JCTVC-M0111

AHG5: on chroma QP for HEVC RExt

E. Francois, P. Onno, G. Laroche, C.Gisquet

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Chroma QP in RExt

- **QPC derived from QPY as follows**
  - Computes intermediate qPi from QPY
    - qPiCb = Clip3(−QpBdOffsetC, 57, QPY + pic_cb_qp_offset + slice_cb_qp_offset)
    - qPiCr = Clip3(−QpBdOffsetC, 57, QPY + pic_cr_qp_offset + slice_cr_qp_offset)

  - Derive QPC from qPi using a look-up table

  - 3 tables QPc=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 ≤ 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
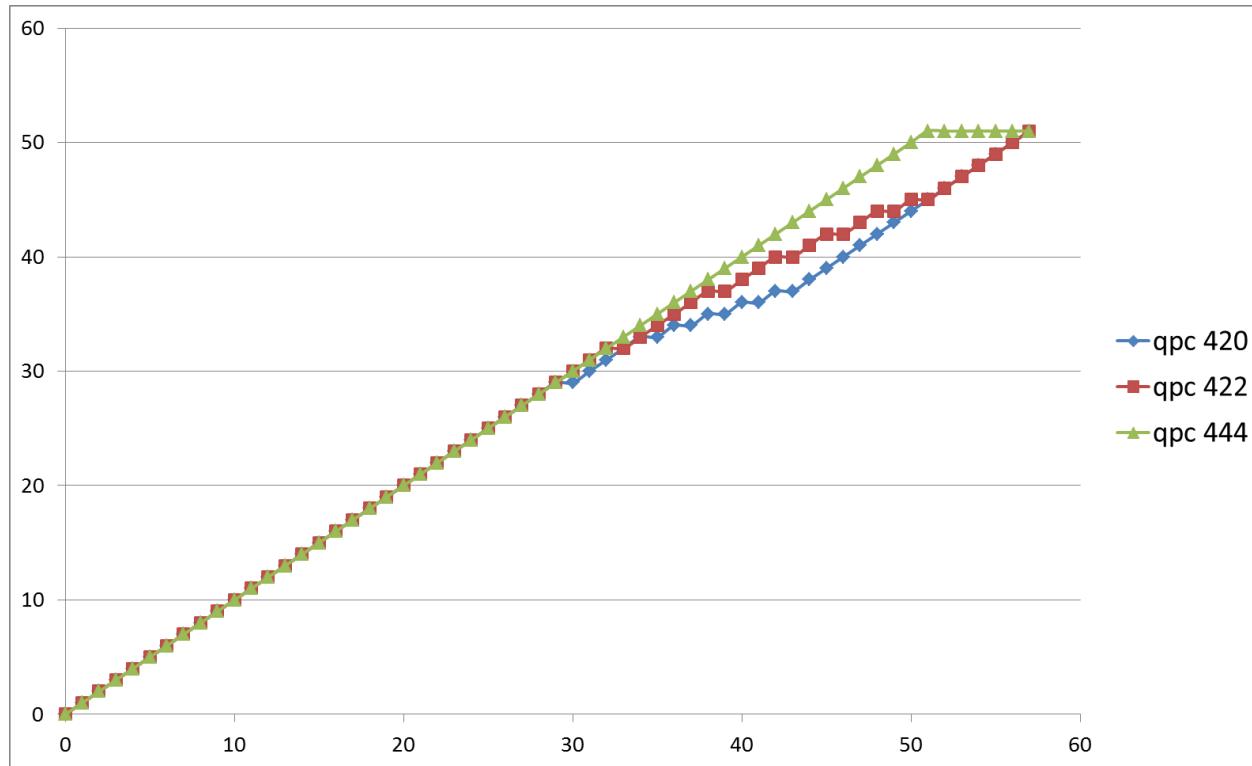
Performance analysis

- 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

  - Average YUV gain, by averaging PSNR over the 3 components
    based on weights (6,1,1)/8 proposed in JCTVC-F386 for YUV 4:2:0
    - YUV 4:2:2 : $(W_Y, W_U, W_V) = (6, 2, 2) / 10$
    - YUV 4:4:4 : $(W_Y, W_U, W_V) = (6, 4, 4) / 14$
    - RGB 4:4:4 : $(W_G, W_R, W_B) = (1, 1, 1) / 3$

  - New BDR computed for each component, using separate-channel bit-rate measures → expected to better reflect the BD-rate variations for each component

  - Cross-checked by Qualcomm (JCTVC-M420)

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Performance analysis – YUV 4:2:2 content

■ Evaluation of tables 4:2:0 and 4:4:4

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	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%	-0.9%	-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%	3.6%	3.6%	**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	0.9%	-4.2%	-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%	5.3%	5.3%	**0.7%**	-0.3%	0.7%	0.8%	**0.1%**

separate channel bitrate

YUV 4:2:2	All Intra Main-tier			All Intra High-tier			
	Y	U	V	Y	U	V	
table 4:2:0	**0.0%**	**-0.2%**	**-0.4%**	0.0%	-0.1%	0.0%	
table 4:2:2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
table 4:4:4	**0.0%**	**0.1%**	**0.1%**	0.0%	0.0%	0.0%	

