White Paper
Blu-ray Disc™
Read-Only Format

Coding constraints on HEVC video streams for BD-ROM Version 3.0

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1 Introduction

This Whitepaper is intended to provide the coding constraints on HEVC video streams as defined in the BD-ROM specification. This information is intended to be used for the development of video encoders, not limited to BD-ROM Licensees to improve the interoperability.

HDMV HEVC video stream shall comply with the ITU-T Rec. H.265. Additional constraints on HEVC video stream are specified in this Section.

2 General Constraints

- **Profile**
  - Main 10 profile
    - `general_profile_idc` in SPS shall be set to 2.

- **Tier**
  - High Tier
    - `general_tier_flag` in SPS shall be set to 1.

- **Level**
  - Level 5.1
    - `general_level_idc` in SPS shall be set to 153.

- The following conditions shall not change in a HDMV HEVC video stream carried within the transport packets with the same PID value in a Clip AV stream file.
  - `pic_width_in_luma_samples`
  - `pic_height_in_luma_samples`
  - `aspect_ratio_idc`
  - `colour_primaries`
  - `transfer_characteristics`
  - `matrix_coeffs`
  - Frame-rate = \( \frac{\text{vui_time_scale}}{\text{vui_num_units_in_tick}} \) (Note)
  - `vui_time_scale` (Note)
  - `vui_num_units_in_tick` (Note)
  - BitRate[\( \text{cpb_cnt_minus1} \)], which is derived from `bit_rate_scale` and `bit_rate_value_minus1` in `hrd_parameters()`.
  - CpbSize[\( \text{cpb_cnt_minus1} \)], which is derived from `cpb_size_scale` and `cpb_size_value_minus1` in `hrd_parameters()`

(\textbf{Note}): It is recommended to use combination of ‘vui_num_units_in_tick’ and ‘vui_time_scale’ in the table below.

<table>
<thead>
<tr>
<th>Frame-rate [Hz]</th>
<th>vui_time_scale</th>
<th>vui_num_units_in_tick</th>
</tr>
</thead>
<tbody>
<tr>
<td>23.976</td>
<td>24000</td>
<td>1001</td>
</tr>
<tr>
<td>24</td>
<td>24000</td>
<td>1000</td>
</tr>
<tr>
<td>25</td>
<td>25000</td>
<td>1000</td>
</tr>
<tr>
<td>50</td>
<td>50000</td>
<td>1000</td>
</tr>
<tr>
<td>59.94</td>
<td>60000</td>
<td>1001</td>
</tr>
<tr>
<td>60</td>
<td>60000</td>
<td>1000</td>
</tr>
</tbody>
</table>

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• The following conditions should not change in a HDMV HEVC video stream carried within the transport packets with the same PID value in an AV stream file.
  □ overscan_info_present_flag
  □ overscan_appropriate_flag

• End of bitstream (end_of_bitstream_rbsp()) shall not occur in the HDMV HEVC video streams, except for the following case.
  □ At the end of the video access unit which contains an end_of_seq_rbsp().

• The following fields in SPS shall have the following pre-determined values.
  □ general_profile_space shall be set to “0”.
  □ sps_temporal_id_nesting_flag shall be set to “1”.
  □ colour_description_present_flag shall be set to “1”.
  □ chroma_format_idc shall be set to “1”.
  □ vui_parameters_present_flag shall be set to “1” (VUI parameters shall be present).
  □ aspect_ratio_info_present_flag in VUI parameters shall be set to “1”.
  □ vui_hrd_parameters_present_flag in VUI parameters shall be set to “1”.
  □ vui_timing_info_present_flag in VUI parameters shall be set to “1”.
  □ nal_hrd_parameters_present_flag in VUI parameters shall be set to “1”.
  □ sub_pic_hrd_params_present_flag in VUI parameters shall be set to “0”.
  □ fixed_pic_rate_general_flag in HRD parameters shall be set to “1”.
  □ overscan_appropriate_flag should be set to “0” if overscan_info_present_flag is set to 1.
  □ bit_depth_luma_minus8 shall be set to “2”.
  □ bit_depth_chroma_minus8 shall be set to “2”.

