



JCTVC-N0141

AHG5: on chroma QP for HEVC RExt

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Chroma QP in RExt

■ QPC derived from QPY as follows

● Computes intermediate qPi from QPY

- $qPiCb = \text{Clip3}(-QpBdOffsetC, 57, QPY + pic_cb_qp_offset + slice_cb_qp_offset)$
- $qPiCr = \text{Clip3}(-QpBdOffsetC, 57, QPY + pic_cr_qp_offset + slice_cr_qp_offset)$

● Derive QPC from qPi using a look-up table

● 3 tables $QP_c = f(qPi)$ specified in current Rext draft, 1 for each chroma format 4:2:0, 4:2:2, 4:4:4

Table 8-9 – Specification of QP_c as a function of qPi and ChromaArrayType

ChromaArrayType = 1 4:2:0	qPi	< 30	30	31	32	33	34	35	36	37	38	39	40	41	42	43	> 43
	QP_c	= qPi	29	30	31	32	33	33	34	34	35	35	36	36	37	37	= qPi - 6

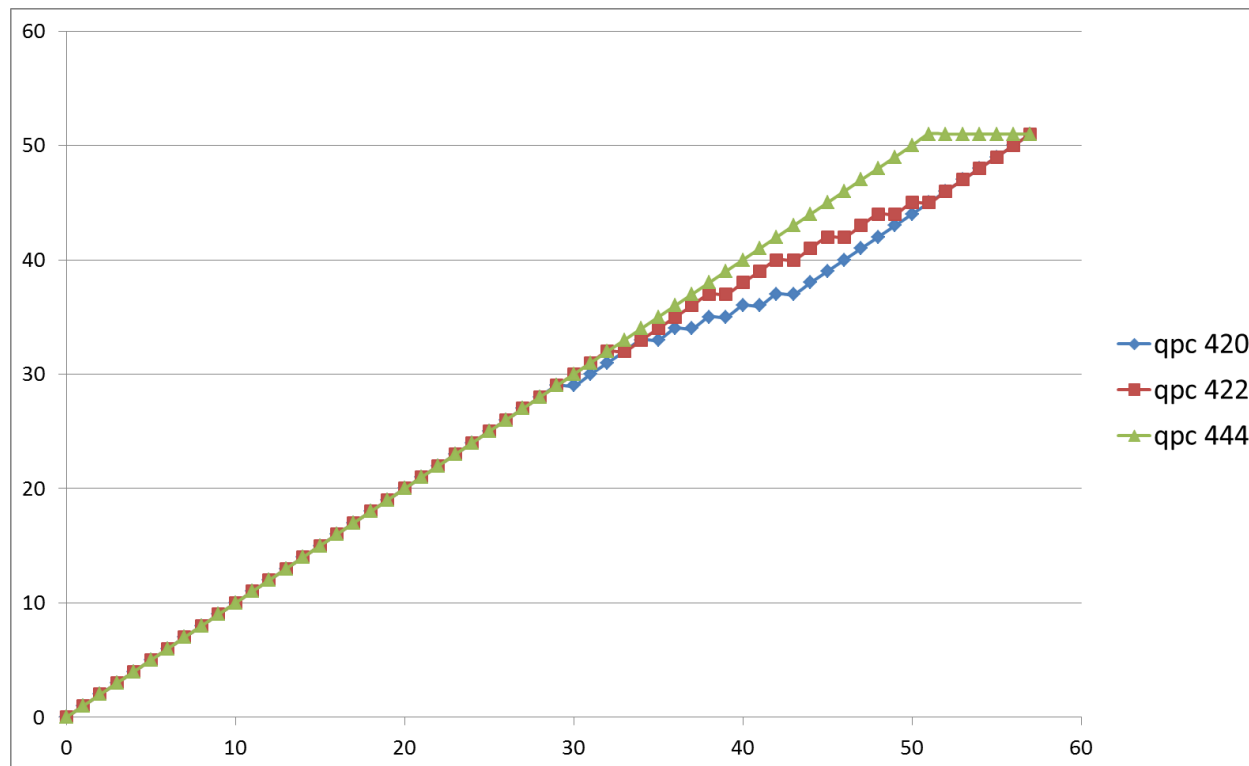
ChromaArrayType = 2 4:2:2	qPi	< 33	$33 \leq qPi < 39$			39	40	41	42	43	44	45	46	47	48	49	50	> 50
	QP_c	= qPi	= (qPi - 1)			37	38	39	40	40	41	42	42	43	44	44	45	= qPi - 6

