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Recommendation ITU-R BT.2073-2
(01/2022)

**Use of high efficiency video coding
for UHD TV and HDTV broadcasting
applications**

BT Series
Broadcasting service
(television)



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SM	Spectrum management
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Note: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.

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RECOMMENDATION ITU-R BT.2073-2

**Use of high efficiency video coding
for UHD TV and HDTV broadcasting applications**

(Question ITU-R 12-3/6)

(2015-2020-2022)

Scope

This Recommendation specifies the use of the high efficiency video coding (HEVC) standard as per Recommendation ITU-T H.265 | ISO/IEC 23008-2 for ultra high definition television (UHDTV) and high definition television (HDTV) broadcasting including high-dynamic range television (HDR-TV).

Keywords

UHDTV, HDR-TV, HDTV, sub-layer coding, parallel coding, sub-bit-stream

The ITU Radiocommunication Assembly,

considering

- a) that there are applications where UHDTV, HDR-TV and HDTV programme material is desired to be transported at a highly reduced bit rates with minimal visible degradation in quality;
- b) that Recommendation ITU-R BT.2020 specifies the parameters for a family of UHDTV video formats;
- c) that Recommendation ITU-R BT.2100 specifies the parameters for HDR-TV video formats;
- d) that Recommendation ITU-R BT.709 specifies the parameters for a family of HDTV video formats;
- e) that Recommendation ITU-T H.265 | ISO/IEC 23008-2 specifies the high efficiency video coding (HEVC) standard that enables significantly improved compression performance relative to former standards;
- f) that HEVC is increasingly adopted for various applications including broadcasting,

recommends

that when it is necessary to transport or record UHDTV, HDR-TV and HDTV programme material at a highly reduced bit rate for broadcasting, the high efficiency video coding (HEVC) standard specified in Recommendation ITU-T H.265 | ISO/IEC 23008-2 should be used.

NOTE 1 – Annex 1 shows basic parameters for UHDTV and HDTV broadcasting including HDR-TV using the HEVC standard.

NOTE 2 – Annex 2 shows a preferred coding scheme for the temporal sub-layer coding of UHDTV at 120 and 100 Hz frame frequencies using the HEVC standard.

NOTE 3 – Annex 3 shows a preferred coding scheme for interlaced video using the HEVC standard.

NOTE 4 – Annex 4 shows a preferred parallel coding scheme for the 7 680 × 4 320 format of UHDTV using the HEVC standard.

Abbreviations

CVS	Coded Video Sequence
DTS	Decoding Time Stamp
GOP	Group of Pictures
HDR	High Dynamic Range
IRAP	Intra Random Access Point
PTS	Presentation Time Stamp
SEI	Supplemental Enhancement Information

Annex 1

Basic parameters for UHD TV and HDTV broadcasting applications including HDR-TV, using the HEVC standard

This Annex shows basic parameters for UHD TV and HDTV broadcasting applications using the HEVC standard.

TABLE 1

Basic parameters for UHD TV and HDTV broadcasting emissions using HEVC standard⁽¹⁾

Video format		Level	Profile	Tier	Maximum bit rate ⁽⁵⁾ (Mbit/s)
Spatial resolution	Frame frequency (Hz)				
7 680 × 4 320	120 ⁽²⁾ , 100 ⁽³⁾	6.2	Main 10	Main	90-120
	60 ⁽²⁾ , 50	6.1	Main 10	Main	80-100
3 840 × 2 160	120 ⁽²⁾ , 100 ⁽³⁾	5.2	Main 10	Main	35-50
	60 ⁽²⁾ , 50	5.1	Main 10	Main	30-40
1 920 × 1 080	60 ⁽²⁾ , 50	4.1	Main 10 or Main	Main	10-15
	30 ⁽²⁾ , 25 (interlaced)	4.1 ⁽⁴⁾	Main 10 or Main	Main	10-15

⁽¹⁾ Video parameters of HDR-TV, including colour primaries and transfer characteristics, can be signalled using the VUI (video usability information) specified in Annex E of ITU T H.265 | ISO/IEC 23008-2.

⁽²⁾ Those divided by 1.001 are also included.

⁽³⁾ The use of temporal sub-layer coding is detailed in Annex 2.

⁽⁴⁾ To enable coding at a sufficient bit rate as needed, level 4.1 (the maximum bit rate is 20 Mbit/s) is preferred to level 4 (the maximum bit rate is 12 Mbit/s).