• The following fields in PPS shall have the following pre-determined values.
  □ dependent_slice_segments_enabled_flag shall be set to “0”.

• Only progressive source is used and all pictures shall be encoded as a frame.
  □ general_progressive_source_flag in SPS shall be set to “1”.
  □ general_interlaced_source_flag in SPS shall be set to “0”.
  □ general_frame_only_constraint_flag in SPS shall be set to “1”.

• The no_output_of_prior_pics_flag shall be set to “0”.

• The following fields in VPS shall have the following pre-determined values.
  □ vps_temporal_id_nesting_flag shall be set to 1.
  □ general_profile_space shall be set to 0.
  □ general_profile_idc shall be set to 2.
  □ general_tier_flag shall be set to 1.
  □ general_level_idc shall be set to 153.
  □ general_progressive_source_flag shall be set to “1”.
  □ general_interlace_source_flag shall be set to “0”.
  □ general_frame_only_constraint_flag shall be set to “1”.
  □ fixed_pic_rate_general_flag in HRD parameters, if present, shall be set to “1”.
2.1 GOP Structures

HDMV HEVC defines a GOP (Group of Pictures) structure for random access point at a reasonable time interval in the BD-ROM specification. The GOP structure is defined by:

- Picture type and reference structure
  - HDMV HEVC defines picture type and the reference structure of each picture type.
    - Picture type is defined as follows.
      - I picture: A picture that consists only of I slices, in which slice_type is set to 2. pic_type in Access unit delimiter is set to 0.
        - IDR picture and CRA picture is a type of I picture. Definition of an IDR picture and CRA picture follows ITU-T Rec. H.265.
      - P picture: A picture that consists only of P slices, in which slice_type is set to 1. pic_type in Access unit delimiter is set to 1.
      - B picture: A picture that consists only of B slices, in which slice_type is set to 0. pic_type in Access unit delimiter is set to 2.
        - Two type of B picture is defined as follows.
          - Bb picture: A B picture, in which bi-directional prediction is allowed.
          - Bu picture: A B picture, in which only uni-directional prediction is allowed.
        - (Note) The terms “Bb picture” and “Bu picture” is defined for the specification explanation purpose only. Both pictures consists only of B slices, in which slice_type is set to 0, and pic_type is set to 2.
- In case consecutive non-reference B pictures precede their reference picture in display order, they shall appear immediately after the reference picture in decoding order.
- The decoding order and display order of reference pictures (I or P or Bu pictures) shall be the same.
- The decoding order and display order of non-reference B pictures shall be the same.

Figure 2-1 and Figure 2-2 show examples of reference structure of a reference Bb picture and a non-reference Bb picture.

![Figure 2-1](image1.png)

**Figure 2-1 – Example of reference structure of a reference Bb picture**

![Figure 2-2](image2.png)

**Figure 2-2 – Example of reference structure of a non-reference Bb picture**
• Data structure
  □ The first access unit is an IDR picture or a CRA picture in a GOP in decoding order.
  □ One SPS (Sequence Parameter Set) shall be provided in the first access unit of every GOP. This SPS is referenced by all PPSs (Picture Parameter Set) in a GOP and no other SPS shall appear in a GOP, i.e. subsequent access units in a GOP shall have no SPS. An I picture which has a SPS indicates the start of a GOP (in decoding order).
  □ One VPS (Video Parameter Set) shall be provided in the first access unit of every GOP.
  □ A PPS shall be stored in the first access unit or in the access unit that refers to this PPS in a GOP with the following restrictions.
    ➢ Maximum number of PPSs that can be stored in an access unit is defined as follows.
      ° There shall be at least one and at most 30 PPSs in the first access unit in a GOP.
      ° There shall be one or zero PPSs in each access unit, except for the first access unit in a GOP
  □ Decoding delay that is indicated by sps_max_num_reorder_pics in SPS shall be equal to or less than 3 pictures (frames) period, i.e. the PTS of the first presented picture in a GOP minus the DTS of the first decoded picture in the GOP shall be less than or equal to 3 pictures period.