ChromaArrayType = 3 4:4:4	qPi	< 51	≥ 51
	QP_c	= qPi	51

Chroma QP in RExt

■ Remarks

- Table 4:2:0 already in HEVC V1
- Table 4:4:4 is straightforwardly derived (clipped version of qPi)
- Table 4:2:2 is new
- Same table used for 4:4:4 RGB and 4:4:4 YUV – no flexibility



Performance analysis

- Evaluation of the 3 tables for each of the chroma formats
- 3 types of measures
 - Usual BDR computed for each component, using the global bit-rate measures
 - BDR computed using average YUV PSNR over the 3 components
 - (YUV 4:2:0: $W_Y=6/8$, $W_U=1/8$, $W_V=1/8$)
 - YUV 4:2:2: $W_Y=1$, $W_U=1$, $W_V=1$
 - YUV 4:4:4: $W_Y=6/10$, $W_U=2/10$, $W_V=2/10$
 - RGB 4:4:4: $W_Y=6/14$, $W_U=4/14$, $W_V=4/14$
 - BDR computed for each component, using separate-channel bit-rate measures → expected to better reflect the BD-rate variations for each component

Performance analysis – YUV 4:2:2 content

YUV 4:2:2	All Intra Main-tier				All Intra High-tier			
	Y	U	V	YUV	Y	U	V	YUV
table 4:2:0	1.8%	-3.7%	-4.9%	-0.3%	0.3%	-0.5%	-0.7%	0.0%
table 4:2:2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
table 4:4:4	-0.3%	1.0%	1.1%	0.2%	0.0%	0.0%	0.0%	0.0%
	Random Access Main-tier				Random Access High-tier			
	Y	U	V	YUV	Y	U	V	YUV
table 4:2:0	1.3%	-5.4%	-5.8%	-0.8%	0.4%	-1.0%	-1.3%	-0.1%
table 4:2:2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
table 4:4:4	-0.9%	3.7%	3.5%	0.3%	-0.2%	0.4%	0.5%	0.0%
	Low delay B Main-tier				Low delay B High-tier			
	Y	U	V	YUV	Y	U	V	YUV
table 4:2:0	0.8%	-4.3%	-4.5%	-0.8%	0.2%	-0.6%	-0.9%	-0.1%
table 4:2:2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
table 4:4:4	-1.0%	5.2%	5.3%	0.6%	-0.3%	0.7%	0.8%	0.1%

global bitrate

YUV 4:2:2	All Intra Main-tier				All Intra High-tier			
	Y	U	V	YUV	Y	U	V	YUV
table 4:2:0	0.0%	-0.2%	-0.4%	-0.3%	0.0%	-0.1%	0.0%	0.0%
table 4:2:2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
table 4:4:4	0.0%	0.1%	0.1%	0.2%	0.0%	0.0%	0.0%	0.0%
	Random Access Main-tier				Random Access High-tier			
	Y	U	V	YUV	Y	U	V	YUV
table 4:2:0	0.2%	-1.8%	-1.8%	-0.8%	0.1%	-0.3%	-0.3%	-0.1%
table 4:2:2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
table 4:4:4	-0.2%	-0.4%	-0.4%	0.3%	0.0%	-0.2%	-0.3%	0.0%
	Low delay B Main-tier				Low delay B High-tier			
	Y	U	V	YUV	Y	U	V	YUV
table 4:2:0	0.2%	-1.9%	-2.0%	-0.8%	0.1%	-0.3%	-0.3%	-0.1%
table 4:2:2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
table 4:4:4	-0.2%	-0.3%	-0.2%	0.6%	-0.1%	-0.2%	-0.3%	0.1%

separate channel bitrate

YUV 4:2:2	Average 3 Cfgs (QPs 32,37,42)			Average 3 Cfgs for QP42		
	Y	U	V	Y	U	V
table 4:2:0	87.6%	7.3%	5.1%	86.1%	8.0%	5.9%
table 4:2:2	91.0%	5.2%	3.8%	91.6%	4.7%	3.7%
table 4:4:4	92.7%	4.2%	3.1%	94.4%	3.1%	2.6%

per-channel bitrate repartition

weight YUV	Y	U	V
RGB 4:4:4	1	1	1
YCbCr 4:4:4	6	4	4
YCbCr 4:2:2	6	2	2

Performance analysis – YUV 4:2:2 content

- Luma loss/gain well balanced by chroma gain/loss
- Limited bitrate variations by using other tables

