-5-Gaming/265/Characterization/.

#### 7.4.2.4 Summary

Table 7.4.2.4-1 provides a summary of BD rate gain in psnr of H.265/HEVC SCC against H.265/HEVC HM for different scenarios and configurations.

Table 7.4.2.4-1 Summary of BD rate gain in psnr of H.265/HEVC SCC against H.265/HEVC HM for different scenarios and configurations

|  |  |  |  |
| --- | --- | --- | --- |
| Scenario | average psnr | min psnr | max psnr |
| S3 no intra | 21.641 | 6.643 | 38.917 |
| S3 intra | 28.272 | 11.41 | 46.169 |
| S5 no intra | 4.239 | 0.396 | 16.644 |
| S5 intra | 5.280 | 0.347 | 17.150 |
| Minimum | 4.239 | 0.347 | 16.644 |
| Maximum | 28.272 | 11.41 | 46.169 |

Editor’s Note: end of the results provided for characterization are based on intermediate non-verified numbers and primarily provide verification of the process. The numbers will be updated accordingly

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