2.1.1 Open GOP and Closed GOP
GOP for HDMV HEVC video streams defined in the BD-ROM specification has “Open GOP” and “Closed GOP” that corresponds to GOP in ISO/IEC 13818-2 (MPEG-2 video). Closed GOP starts with an IDR picture and Open GOP starts with a CRA picture.

Closed GOP:
The first picture in decoding order is an IDR-picture. Because an IDR picture resets picture referencing over GOP boundary, all pictures in a closed-GOP can correctly be decoded even when random access to this GOP is executed.

![Figure 2-3 – Example of Closed GOP](image-url)
Open GOP:
The first picture in decoding order is a CRA picture. Because a CRA picture does not reset picture referencing over GOP boundary, pictures prior to the CRA picture in display order cannot be correctly decoded when random access to this GOP is executed.

Figure 2-4 – Example of Open GOP

2.1.2 Other constraints on GOP
HDMV HEVC video streams shall conform to the following constraints. The number of video pictures displayed in a GOP of the HDMV HEVC video stream shall be less than or equal to the maximum number as defined in Table 2-1.

<table>
<thead>
<tr>
<th>Video format</th>
<th>Frame-rate [Hz]</th>
<th>general_frame_only_constraint_flag</th>
<th>Maximum number of frames displayed in a GOP</th>
</tr>
</thead>
<tbody>
<tr>
<td>3840x2160 video format</td>
<td>23.976</td>
<td>1</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>1</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>59.94</td>
<td>1</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>1</td>
<td>60</td>
</tr>
<tr>
<td>1920x1080 video format</td>
<td>23.976</td>
<td>1</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td>1</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>50</td>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>59.94</td>
<td>1</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>1</td>
<td>60</td>
</tr>
</tbody>
</table>
2.2 NAL units in Access Unit

An access unit (AU) in HDMV HEVC video streams shall be composed of multiple of segments, each of which is carried by following NAL (Network Abstraction Layer) units.

- First access unit (AU) in a GOP shall have following NAL units in listed order.
  - An Access unit delimiter NAL unit
  - A VPS NAL unit
  - A SPS NAL unit
  - PPS NAL unit(s)
  - Prefix SEI NAL unit(s) – if exist\(^{\text{Note1}}, \text{(Note2)}, \text{(Note3)}, \text{(Note4)}\)
  - Slice segment(s) NAL units of an IDR or a CRA picture
  - Suffix SEI NAL unit(s) – if exist
  - A Filler data NAL unit – if exist\(^{\text{Note5}}\)
  - An End of sequence NAL unit – if exist
  - An End of bitstream NAL unit – if exist

- Subsequent access unit (AU) in a GOP shall have following NAL units in listed order.
  - An Access unit delimiter NAL unit
  - A PPS NAL unit – if exist
  - Prefix SEI NAL unit(s) – if exist\(^{\text{Note1}}, \text{(Note2)}, \text{(Note3)}, \text{(Note4)}\)
  - Slice segment(s) NAL units of a picture
  - Suffix SEI NAL unit(s) – if exist
  - A Filler data NAL unit – if exist\(^{\text{Note5}}\)
  - An End of sequence NAL unit – if exist
  - An End of bitstream NAL unit – if exist

\(^{\text{Note1}}\): Active parameter sets SEI message shall exist in the first AU in a GOP.
\(^{\text{Note2}}\): Buffering period SEI message shall exist in the first AU in a GOP.
\(^{\text{Note3}}\): Picture timing SEI message shall exist in every AU.
\(^{\text{Note4}}\): User data unregistered SEI message and Mastering display colour volume SEI shall be stored in a Prefix SEI NAL unit, if exist.
\(^{\text{Note5}}\): Filler data NAL unit can be placed in any position unless it precedes the first Slice segment NAL unit.
2.3 Use of temporal sub-layer
If HDMV HEVC video stream is coded with temporal scalability, fast playback can be done by decoding part of temporal sub-layers. Temporal scalability is realized by using TSA (Temporal Sub-layer Access) NAL unit. As defined in ITU-T Rec. H.265, a TSA picture and pictures following the TSA picture in decoding order do not use pictures prior to the TSA picture in decoding order with TemporalId greater than or equal to that of the TSA picture for inter prediction reference. A TSA picture enables up-switching, at the TSA picture, to the sub-layer containing the TSA picture or any higher sub-layer, from the immediately lower sub-layer. TSA pictures must have TemporalId greater than 0.

