JCTVC-M0111

AHG5: on chroma QP for HEVC RExt

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JCT-VC 13th Meeting, Incheon, April 2013

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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
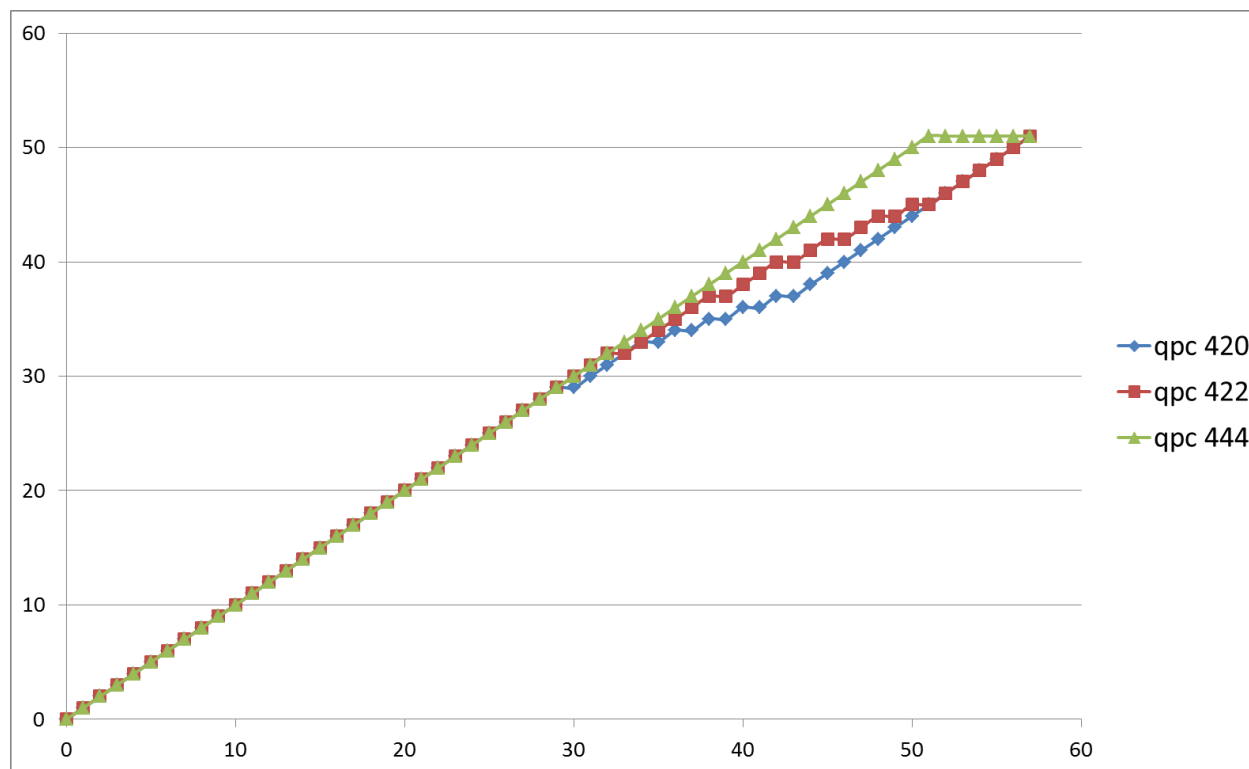
Performance analysis

■ 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
    - 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: $W_Y=6/14$, $W_U=4/14$, $W_V=4/14$

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

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Performance analysis – YUV 4:2:2 content

- Evaluation of existing tables for other chroma formats

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%	**-2.1%**	0.3%	-0.5%	-0.7%	**-0.3%**
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%	**0.5%**	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%	**-2.6%**	0.4%	-0.9%	-1.3%	**-0.5%**
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%	**1.5%**	-0.2%	0.4%	0.5%	**0.2%**
	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%	**-2.2%**	0.2%	-0.6%	-0.9%	**-0.3%**
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%	**2.2%**	-0.3%	0.7%	0.8%	**0.3%**

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
in particular 4:4:4 table looks OK
→ Other tables than 4:2:2 table can be used

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Performance analysis – YUV 4:4:4 content

- Evaluation of existing tables for other chroma formats

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%	**-1.5%**	0.6%	-0.6%	-0.8%	**-0.3%**
table 4:2:2	0.5%	-0.8%	-0.9%	**-0.4%**	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%	-6.0%	-6.5%	**-1.9%**	1.3%	-1.2%	-1.5%	**-0.4%**
table 4:2:2	2.0%	-3.0%	-3.0%	**-0.7%**	0.5%	-0.5%	-0.5%	**-0.1%**
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%	**-2.4%**	1.1%	-1.2%	-1.7%	**-0.6%**
table 4:2:2	2.3%	-4.0%	-4.9%	**-1.4%**	0.6%	-0.7%	-1.0%	**-0.3%**
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%	

- benefits
- neutral
- losses

4:2:2 table leads to losses
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 existing tables for other chroma formats

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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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
  - light impact in coding performance for 4:2:2 content – in any QP offset can be used for finer chroma QP control

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Proposal 2

■ 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)
...	
}	

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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 the 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.

  - 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.

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Annex

■ **Usage of separate-channel bit-rate measures**

- Example: Traffic_2560x1600_30_10bit_422_crop using 4:4:4 ChromaQP table

global bitrate

	Joint YUV	Y	U	V	Joint YUV	Y	U	V		Non separate	
22	17206	41.82	41.47	44.93	17206	41.82	41.47	44.93	-1.4%	4.6%	5.0%
27	5456	38.85	39.33	42.78	5456	38.85	39.33	42.78			
32	2214	36.01	37.95	41.13	2140	36.01	37.71	40.84			
37	990	33.21	36.49	39.42	977	33.20	36.16	39.06			

separate channel bitrate

	Separate Y anchor	Separate U anchor	Separate V anchor	Separate Y test	Separate U test	Separate V test	Separate BDR		
22	12185	3856	1165	12185	3856	1165	-0.3%	-0.7%	-0.5%
27	4529	684	243	4529	684	243			
32	1984	161	69	1969 (99%)	117 (73%)	54 (78%)			
37	943	30	18	940 (100%)	22 (73%)	14 (78%)			

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