→ Other tables than 4:2:2 table can be used without noticeable impact

Performance analysis – YUV 4:4:4 content

YUV 4:4:4	All Intra Main-tier				All Intra High-tier			
	Y	U	V	YUV	Y	U	V	YUV
table 4:2:0	3.7%	-3.5%	-4.8%	-0.8%	0.6%	-0.6%	-0.8%	-0.1%
table 4:2:2	0.5%	-0.8%	-0.9%	-0.2%	0.0%	0.0%	0.0%	0.0%
table 4:4:4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Random Access Main-tier				Random Access High-tier			
	Y	U	V	YUV	Y	U	V	YUV
table 4:2:0	4.5%	-6.1%	-6.6%	-0.8%	1.3%	-1.2%	-1.5%	-0.1%
table 4:2:2	2.0%	-3.0%	-3.0%	-0.2%	0.5%	-0.5%	-0.5%	0.0%
table 4:4:4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Low delay B Main-tier				Low delay B High-tier			
	Y	U	V	YUV	Y	U	V	YUV
table 4:2:0	4.1%	-6.0%	-7.3%	-1.3%	1.1%	-1.2%	-1.7%	-0.3%
table 4:2:2	2.3%	-4.0%	-4.9%	-0.8%	0.6%	-0.7%	-1.0%	-0.2%
table 4:4:4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

global bitrate

YUV 4:4:4	All Intra Main-tier				All Intra High-tier			
	Y	U	V	YUV	Y	U	V	YUV
table 4:2:0	0.1%	-0.1%	-0.3%	-0.8%	0.0%	0.0%	0.0%	-0.1%
table 4:2:2	0.0%	-0.1%	-0.1%	-0.2%	0.0%	0.0%	0.0%	0.0%
table 4:4:4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Random Access Main-tier				Random Access High-tier			
	Y	U	V	YUV	Y	U	V	YUV
table 4:2:0	1.0%	-1.5%	-0.4%	-0.8%	0.4%	-0.4%	0.1%	-0.1%
table 4:2:2	0.4%	0.3%	0.7%	-0.2%	0.1%	0.1%	0.3%	0.0%
table 4:4:4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Low delay B Main-tier				Low delay B High-tier			
	Y	U	V	YUV	Y	U	V	YUV
table 4:2:0	1.3%	-1.7%	-0.9%	-1.3%	0.4%	-0.5%	-0.1%	-0.3%
table 4:2:2	0.6%	-0.2%	0.4%	-0.8%	0.2%	0.0%	0.2%	-0.2%
table 4:4:4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

separate channel bitrate

YUV 4:4:4	Average 3 Cfgs (QPs 32,37,42)			Average 3 Cfgs for QP42		
	Y	U	V	Y	U	V
table 4:2:0	77.1%	12.6%	10.2%	75.2%	13.4%	11.4%
table 4:2:2	82.5%	9.6%	7.9%	83.9%	8.6%	7.5%
table 4:4:4	85.6%	7.9%	6.5%	89.0%	5.9%	5.2%

per-channel bitrate repartition

weight YUV	Y	U	V
RGB 4:4:4	1	1	1
YCbCr 4:4:4	6	4	4
YCbCr 4:2:2	6	2	2

Performance analysis – YUV 4:4:4 content

- 4:2:2 and 4:2:0 table provides good luma/chroma gain balance (rather neutral)
- Bitrate variations by using 4:2:0 table noticeable on U and V

→ 4:2:0/4:2:2 tables could be used alternatively to 4:4:4 table

Performance analysis – RGB 4:4:4 content

RGB 4:4:4	All Intra Main-tier				All Intra High-tier			
	Y	U	V	YUV	Y	U	V	YUV
table 4:2:0	8.0%	-1.5%	-1.5%	0.9%	1.3%	-0.2%	-0.2%	0.2%
table 4:2:2	1.1%	-0.2%	-0.3%	0.1%	0.0%	0.0%	0.0%	0.0%
table 4:4:4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Random Access Main-tier				Random Access High-tier			
	Y	U	V	YUV	Y	U	V	YUV
table 4:2:0	15.6%	-1.8%	-0.3%	3.3%	3.7%	-0.6%	0.2%	0.8%
table 4:2:2	6.0%	-0.6%	-0.5%	1.4%	1.1%	-0.1%	-0.1%	0.2%
table 4:4:4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Low delay B Main-tier				Low delay B High-tier			
	Y	U	V	YUV	Y	U	V	YUV
table 4:2:0	17.0%	-1.9%	0.0%	3.6%	3.9%	-0.7%	0.3%	0.9%
table 4:2:2	8.7%	-0.5%	-0.5%	2.3%	1.8%	0.0%	-0.1%	0.4%
table 4:4:4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