Use of temporal sub-layer is optional. Following constraints are applied if temporal sub-layer is used:

- Maximum number of temporalID is 3, i.e. sps_max_sub_layers_minus1 is 3.
- TemporalId of I, P, Bu picture shall be set to 0.

2.4 Still picture
HDMV HEVC video streams uses “HEVC still picture” defined in “13818-1:2013/AMD 3” for still picture. In addition to the above definition HDMV HEVC video streams further restricts the following conditions.

- fixed_pic_rate_general_flag shall be set to 1 in the vui_parameters() of SPS that precedes an HEVC still pictures.
- An HEVC still picture shall contain End of sequence NAL unit to terminate HEVC video streams.
- An HEVC still picture shall be a frame with frame coding.
- An HEVC still picture is repeatedly displayed until the PTS of the next AU, if present.
- Minimum PTS interval of the two consecutive still pictures is 0.5 second.
- Access unit (AU) of an HEVC still picture shall have following NAL units in listed order(Note):
  - An Access unit delimiter NAL unit
  - A VPS NAL unit
  - A SPS NAL unit
  - A PPS NAL unit
  - Prefix SEI NAL unit(s) – if exist
  - Slice segment(s) NAL units of an IDR picture
  - Suffix SEI NAL unit(s) – if exist
  - A Filler data NAL unit – if exist(Note1)
  - An End of sequence NAL unit
  - An End of bitstream NAL unit – if exist

(Note): Filler data NAL unit can be placed in any position unless it precedes the first slice NAL unit.

2.4.1 Frame-rate of still pictures
End of sequence NAL unit terminates the HEVC sequence. The display behavior of still picture is defined as follows: Display of still picture shall be kept until display of next still picture or display reset given by navigation.

Frame-rate of still picture’s video signal while being displayed is given by:

Frame-rate = vui_time_scale / vui_num_units_in_tick

where: vui_num_units_in_tick and vui_time_scale are provided in the vui_parameters of SPS that precedes a still picture.
2.5 Other constraints
For HDMV HEVC video stream, following constraints are applied.

2.5.1 Parameter limits
- Minimum size per one slice segment is 1 row of a coding tree block. A slice segment shall be composed of one or more rows of a coding tree block. A row of a coding tree block indicates all the coding tree blocks in a horizontal row of coding tree block.
- Maximum number of slice segments is 34.
- Maximum number of pictures which are stored in DPB is restricted in addition to the definition of MaxDpbSize in ITU-T Rec. H.265.
  - For 3840x2160: 6 (as defined in ITU-T Rec. H.265)
  - For 1920x1080: 6

2.5.2 Prohibited NAL unit
Following NAL units shall not be present.
  - Coded slice segment of an BLA picture NAL unit (nal_unit_type= 16, 17 or 18)

2.5.3 STD delay
Maximum of STD delay is 1 second for video stream, 60 seconds for still picture.

2.5.4 HRD conformance
HDMV HEVC video stream shall conform to Type 2 (NAL level) HRD conformance. The definition of Type2 HRD conformance is described in Annex C of the ITU-T Rec. H.265.
- It shall comply with output timing conformance.
- HRD conformance can be verified by using parameters provided in Buffering Period SEI and Picture Timing SEI. Or the PTS/DTS information in the MPEG-2 TS can also be used to obtain the timing instants to verify HRD conformance.
2.6 1920x1080 video format
This Section describes the coding constraints on 1920x1080 video format.