⁽⁵⁾ The data rates indicated are maximum values for a constant data rate transport for critical test sequences to be rated sufficiently high quality for broadcast emission when assessed by experts. Lower data rates may be used for less critical pictures.

TABLE 2

Basic parameters for UHD TV contribution, primary distribution and ENG using HEVC standard⁽¹⁾

Video format		Level	Profile	Tier	Maximum bit rate ⁽³⁾ (Mbit/s)
Spatial resolution	Frame frequency (Hz)				
7 680 × 4 320	120 ⁽²⁾ , 100	6.2	Main 422 10 or Main 10	High	285 ⁽⁴⁾
	60 ⁽²⁾ , 50	6.1	Main 422 10 or Main 10	High	285
3 840 × 2 160	120 ⁽²⁾ , 100	5.2	Main 422 10 or Main 10	High	145 ⁽⁴⁾
	60 ⁽²⁾ , 50	5.1	Main 422 10 or Main 10	High	145
1 920 × 1 080	60 ⁽²⁾ , 50	4.1	Main 10 or Main	High	30
	30 ⁽²⁾ , 25 (interlaced)	4.1	Main 10 or Main	High	30

⁽¹⁾ Video parameters of HDR-TV, including colour primaries and transfer characteristics, can be signalled using the VUI specified in Annex E of ITU T H.265 | ISO/IEC 23008-2.

⁽²⁾ Those divided by 1.001 are also included.

⁽³⁾ The data rates indicated are values for the constant data rate for critical test sequences to be rated sufficiently high quality for three codecs in tandem when assessed by experts. Lower data rates may be used for less critical pictures. See Recommendation ITU-R BT.1872.

⁽⁴⁾ Required data rates for 120 and 100 Hz are assumed to be similar to those for 60 and 50 Hz.

TABLE 3

Basic parameters for UHD TV programme production and exchange using HEVC standard⁽¹⁾

Video format		Level	Profile	Tier	Maximum bit rate ⁽²⁾ (Mbit/s)
Spatial resolution	Frame frequency (Hz)				
7 680 × 4 320	120 ⁽³⁾ , 100	6.2	Main 422 10 or Main 10	High	600 ⁽⁴⁾
	60 ⁽³⁾ , 50	6.1 or 6.2 ⁽⁵⁾	Main 10	High	600
		6.1	Main 422 10		

TABLE 3 (*end*)

Video format		Level	Profile	Tier	Maximum bit rate ⁽²⁾ (Mbit/s)
Spatial resolution	Frame frequency (Hz)				
3 840 × 2 160	120 ⁽³⁾ , 100	5.2	Main 422 10 or Main 10	High	200 ⁽⁴⁾
	60 ⁽³⁾ , 50	5.1 or 5.2 ⁽⁶⁾	Main 10	High	200
		5.1	Main 422 10		

- ⁽¹⁾ Video parameters of HDR-TV, including colour primaries and transfer characteristics, can be signalled using the VUI specified in Annex E of ITU T H.265 | ISO/IEC 23008-2.
- ⁽²⁾ The data rates indicated are values for the constant data rate for critical test sequences to be rated sufficiently high quality for programme production and exchange when assessed by experts. Lower data rates may be used for less critical pictures.
- ⁽³⁾ Those divided by 1.001 are also included.
- ⁽⁴⁾ Required data rates for 120 and 100 Hz are assumed to be similar to those for 60 and 50 Hz.
- ⁽⁵⁾ When the bit rate is more than 480 Mbit/s, Level 6.2 is required.
- ⁽⁶⁾ When the bit rate is more than 160 Mbit/s, Level 5.2 is required.

Annex 2

Preferred coding scheme for temporal sub-layer coding for UHD TV at 120¹ or 100 Hz frame frequency using the HEVC standard

This Annex shows a preferred coding scheme to achieve temporal sub-layer coding for UHD TV at 120 or 100 Hz frame frequency using the HEVC standard.

Introduction

The purpose of this preferred coding scheme is to enable a decoder with the decoding capability of Level 6.1 (or 5.1) bitstream for 60 or 50 Hz video to correctly decode the 60 or 50 Hz portion of a Level 6.2 (or 5.2) bitstream for 120 or 100 Hz video. Such decoding capability is realized by temporal sub-layer coding specified in the HEVC standard.