global bitrate

RGB 4:4:4	All Intra Main-tier				All Intra High-tier			
	Y	U	V	YUV	Y	U	V	YUV
table 4:2:0	0.3%	0.4%	0.4%	0.9%	0.0%	0.3%	0.1%	0.2%
table 4:2:2	0.0%	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%
table 4:4:4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Random Access Main-tier				Random Access High-tier			
	Y	U	V	YUV	Y	U	V	YUV
table 4:2:0	4.4%	0.6%	1.5%	3.3%	1.1%	0.1%	0.4%	0.8%
table 4:2:2	1.7%	0.5%	1.2%	1.4%	0.3%	0.1%	0.2%	0.2%
table 4:4:4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	Low delay B Main-tier				Low delay B High-tier			
	Y	U	V	YUV	Y	U	V	YUV
table 4:2:0	5.1%	0.8%	2.4%	3.6%	1.1%	0.2%	0.5%	0.9%
table 4:2:2	2.6%	1.1%	2.1%	2.3%	0.5%	0.3%	0.4%	0.4%
table 4:4:4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

separate channel bitrate

RGB 4:4:4	Average 3 Cfgs (QPs 32,37,42)			Average 3 Cfgs for QP42		
	Y	U	V	Y	U	V
table 4:2:0	31.6%	40.5%	27.8%	31.5%	36.4%	32.1%
table 4:2:2	39.7%	34.4%	25.9%	44.2%	28.0%	27.9%
table 4:4:4	45.9%	30.3%	23.8%	54.7%	22.0%	23.3%

per-channel bitrate repartition

weight YUV	Y	U	V
RGB 4:4:4	1	1	1
YCbCr 4:4:4	6	4	4
YCbCr 4:2:2	6	2	2

Performance analysis – RGB 4:4:4 content

- Noticeable losses observed when using other tables than the 4:4:4 table

→ 4:4:4 table is the most relevant one for RGB 4:4:4

Proposals

	Proposals	Comments
1	Add a Syntax Element to enable the table selection <ul style="list-style-type: none">• SPS or PPS level	<ul style="list-style-type: none">• Flexibility: more flexibility to control the chroma QP depending on the content.• For 4:4:4 case: enables to select the right table depending if format is RGB or YUV• For 4:2:2 case: can choose the right table depending on colour content
2	Remove table 4:2:2 <ul style="list-style-type: none">• enforce YUV 4:2:2 to use 4:2:0 or 4:4:4 table	<ul style="list-style-type: none">• Simplification: use only existing HEVC V1 table + straightforward 4:4:4 table• light impact in coding performance for 4:2:2 content
3	Combining proposals 1 & 2	<ul style="list-style-type: none">• Simplification & Flexibility

Syntax changes in Proposal 3 (proposal 2 very similar)

- Add a syntax element **chroma_420_not_used_flag** in the SPS, signaled in case of 4:4:4 or 4:2:2 chroma format, indicating which table is used.

seq_parameter_set_rbsp() {	Descriptor
...	
chroma_format_idc	ue(v)
if(chroma_format_idc == 3)	
separate_colour_plane_flag	u(1)
if(ChromaArrayType > 1)	
chroma_420_not_used_flag	u(1)
...	
}	

chroma_420_not_used_flag specifies the chroma look-up table used to derive the chroma quantization parameters from the luma quantization parameter. When chroma_420_not_used_flag is equal to 1, the second one of tables 8-9 is used. When chroma_420_not_used_flag is equal to 0, the first one of tables 8-9 is used. When not present, chroma_420_not_used_flag is set equal to 0.

Conclusions

- **Simplification:** only the straightforward 4:4:4 table is added in the HEVC RExt version compared to the HEVC V1 version.
- **Flexibility:** the addition of a syntax element to select one table among the defined RExt tables gives more flexibility to control the chroma QP, depending on the content.
 - This can be in particular of interest for YUV 4:2:2 or YUV 4:4:4 content, which may benefit of using the 4:2:0 table instead of the 4:4:4 one.
 - In addition, chroma QP can still be controlled by SEs `cr/cb_qp_offset` (picture and slice level).