2.6.1 Sequence parameter set (SPS) for 1920x1080 video format
The allowed combinations of horizontal size of picture, vertical size of picture, Frame-rate derived from SPS are listed in Table 2-2.

<table>
<thead>
<tr>
<th>horizontal size of frame</th>
<th>vertical size of frame</th>
<th>pic_width_in_luma_samples</th>
<th>pic_height_in_luma_samples</th>
<th>general_frame_only_constraint_flag</th>
<th>Frame-rate</th>
<th>progressiv e/interlace</th>
</tr>
</thead>
<tbody>
<tr>
<td>1920</td>
<td>1080</td>
<td>1920</td>
<td>1080</td>
<td>1</td>
<td>60</td>
<td>progressive</td>
</tr>
<tr>
<td>1920</td>
<td>1080</td>
<td>1920</td>
<td>1088</td>
<td>1</td>
<td>60</td>
<td>progressive</td>
</tr>
<tr>
<td>1920</td>
<td>1080</td>
<td>1920</td>
<td>1080</td>
<td>1</td>
<td>59.94</td>
<td>(60000/1001)</td>
</tr>
<tr>
<td>1920</td>
<td>1080</td>
<td>1920</td>
<td>1088</td>
<td>1</td>
<td>59.94</td>
<td>(60000/1001)</td>
</tr>
<tr>
<td>1920</td>
<td>1080</td>
<td>1920</td>
<td>1080</td>
<td>1</td>
<td>50</td>
<td>progressive</td>
</tr>
<tr>
<td>1920</td>
<td>1080</td>
<td>1920</td>
<td>1088</td>
<td>1</td>
<td>50</td>
<td>progressive</td>
</tr>
<tr>
<td>1920</td>
<td>1080</td>
<td>1920</td>
<td>1080</td>
<td>1</td>
<td>25</td>
<td>progressive</td>
</tr>
<tr>
<td>1920</td>
<td>1080</td>
<td>1920</td>
<td>1088</td>
<td>1</td>
<td>25</td>
<td>progressive</td>
</tr>
<tr>
<td>1920</td>
<td>1080</td>
<td>1920</td>
<td>1080</td>
<td>1</td>
<td>24</td>
<td>progressive</td>
</tr>
<tr>
<td>1920</td>
<td>1080</td>
<td>1920</td>
<td>1088</td>
<td>1</td>
<td>24</td>
<td>progressive</td>
</tr>
<tr>
<td>1920</td>
<td>1080</td>
<td>1920</td>
<td>1080</td>
<td>1</td>
<td>23.976</td>
<td>(24000/1001)</td>
</tr>
<tr>
<td>1920</td>
<td>1080</td>
<td>1920</td>
<td>1088</td>
<td>1</td>
<td>23.976</td>
<td>(24000/1001)</td>
</tr>
</tbody>
</table>

(Note1): The 1080 lines to be encoded or where decoded video should be placed vertically in the 1920x1080 video format are shown from line 42 to line 1121.
(Note2): 1088 is the height of the encoded luma component of frame pictures in lines.

aspect_ratio_idc: The aspect_ratio_idc shall be set to 1 (square sample).

bit_rate_scale, bit_rate_value_minus1: BitRate derived from these parameters shall indicate a value that is less than or equal to 100000000 bits/second.

cpb_size_scale, cpb_size_value_minus1: CpbSize derived from those parameters shall indicate a value that is less than or equal to 100000000 bits.
**low_delay_hrd_flag:** The low_delay_hrd_flag shall be set to 0.

Allowed combinations of the following parameters for 1920x1080 video format are listed in Table 2-3.