To maximize the adaptability of a Level 6.1 (or 5.1) decoder to a Level 6.2 (or 5.2) temporal sub-layer coding bitstream, a further constraint on decoding order is introduced in such a way that the DTS/PTS value of an access unit in Level 6.1 (or 5.1) sub-bitstream can be applied both to Level 6.2 (or 5.2) bitstream decoding and Level 6.1 (or 5.1) sub-bitstream decoding.

Temporal sub-layer coding

Every second frame of a 120 or 100 Hz video is encoded into an access unit of a sub-bitstream. All the other frames of the 120 or 100 Hz video are encoded into access units in a subset.

¹ Also includes 120/1.001.

A Level 6.1 (or 5.1) decoder decodes the sub-bitstream and outputs decoded frames with the frame frequency of 60 or 50 Hz.

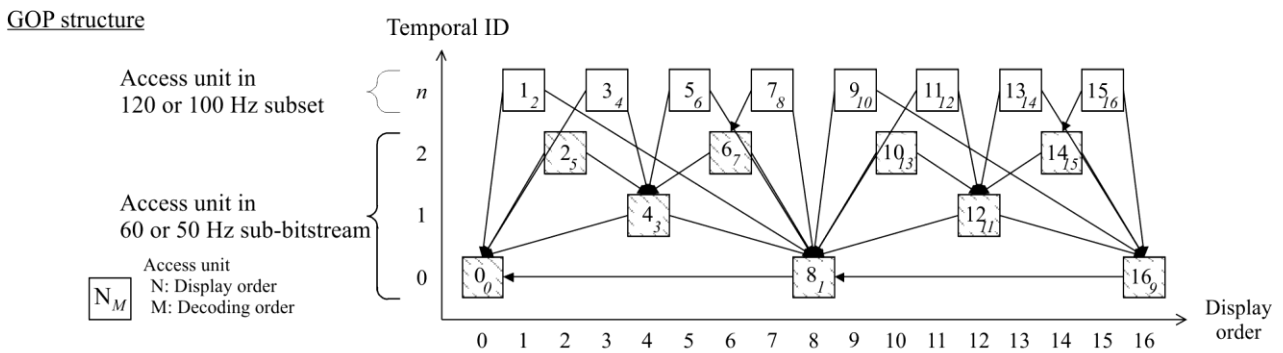
A Level 6.2 (or 5.2) decoder decodes both the sub-bitstream and the subset and outputs decoded frames with the frame frequency of 120 Hz.

Constraint on decoding order

It is mandated that the decoding order of each access unit in the sub-bitstream and each access unit in the subset shall be interleaved. That is, an access unit in the sub-bitstream is decoded immediately after an access unit in the subset, and vice versa.

Figure 1 shows an example of the decoding order of an access unit in a Level 6.2 (or 5.2) temporal sub-layer coding bitstream. It is noted that there is no need to overwrite the values of `au_cpb_removal_delay_minus1` and `pic_dpb_output_delay` of an access unit in the sub-bitstream for decoding the sub-bitstream in a Level 6.1 (or 5.1) decoder. That is, a nested picture timing SEI message is not needed.

FIGURE 1
Constraint on decoding order for temporal sub-layer coding bitstream



In L6.2 or 5.2 decoder

Output frame rate: 120 or 100 Hz

Decoding order of access unit

0 ₀	8 ₁	1 ₂	4 ₃	3 ₄	2 ₅	5 ₆	6 ₇	7 ₈	16 ₉	9 ₁₀	12 ₁₁	11 ₁₂	10 ₁₃	13 ₁₄	14 ₁₅	15 ₁₆	
(au_cpb_removal_delay_minus 1 + 1) of access unit	-	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
pic_dpb_output_delay of access unit	4	10	2	4	2	0	2	2	2	10	2	4	2	0	2	2	2

Output order of access unit

0 ₀	1 ₂	2 ₅	3 ₄	4 ₃	5 ₆	6 ₇	7 ₈	8 ₁	9 ₁₀	10 ₁₃	11 ₁₂	12 ₁₁	13 ₁₄	14 ₁₅	15 ₁₆	16 ₉
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In L6.1 or 5.1 decoder

Output frame rate: 60 or 50 Hz

Decoding order of access unit

0 ₀	8 ₁	4 ₃	2 ₅	6 ₇	16 ₉	12 ₁₁	10 ₁₃	14 ₁₅	
(au_cpb_removal_delay_minus 1 + 1) of access unit	-	2	4	6	8	10	12	14	16
pic_dpb_output_delay of access unit	4	10	4	0	2	10	4	0	2