	Random Access Main-tier			Random Access High-tier			
	Y	U	V	Y	U	V	
table 4:2:0	**0.2%**	**-1.7%**	**-1.9%**	0.1%	-0.3%	-0.3%	
table 4:2:2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
table 4:4:4	**-0.2%**	**-0.4%**	**-0.4%**	0.0%	-0.2%	-0.3%	

	Low delay B Main-tier			Low delay B High-tier			
	Y	U	V	Y	U	V	
table 4:2:0	**0.2%**	**-1.9%**	**-2.1%**	0.1%	-0.2%	-0.3%	
table 4:2:2	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
table 4:4:4	**-0.2%**	**-0.2%**	**-0.3%**	0.0%	-0.2%	-0.3%	

benefits

neutral

losses

Luma loss/gain well balanced by chroma gain/loss

→ Other tables than 4:2:2 table can be used

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Performance analysis – YUV 4:4:4 content

- Evaluation of tables 4:2:0 and 4:2:2

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	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%**

YUV 4:4:4	Random Access Main-tier				Random Access High-tier			
	Y	U	V	YUV	Y	U	V	YUV
table 4:2:0	4.5%	-6.0%	-6.5%	**-0.7%**	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%**

YUV 4:4:4	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%**

separate channel bitrate

YUV 4:4:4	All Intra Main-tier			All Intra High-tier		
	Y	U	V	Y	U	V
table 4:2:0	**0.1%**	**-0.1%**	**-0.3%**	0.0%	0.0%	0.0%
table 4:2:2	**0.0%**	**-0.1%**	**-0.1%**	0.0%	0.0%	0.0%
table 4:4:4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

	Random Access Main-tier			Random Access High-tier		
	Y	U	V	Y	U	V
table 4:2:0	**1.0%**	**-1.4%**	**-0.3%**	0.4%	-0.3%	0.1%
table 4:2:2	**0.4%**	**0.3%**	**0.7%**	0.1%	0.1%	0.3%
table 4:4:4	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	Y	U	V
table 4:2:0	**1.3%**	**-1.7%**	**-0.9%**	0.4%	-0.5%	-0.1%
table 4:2:2	**0.6%**	**-0.2%**	**0.4%**	0.2%	0.0%	0.2%
table 4:4:4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Legend:
- benefits
- neutral
- losses

4:2:2 table leads to losses in per-channel measures
4:2:0 table provides good luma/chroma gain balance
→ 4:2:0 table can be used alternatively to 4:4:4 table

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Performance analysis – RGB 4:4:4 content

- Evaluation of tables 4:2:0 and 4:2:2

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	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%	-0.2%	**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%**

separate channel bitrate

RGB 4:4:4	All Intra Main-tier			All Intra High-tier		
	Y	U	V	Y	U	V
table 4:2:0	0.3%	0.4%	0.4%	0.0%	0.3%	0.1%
table 4:2:2	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%
table 4:4:4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

	Random Access Main-tier			Random Access High-tier		
	Y	U	V	Y	U	V
table 4:2:0	4.4%	0.6%	1.6%	1.2%	0.1%	0.4%
table 4:2:2	1.6%	0.5%	1.2%	0.3%	0.1%	0.2%
table 4:4:4	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	Y	U	V
table 4:2:0	5.1%	0.8%	2.4%	1.1%	0.2%	0.5%
table 4:2:2	2.6%	1.1%	2.1%	0.5%	0.3%	0.4%
table 4:4:4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

- benefits
- neutral
- losses

Noticeable losses observed when using other tables than the 4:4:4 table
→ 4:4:4 table most relevant for RGB 4:4:4

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Conclusions from performance analysis

- **4:2:2 table does not look really necessary**
  - not adapted for YUV 4:4:4 or RGB 4:4:4
  - 4:2:0 or 4:4:4 tables can be used for YUV 4:2:2 content

- **It can be interesting to allow switching between 4:2:0 and 4:4:4 tables**
  - Especially for YUV 4:4:4 and YUV 4:2:2

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Proposal 1

- Keep only 2 chroma QP tables, namely the 4:2:0 and 4:4:4 tables
- By default, in case of 4:2:2 or 4:4:4 content, the 4:4:4 table is used.

- Comments:
  - design simplification by removing of 1 table
  - minor impact in coding performance for 4:2:2 content
    - small benefits by using 4:4:4 table, 4:2:0 table more neutral
    - in any case QP offset can be used for finer chroma QP control
      - qPiCb = Clip3($-$QpBdOffsetC, 57, QPY + pic_cb_qp_offset + slice_cb_qp_offset)
      - qPiCr = Clip3($-$QpBdOffsetC, 57, QPY + pic_cr_qp_offset + slice_cr_qp_offset)

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Proposal 2

■ Add a syntax element **chroma_420_not_used_flag** (currently in SPS, could be in PPS), 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.

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Conclusions

- **Simplification: removal of 4:2:2 table**
  only the straightforward 4:4:4 table is added in the HEVC RExt version compared to the HEVC V1 version.

- **Flexibility: addition of a syntax element** to select one table among the 4:2:0 and 4:4:4 tables gives more flexibility to control the chroma QP, depending on the content.
  - 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 be controled by SEs   cr/cb_qp_offset (picture and slice level).

- Software joint to contribution, cross-checked by Qualcomm (JCTVC-M420)

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