- aspect_ratio,
- horizontal size of frame, vertical size of frame, aspect_ratio_idc,
- general_frame_only_constraint_flag, conf_win_left_offset, conf_win_right_offset,
- conf_win_top_offset, conf_win_bottom_offset

Table 2-3 – Allowed combinations of parameters for 1920x1080 video format

<table>
<thead>
<tr>
<th>aspect_ratio</th>
<th>SPS</th>
<th>pic_width_in_luma_samples</th>
<th>pic_height_in_luma_samples</th>
<th>aspect_ratio_idc</th>
<th>general_frame_only_constraint_flag</th>
<th>conf_win_left_offset</th>
<th>conf_win_right_offset</th>
<th>conf_win_top_offset</th>
<th>conf_win_bottom_offset</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 (16:9 aspect ratio)</td>
<td>1920</td>
<td>1080</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1920</td>
<td>1088</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4</td>
</tr>
</tbody>
</table>

### 2.6.2 Colour description for 1920x1080 video format

**colour primaries:** The colour_primaries is set to 1 for ITU-R BT.709 for SDR, and 9 for ITU-R BT.2020 (Note) for SDR and HDR.

**transfer_characteristics:** The transfer_characteristics shall be set to 1 for ITU-R BT.709, and 14 for ITU-R BT.2020 (Note) for SDR. This value shall be set to 16 for HDR.

**matrix_coeffs:** The matrix_coeffs is set to 1 for ITU-R BT.709 for SDR, and 9 for ITU-R BT.2020 (Note) for SDR and HDR.

*(Note):* As for BT.2020, non-constant luminance shall be used.

If the video_signal_type_present_flag is set to 1, the video_full_range_flag shall be set to 0.

### 2.6.3 Location of chroma samples

For ITU-R BT.709 (colour primaries is set to 1), chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field shall be set to 0 or 2 if chroma_loc_info_present_flag is set to 1. If chroma_loc_info_present_flag is set to 0, the location of chroma sample is type 0 and chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field are both inferred to be equal to 0.

For ITU-R BT.2020 (colour primaries is set to 9), chroma_loc_info_present_flag shall be set to 1 and chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field shall be set to 2.

chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field shall have the same value.
2.7 3840x2160 video format
This Section describes the coding constraints on 3840x2160 video format.

2.7.1 Sequence parameter set (SPS) for 3840x2160 video format
The allowed combinations of horizontal size of picture, vertical size of picture, Frame-rate derived from SPS are listed in Table 2-4.

<table>
<thead>
<tr>
<th>horizontal size of frame</th>
<th>vertical size of frame</th>
<th>pic_width_in_luma_samples</th>
<th>pic_height_in_luma_samples</th>
<th>general_frame_only_constraint_flag</th>
<th>Frame-rate</th>
<th>progressiv e/interlace</th>
</tr>
</thead>
<tbody>
<tr>
<td>3840</td>
<td>2160</td>
<td>3840</td>
<td>2160</td>
<td>1</td>
<td>60</td>
<td>progressive</td>
</tr>
<tr>
<td>3840</td>
<td>2160</td>
<td>3840</td>
<td>2160</td>
<td>1</td>
<td>59.94 (60000/1001)</td>
<td>progressive</td>
</tr>
<tr>
<td>3840</td>
<td>2160</td>
<td>3840</td>
<td>2160</td>
<td>1</td>
<td>50</td>
<td>progressive</td>
</tr>
<tr>
<td>3840</td>
<td>2160</td>
<td>3840</td>
<td>2160</td>
<td>1</td>
<td>25</td>
<td>progressive</td>
</tr>
<tr>
<td>3840</td>
<td>2160</td>
<td>3840</td>
<td>2160</td>
<td>1</td>
<td>24</td>
<td>progressive</td>
</tr>
<tr>
<td>3840</td>
<td>2160</td>
<td>3840</td>
<td>2160</td>
<td>1</td>
<td>23.976 (24000/1001)</td>
<td>progressive</td>
</tr>
</tbody>
</table>

aspect_ratio_idc: The aspect_ratio_idc shall be set to 1 (square sample).

bit_rate_scale, bit_rate_value_minus1: BitRate derived from these parameters shall indicate a value that is less than or equal to 100000000 bits/second.

cpb_size_scale, cpb_size_value_minus1: CpbSize derived from those parameters shall indicate a value that is less than or equal to 100000000 bits.

low_delay_hrd_flag: The low_delay_hrd_flag shall be set to 0.