Output order of access unit

0 ₀	2 ₅	4 ₃	6 ₇	8 ₁	10 ₁₃	12 ₁₁	14 ₁₅	16 ₉
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Annex 3 (informative)

Preferred coding scheme for interlaced video using the HEVC standard

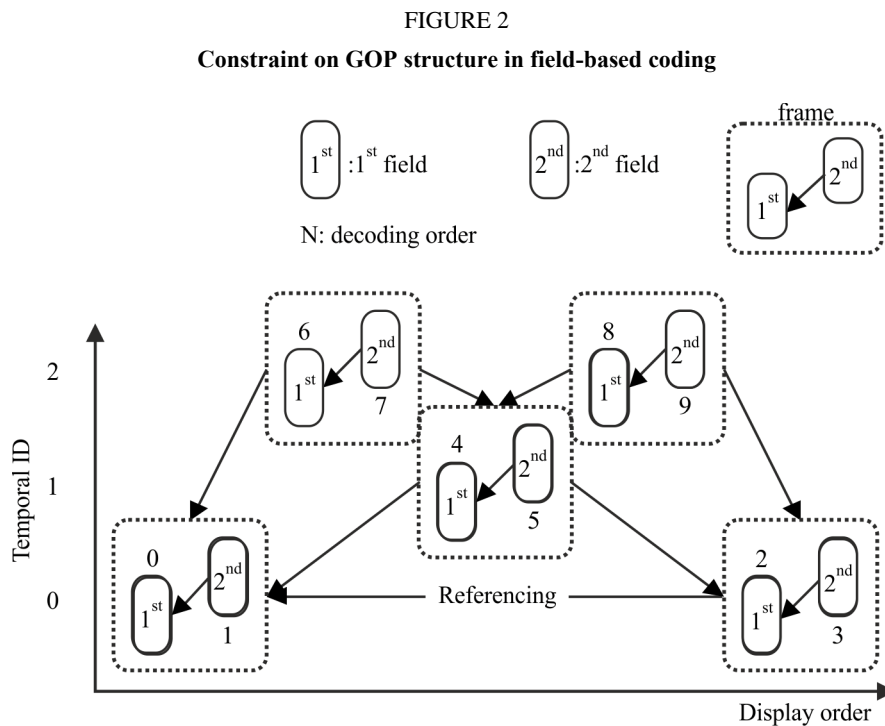
This Annex shows a preferred coding scheme for interlaced video using the HEVC standard.

Introduction

The preferred coding scheme in this Annex utilizes the coding capability for interlaced video of the HEVC standard. That is, either frame-based coding or field-based coding is used in each CVS. If a CVS is encoded by field-based coding (i.e. `field_seq_flag` equal to 1), constraints described below are imposed. Otherwise, if a CVS is encoded by frame-based coding (i.e. `field_seq_flag` is equal to 0), no further constraints are imposed.

Constraint on GOP structure

It is mandated that the first and second field pictures shall be encoded successively if the two fields are contained in the same frame. Figure 2 shows an example of the GOP structure according to the constraint of this Annex. It is noted that any field in a frame can refer to any previously decoded fields in other frames.



Constraint on IRAP access unit

Since the HEVC standard does not allow encoding a trailing picture access unit before any leading picture access unit that has an earlier display order than the trailing picture access unit, the following constraint is imposed to satisfy the constraint on the GOP structure described above.

When a leading picture access unit appears in a bitstream, an IRAP picture access unit shall appear only at the beginning of a CVS.

To have frequent random access points, multiple access units associated with a recovery point SEI message may be present in a CVS. In this case, it is encouraged to encode a CVS in such a way that `recovery_poc_cnt` and `exact_match_flag` of the recovery point SEI message can be set equal to 0 and 1, respectively.

Annex 4 (informative)

Preferred parallel coding scheme for the 7 680 × 4 320 format of UHD TV using the HEVC standard

This Annex shows a preferred parallel coding scheme for the 7 680 × 4 320 format of UHD TV using the HEVC standard.

