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| *Title:* | **AHG8 and AHG5: Mismatch between text specification and software for rotation and inter RDPCM** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

It is asserted that there is a mismatch between the HEVC Range Extensions text specification draft 4 and the test model software HM12.0-RExt-4.1. For lossy coding of blocks using inter RDPCM (inter and intra block copy), on the decoder side, the order of operation in software is entropy decoding, inverse quantization, inverse RDPCM, inverse transform-skip and rotation, whereas in the text specification the order of operations is entropy decoding, rotation, inverse quantization, inverse transform-skip and inverse RDPCM. Four different options are presented to reconcile the differences between text specification and software. Each option results in no gain or small losses for most classes. For SC GBR (optional) and SC YUV (optional) classes for lowdelay configuration, some BD-rate gains are observed.

# Introduction

In the 14th JCT-VC meeting, rotation for 4×4 blocks [1], intra residual DPCM (RDPCM) for lossy coding [2] and inter RDPCM for lossy and lossless coding [3] were adopted into the HEVC Range Extensions text specification draft 4 [4]. As per the text specification, on the decoder side, the order of operations for transform-skip and transquant-bypass blocks using RDPCM is:

For transquant bypass blocks,

Entropy decoding » rotation » inverse RDPCM » residual

For transform-skip blocks,

Entropy decoding » rotation » inverse quantization » inverse transform-skip » inverse RDPCM » residual

On the other hand, in the updated HM12.0-RExt-4.1 software, different order is followed for rotation, inter RDPCM and transform-skip for lossy coding. The order of operations for lossy coding of transform-skip blocks using inter RDPCM (inter and intra block copy) on the decoder side is as follows:

Entropy decoding » inverse quantization » inverse RDPCM » inverse transform-skip » rotation » residual

In this document, we propose several options to reconcile the differences between the text specification and software.

# Technical Description

We propose 4 different options for reconciling text specification and software.

## Option 1: Change the software to align with text specification

This leaves the specification unchanged.

## Option 2: Change the order of inter RDPCM and transform-skip in software

In this case, for lossy coding of transform-skip blocks using inter RDPCM (inter and intra block copy), the order of operations on the decoder side in software is modified as follows:

Entropy decoding » inverse quantization » inverse transform-skip » inverse RDPCM » rotation » residual

For inter RDPCM, residuals in the first row (for vertical RDPCM) or the first column (for horizontal RDPCM) contain more energy since they are not predicted from other residuals. Performing rotation after inter RDPCM moves these high energy residuals towards the bottom-right corner of the block, making them less suitable for entropy coding. Hence we propose that the text specification be modified to perform inter RDPCM before rotation on the *decoder* side for lossy coding.

## Option 3: Option 1 + Disable rotation in case of inter RDPCM for transform-skip blocks for lossy coding

As mentioned in the previous paragraph, performing rotation after RDPCM is not desirable for transform-skip blocks. In this case, the software is modified as proposed in option 1. Furthermore for lossless as well as lossy coding of transform-skip and transquant-bypass blocks using inter RDPCM (inter and intra block copy), rotation is disabled.

In this case, we propose that the text be modified to disable rotation for transform-skip blocks using inter RDPCM for lossy and lossless coding.

## Option 4: Option 1 + Disable rotation for all inter and intra\_BC blocks

In this case, the software is modified as proposed in option 1. In addition, the rotation is disabled for all inter blocks and blocks using intra block copy.

In this case, we propose that the text be modified to disable rotation for transform-skip blocks using inter RDPCM for lossy coding.

# Results

The coding efficiency impact of the 4 options was measured under AHG8 test sequences and conditions. The simulations were run on a homogeneous cluster using 64-bit LINUX.

The BD-rate results for lossy coding for options 1-4 are presented in Tables 1-4, respectively. Lossless coding results for option 3 and 4 are provided in tables 5 and 6, respectively. For options 1 and 2, lossless coding results are unchanged from the anchor.



Table : Lossy coding results for option 1 (changing the software to match with the text specification)



Table 2: Lossy coding results for option 2 (change the order of transform-skip and inter RDPCM in software)



Table 3: Lossy coding results for option 3 (option 1 + disable rotation for inter RDPCM blocks)



Table : Lossy coding results for option 4 (option 1 + disable rotation for all inter and INTER\_BC blocks)







Table 5: Lossless coding results for option 3 (option 1 + disable inter RDPCM rotation)







Table 6: Lossless results for option 4 (option 1 + disable rotation for inter and intra BC blocks

# Conclusion

There is a mismatch between the HEVC Range Extensions text specification draft 4 and the test model software HM12.0-RExt-4.1. For lossy coding of blocks using inter RDPCM (inter and intra block copy), on the decoder side, the order of operation in software is entropy decoding, inverse quantization, inverse RDPCM, inverse transform-skip and rotation, whereas in the text specification the order of operations is entropy decoding, rotation, inverse quantization, inverse transform-skip and inverse RDPCM. Four different options are presented to reconcile the differences between the text specification and the software. Each option results in no gain or small losses for most classes. For SC GBR optional and SC YUV optional classes for lowdelay configuration some BD-rate gains are observed.

# References

[1] J. Sole, R. Joshi, M. Karczewicz, R. Joshi, “RCE2 Test B.1: Residue rotation and significance map context”, JCTVC-N0044, Vienna, AT, August 2013.

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