Allowed combinations of the following parameters for 3840x2160 video format are listed in Table 2-5.

- aspect_ratio,
- horizontal size of frame, vertical size of frame, aspect_ratio_idc,
- general_frame_only_constraint_flag, conf_win_left_offset, conf_win_right_offset,
- conf_win_top_offset, conf_win_bottom_offset

<table>
<thead>
<tr>
<th>aspect_ratio</th>
<th>SPS</th>
<th>horizontal size of frame</th>
<th>vertical size of frame</th>
<th>aspect_ratio_idc</th>
<th>general_frame_only_constraint_flag</th>
<th>conf_win_left_offset</th>
<th>conf_win_right_offset</th>
<th>conf_win_top_offset</th>
<th>conf_win_bottom_offset</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 (16:9 aspect ratio)</td>
<td>3840</td>
<td>2160</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
2.7.2 Colour description for 3840x2160 video format

**colour primaries**: The colour_primaries is set to 1 for ITU-R BT.709 for SDR, and 9 for ITU-R BT.2020 (Note) for SDR and HDR.

**transfer_characteristics**: The transfer_characteristics shall be set to 1 for ITU-R BT.709, and 14 for ITU-R BT.2020 (Note) for SDR. This value shall be set to 16 for HDR.

**matrix_coeffs**: The matrix_coeffs is set to 1 for ITU-R BT.709 for SDR, and 9 for ITU-R BT.2020 (Note) for SDR and HDR.

(Note): As for BT.2020, non-constant luminance shall be used.

If the video_signal_type_present_flag is set to 1, the video_full_range_flag shall be set to 0.

2.7.3 Location of chroma samples

For ITU-R BT.709 (colour primaries is set to 1), chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field shall be set to 0 or 2 if chroma_loc_info_present_flag is set to 1. If chroma_loc_info_present_flag is set to 0, the location of chroma sample is type 0 and chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field are both inferred to be equal to 0.

For ITU-R BT.2020 (colour primaries is set to 9), chroma_loc_info_present_flag shall be set to 1 and chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field shall be set to 2.

chroma_sample_loc_type_top_field and chroma_sample_loc_type_bottom_field shall have the same value.

3 HDR video format

Dynamic range of video is defined as the difference between the brightest whites and the darkest blacks in the image. HDR (High Dynamic Range) increases maximum luminance to reproduce bright images such as sunlight, reflections. Increased maximum luminance allows reproduction of images with higher contrast than traditional SDR (Standard Dynamic Range) images in which maximum luminance has typically been set up to 100 cd/m².

The BD-ROM specification defines BDMV HDR video formats. The BDMV HDR is the HDR video format which is mandatory for player in the BD-ROM specification.

3.1 BDMV HDR

The BDMV HDR is characterized by the following constraints.

- BDMV HDR video stream shall be HDMV HEVC video stream specified in ITU-T Rec. H.265.
- colour primaries shall be BT.2020 with non-constant luminance.
- transfer_characteristics shall be SMPTE 2084 EOTF.

4 SDR video format

The SDR video format is characterized by the following constraints.

- SDR video stream shall be HDMV MPEG-4 AVC video stream or HDMV HEVC video stream.
- colour primaries shall be BT.709 or BT.2020 with non-constant luminance for HDMV HEVC video stream and shall be BT.709 for HDMV MPEG-4 AVC video stream.
- transfer_characteristics in VUI parameters shall be set to 1 for ITU-R BT.709, and 14 for ITU-R BT.2020.
5 Allowed combination of video attributes for HDMV HEVC video stream

This section describes video attributes (resolution, colour primaries, transfer characteristics, and bit depth) for HDMV HEVC video streams. Allowed combinations of video attributes are defined in Table 5-1.