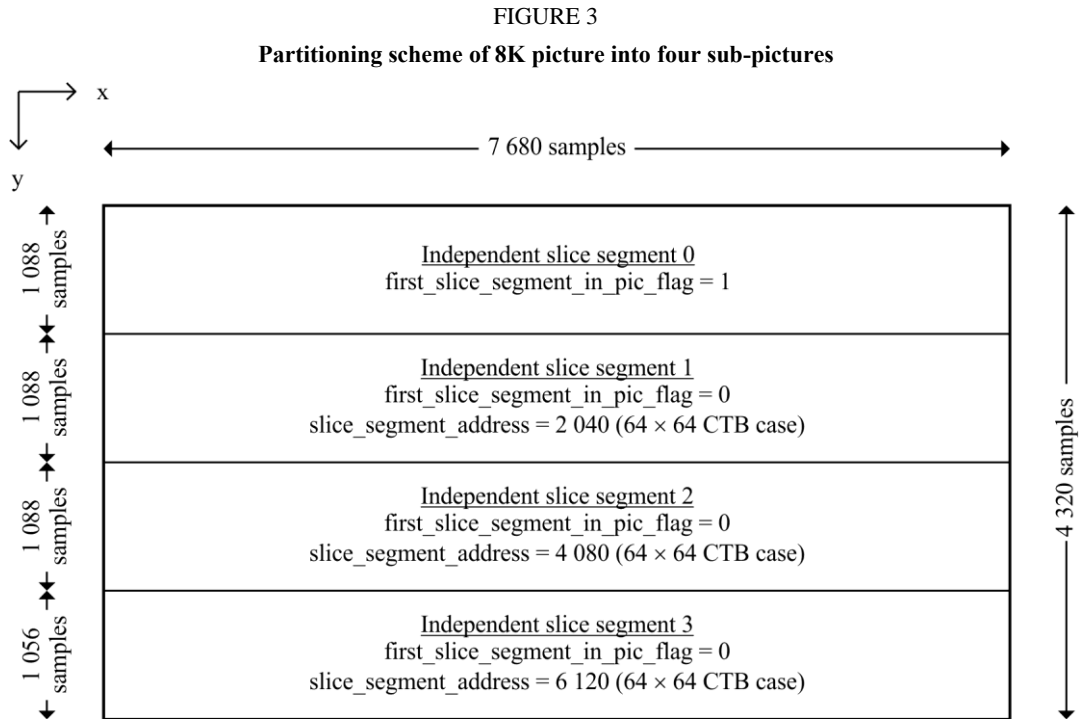
Introduction

Considering the latest technology trends in the broadcasting industry, it is strongly hoped that real-time HEVC decoder of 4K video will be implemented on a single-chip LSI in a short period. On the other hand, it is envisaged that it will take another 5-10 years to realize a single-chip LSI that can decode 8K video in real-time. Therefore the structure of an HEVC bitstream of 8K video shall be defined so that it can be decoded by using multiple 4K HEVC LSIs.

This preferred coding scheme for 8K video adopts a parallel coding scheme. An 8K picture is equally partitioned into four sub-pictures. To minimize the loss in coding efficiency caused by the partitioning, sharing reference pictures among sub-pictures and enabling in-loop filters at the boundary of sub-pictures are mandated.

Sub-picture partitioning

An 8K picture is partitioned into four sub-pictures. Each sub-picture is encoded by each processing core as an independent slice segment with the parameters shown in Fig. 3. Each slice segment may be further portioned into multiple slices.



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Constraints on parameters

The constraints on parameters in Table 4 are applied.

TABLE 4

Constraints on parameters for slice-based sub-picture partitioning

Parameter	Constraint
pic_width_in_luma_samples	7 680
pic_height_in_luma_samples	4 320
first_slice_segment_in_pic_flag slice_segment_address	Values shown in Fig. 3
pps_loop_filter_across_slices_enabled_flag slice_loop_filter_across_slices_enabled_flag	1
tiles_enabled_flag	0 NOTE – Tile-based partition is not recommended since the vertical partitioning of tile causes significant loss in coding efficiency at typical scenes in programmes that have a large horizontal motion when each processing core shares a limited amount of reference samples for motion compensation.

TABLE 4 (end)

Parameter	Constraint
The range of the vertical component of a motion vector that crosses a slice boundary	<p>It shall be constrained in such a way that any prediction block in an independent slice segment does not refer to samples in a different independent slice segment whose vertical position relative to the boundary of two independent slices is outside the range of $(-128, 128)$ for a luma sample and $(-64, 64)$ for a chroma sample (in the case of 4:2:0 chroma subsampling).</p> <p>See Fig. 4 for detailed explanation.</p> <p>NOTE – This constraint is introduced to reduce additional bandwidth between processing cores while maintaining coding efficiency at typical scenes in programmes.</p>

FIGURE 4

Constraints on motion vectors crossing the slice boundary

