



# AHG6: Further cleanups and simplifications of the ALF in JCTVC-J0048

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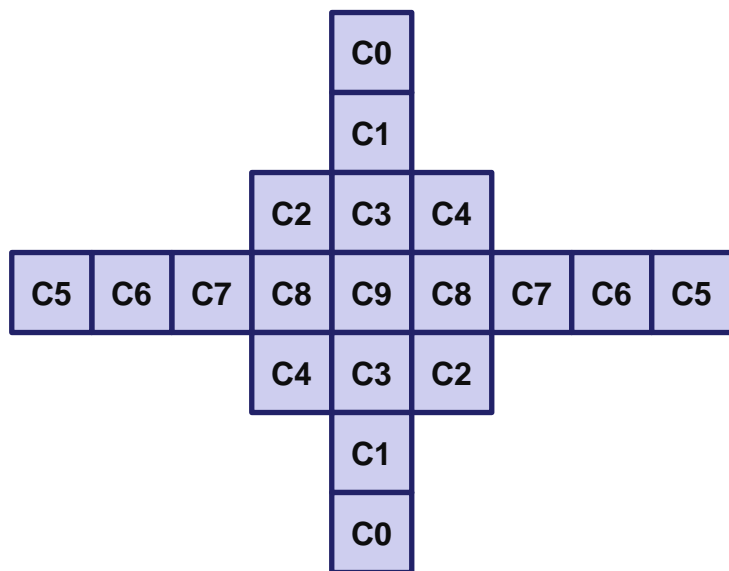
# Overall Summary

- JCTVC-J0048 provides ALF non-normative improvements
- Based on JCTVC-J0048, further cleanups and simplifications are presented as a response to suggestions from email reflector.
  - Item 1: Reduce the filter shape from Cross9x7+Square3x3 to Cross7x7+Square3x3
  - Item 2: Reduce the filter coefficient precision from 9 bits to 7 bits
  - Item 3: Normatively constraint filter coefficients on the encoder side to allow 16-bit accumulation for 8-bit samples
  - Miscellaneous cleanups and fixes
- Average BD-rate of Main-AI/RA/LB/LP & HE10-AI/RA/LB/LP

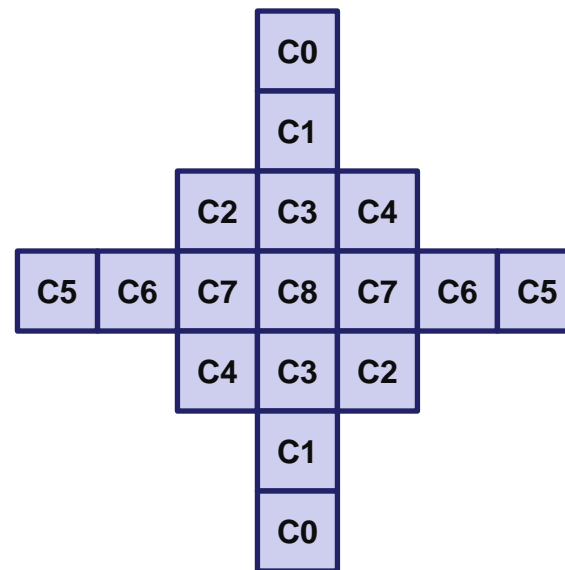
Anchor: ALF-off	JCTVC-J0048			Software 1 Including items 1-2			Software 2 including items 1-3		
	Y	Cb	Cr	Y	Cb	Cr	Y	Cb	Cr
CTC Seq.	-2.9%	-4.0%	-4.0%	-2.8%	-4.0%	-4.0%	-2.8%	-4.0%	-4.0%
KTA Seq.	-5.2%	-5.4%	-5.3%	-5.0%	-5.0%	-4.6%	-5.0%	-5.0%	-4.7%

# Reduction of Filter Shape

- In HM7.0, the filter shape is Cross9x7+Square3x3
- Propose to use Cross7x7+Square3x3
  - The number of multiplications is reduced from 10 to 9



HM7.0: Cross9x7+Square3x3



Proposed: Cross7x7+Square3x3

# Reduction of Filter Coefficient Precision

- In HM7.0, filter coefficient precision is 9-bit.
  - Center coefficient: [0, 511], 9-bit magnitude
  - Non-center coefficients: [-256, 255], 1-bit sign and 8-bit magnitude
- Proposed to reduce the filter coefficient to 7 bits
  - Center coefficient: [0, 127], 7-bit magnitude
  - Non-center coefficients: [-64, 63], 1-bit sign and 6-bit magnitude
- Multiplication in ALF in Main conditions
  - One 7-bit unsigned center coefficient \* one 8-bit sample
  - One 7-bit signed non-center coefficient \* one 9-bit sum of two 8-bit samples
  - The multiplication output can be represented within 16 bits, which is beneficial for SIMD instructions