<table>
<thead>
<tr>
<th>horizontal size of frame</th>
<th>vertical size of frame</th>
<th>colour_premaries</th>
<th>transfer_characteristics</th>
<th>bit depth</th>
<th>content type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1920</td>
<td>1080</td>
<td>1 (BT.709)</td>
<td>1</td>
<td>10</td>
<td>SDR</td>
</tr>
<tr>
<td>1920</td>
<td>1080</td>
<td>9 (BT.2020)</td>
<td>14</td>
<td>10</td>
<td>SDR</td>
</tr>
<tr>
<td>1920</td>
<td>1080</td>
<td>9 (BT.2020)</td>
<td>16 (ST 2084)</td>
<td>10</td>
<td>BDMV HDR</td>
</tr>
<tr>
<td>3840</td>
<td>2160</td>
<td>1 (BT.709)</td>
<td>1</td>
<td>10</td>
<td>SDR</td>
</tr>
<tr>
<td>3840</td>
<td>2160</td>
<td>9 (BT.2020)</td>
<td>14</td>
<td>10</td>
<td>SDR</td>
</tr>
<tr>
<td>3840</td>
<td>2160</td>
<td>9 (BT.2020)</td>
<td>16 (ST 2084)</td>
<td>10</td>
<td>BDMV HDR</td>
</tr>
</tbody>
</table>

6 HEVC video stream decoder model

In case an input to TB (Transport buffer) is an HEVC video stream, the BDAV-STD decodes the input in the same way as T-STD defined in ISO/IEC 13818-1. For transferring the HEVC video stream data from MB (Multiplexing buffer) to EB (Elementary stream buffer), ISO/IEC 13818-1 defines two methods: the leak method and HRD. It is restricted that the BDAV-STD shall use the leak method for transferring the HEVC video stream data from MB to EB. (The BDAV-STD shall not use the HRD for the transfer of data from MB to EB).
6.1 BDAV-STD model parameter limits

This parameter limits for BDAV-STD model for the HEVC video stream decoder are defined in Table 6-1.

<table>
<thead>
<tr>
<th>Notation</th>
<th>Meaning</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>R_{x1}</td>
<td>Leak rate from TB1 for HEVC video stream</td>
<td>1.1<em>100</em>10^6 [bits/second]</td>
</tr>
<tr>
<td>R_{ox1}</td>
<td>Leak rate from MB1 for HEVC video stream</td>
<td>1.0<em>100</em>10^6 [bits/second]</td>
</tr>
<tr>
<td>MB1</td>
<td>Multiplexing buffer for HEVC stream</td>
<td>73333 [bytes]</td>
</tr>
<tr>
<td>EB1</td>
<td>Elementary stream buffer for HEVC stream</td>
<td>12500000 [bytes]</td>
</tr>
<tr>
<td>DPB1</td>
<td>Decoded picture buffer for HEVC stream</td>
<td>93312000 [bytes]</td>
</tr>
</tbody>
</table>

7 HEVC video streams constraints for seamless connection

1) The following conditions shall not change in the HEVC video streams in Clip AV streams (TS1 and TS2) with seamless connection.
   - general_profile_idc
   - general_tier_flag
   - general_level_idc
   - pic_width_in_luma_samples
   - pic_height_in_luma_samples
   - aspect_ratio_idc
   - Frame-rate = vui_time_scale / vui_num_units_in_tick
   - BitRate[cpb_cnt_minus1], which is derived from bit_rate_scale and bit_rate_value_minus1.
   - CpbSize[cpb_cnt_minus1], which is derived from cpb_size_scale and cpb_size_value_minus1.
   - colour primaries
   - transfer_characteristics
   - matrix_coeffs
2) Video data in TS1 shall terminate with end of sequence (end_of_sequence_rbsp()).
3) Video data in TS2 shall start with VPS, SPS, PPS(s), and an IDR picture.
4) The video presentation units (frame) defined in the bit-stream shall be continuous across the connection. There shall be neither gap nor overlap in the presentation at the connection.
5) The video access units defined in the bit-stream shall be continuous across the connection. There shall be neither gap nor overlap in the decoding process at the connection.
6) The decoding delay of TS1 shall be the same as the decoding delay of TS2. Here, "decoding delay means the PTS of the first presented picture in a GOP minus the DTS of the first decoded picture in the GOP."