# 16-bit Accumulation for 8-bit Samples

- Propose two normative constraints on the encoder side
- Sum of positive non-center filter coefficients times 510 plus center filter coefficient times 255 shall be in the range of  $[0, 215-1-32)$
- Sum of negative filter coefficients times 510 shall be in the range of  $[-215, 0)$
- Allow to use 16-bit accumulation during filtering for 8-bit samples

# Software Packages

- Software 1, based on HM-7.0, on top of JCTVC-J0048
  - Filter shape reduction
  - Filter coefficient precision reduction
  - RDO fix and code cleanups
- Software 2, based on HM-7.0, on top of software 1
  - Constraint on sum of positive filter coefficients
  - Constraint on sum of negative filter coefficients
- Software 3, based on HM-7.1
  - ALF from JCTVC-J0048, software 1, and software 2
  - Cleanups and fixes in JCTVC-J0047
  - Filter coefficient exp-Golomb codewords with leading zeros
  - Virtual boundary processing for the last luma LCU row and the first chroma LCU row

# CTC Sequences

- Compared to ALF-off

CTC	JCTVC-J0048			Software 1			Software 2			Software 3		
BD-rate	Y(%)	Cb(%)	Cr(%)	Y(%)	Cb(%)	Cr(%)	Y(%)	Cb(%)	Cr(%)	Y(%)	Cb(%)	Cr(%)
M-AI	-1.6	-3.1	-3.3	-1.5	-3.0	-3.2	-1.5	-3.0	-3.2	-1.5	-3.0	-3.2
M-RA	-3.1	-2.5	-2.3	-3.0	-2.4	-2.3	-3.0	-2.4	-2.3	-3.0	-2.4	-2.3
M-LB	-2.3	-3.0	-3.1	-2.2	-3.2	-3.1	-2.3	-3.2	-3.0	-2.3	-3.1	-3.1
M-LP	-3.6	-4.1	-4.0	-3.7	-4.4	-4.2	-3.7	-4.3	-4.2	-3.7	-4.3	-4.3
H-AI	-1.8	-4.2	-4.6	-1.6	-4.1	-4.4	-1.6	-4.1	-4.4			
H-RA	-3.3	-4.0	-4.1	-3.1	-3.8	-4.0	-3.1	-3.8	-4.0			
H-LB	-2.6	-4.6	-4.5	-2.4	-4.6	-4.5	-2.4	-4.6	-4.5			
H-LP	-4.5	-6.2	-6.2	-4.5	-6.6	-6.3	-4.5	-6.6	-6.3			
Avg.	-2.9	-4.0	-4.0	-2.8	-4.0	-4.0	-2.8	-4.0	-4.0			

# KTA Sequences

- Compared to ALF-off

KTA	JCTVC-J0048			Software 1			Software 2			Software 3		
BD-rate	Y(%)	Cb(%)	Cr(%)	Y(%)	Cb(%)	Cr(%)	Y(%)	Cb(%)	Cr(%)	Y(%)	Cb(%)	Cr(%)
M-AI	-2.5	-3.2	-3.3	-2.4	-3.2	-3.0	-2.4	-3.2	-3.0			
M-RA	-4.3	-3.4	-3.0	-4.1	-3.0	-2.7	-4.1	-3.0	-2.8			
M-LB	-3.8	-3.7	-3.7	-3.5	-3.2	-3.0	-3.5	-3.2	-3.1			
M-LP	-9.0	-6.6	-6.9	-8.7	-6.1	-5.9	-8.7	-6.3	-6.2			
H-AI	-2.6	-3.8	-4.2	-2.5	-3.8	-3.6	-2.5	-3.8	-3.6			
H-RA	-4.6	-4.5	-4.6	-4.3	-4.1	-3.8	-4.3	-4.1	-3.8			
H-LB	-4.3	-6.3	-5.8	-3.8	-5.6	-4.8	-3.8	-5.6	-4.8			
H-LP	-10.7	-11.3	-11.2	-10.3	-10.7	-10.4	-10.3	-10.7	-10.4			
Avg.	-5.2	-5.4	-5.3	-5.0	-5.0	-4.6	-5.0	-5.0	-4.7			



# Decoding Time under Main Conditions

- Software2
  - Cross7x7+Square3x3
  - 7-bit coefficients
  - 16-bit accumulation
- With SIMD instructions, 4.34X speed-up for ALF can be achieved.

	Main-AI	Main-RA	Main-LB	Main-LP	Average
<b>ALF without SIMD</b>	111.2%	109.6%	108.8%	110.0%	110.0%
<b>ALF with SIMD</b>	102.2%	102.3%	102.4%	102.2%	102.3%

# Conclusion

- On top of the ALF in JCTVC-J0048, further cleanups and simplifications are presented
  - Reduce the filter shape from Cross9x7+Square3x3 to Cross7x7+Square3x3
  - Reduce the filter coefficient precision from 9 bits to 7 bits
  - Normatively constraint filter coefficients on the encoder side to allow 16-bit accumulation for 8-bit samples
  - Miscellaneous cleanups and fixes
- Coding efficiency loss is minor, while complexity is decreased

# MEDIATEK

**Thank you**

