

Title: AHG7: Analysis on high internal bit depth processing

Status: Input Document to JCT-VC

Purpose: Information

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Abstract

This document presents an investigation of the coding efficiency of the HM software model when the internal processing bit depth is increased beyond the input bit depth of the source video sequence. It is noted that the expected increase of the codec performance at high internal bit depths may not be achieved, particularly beyond 10 bits.

1 Introduction

In video codec developments, there is a common hypothesis that increasing the internal processing bit depth within the codec above the external (or input) signal bit depth would increase the coding performance. This has been shown with evidence for AVC-based codecs in a number of previous papers as the one described in [1]. However, an analysis of this property for HEVC using HM software model (HM-range-extensions) yields inconclusive results, as discussed in this contribution.

2 Experiment setup

The codec performance analysis is carried out using 8, 10 and 12 bit input sequences in YCbCr 420, 422 and 444 and RGB 444, available in HEVC both common test conditions [2] and AHG 7 (range extension) [3] test conditions. Table 1 shows the test video sequence classification for the experiment.

The internal bit depth in the codec is varied in the range {8, 10, 12, 14}. In all tests, the internal bit depth is set to be at least the value of input bit depth to avoid data losses due to truncation.

Test set	Source bit depth	Chroma sub sampling	Tested internal bit depths
Class B	8	YCbCr 420	8, 10, 12, 14
AHG7 (Chroma Extension)	8	RGB 444	8, 10, 12, 14
AHG7 (Chroma Extension)	10	YCbCr 422, 444, RGB 444	10, 12, 14
AHG7 (Chroma Extension)	12	RGB 444	12, 14

Table 1: Test sequence classification

The BD rate gains for higher internal bit depths are computed relative to the case where the internal bit depth is equal to the input bit depth. The BD rate gain values for each test category in Table 1 are averaged over all sequences in that category.

All experiments are run using the HM-range-extensions codec (version 3055).

3 Results

The results are presented as the incremental BD rate gain of using higher internal bit depths relative to the case where the internal bit depth is equal to the input bit depth.

AI

	class B			AHG7 - 8 bit			AHG7 - 10 bit			AHG7 - 12 bit		
	Y	Cb	Cr	Y	Cb	Cr	Y	Cb	Cr	Y	Cb	Cr
10bit	-1.4%	-1.7%	-1.7%	-2.6%	-2.4%	-2.0%						
12bit	-1.2%	-1.6%	-1.6%	-2.4%	-2.2%	-1.9%	0.2%	0.0%	0.0%			
14bit	-1.3%	-1.7%	-1.7%	-2.2%	-2.1%	-1.7%	0.1%	0.1%	0.0%	0.0%	0.1%	0.1%

RA

	class B			AHG7 - 8 bit			AHG7 - 10 bit			AHG7 - 12 bit		
	Y	Cb	Cr	Y	Cb	Cr	Y	Cb	Cr	Y	Cb	Cr
10bit	-2.3%	-5.2%	-5.8%	-3.6%	-3.0%	-2.5%						
12bit	-1.3%	-5.5%	-6.0%	-3.1%	-2.6%	-2.1%	0.4%	0.0%	0.0%			
14bit	-1.4%	-5.2%	-6.1%	-3.0%	-2.4%	-1.9%	0.4%	0.2%	0.1%	-0.1%	0.1%	-0.1%

LD-B

	class B			AHG7 - 8 bit			AHG7 - 10 bit			AHG7 - 12 bit		
	Y	Cb	Cr	Y	Cb	Cr	Y	Cb	Cr	Y	Cb	Cr
10bit	-2.4%	-6.2%	-7.3%	-3.4%	-2.2%	-1.7%						
12bit	-1.3%	-5.4%	-6.6%	-2.7%	-1.7%	-1.2%	0.5%	0.3%	-0.2%			
14bit	-0.5%	-4.6%	-5.1%	-2.7%	-1.5%	-0.9%	0.7%	0.6%	0.2%	-0.3%	-0.2%	-0.4%

Table 2 Experimental results

(Note: the results for class B sequences in random access configuration are to be added in a future revision of this document)

The plots of the BD rate gains (Luma only) with increasing internal bit depth are shown in Figure 1 and Figure 2. The overlaid dashed line approximately indicates the expected BD rate gain with the increasing internal bit depth.

Class B sequences

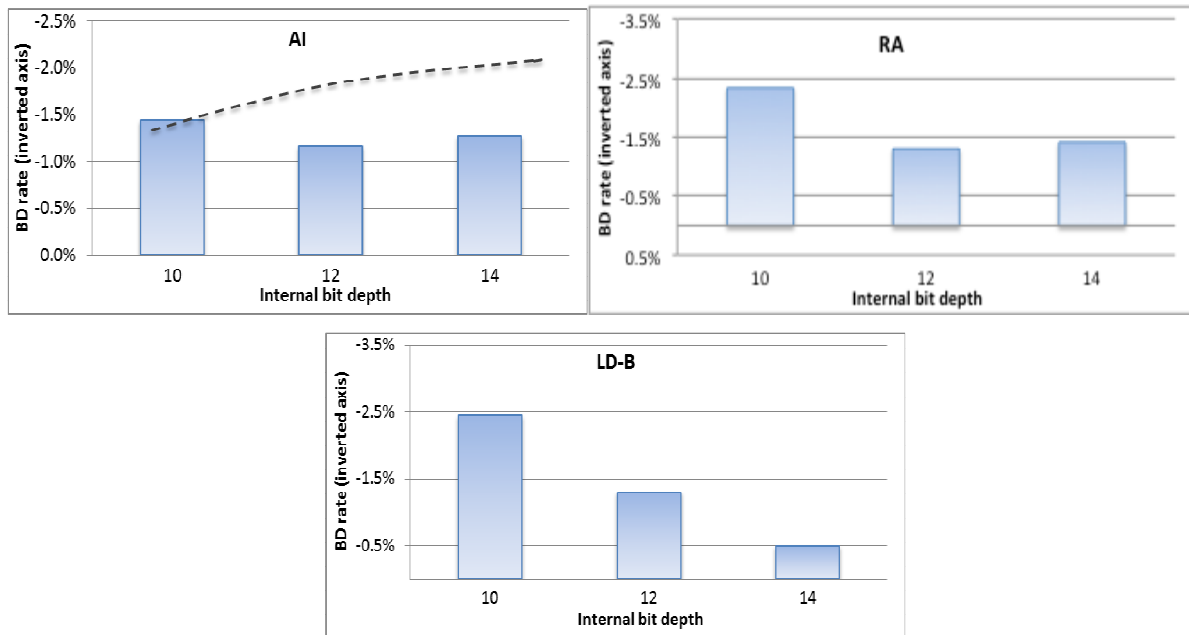


Figure 1: BD rate gain plots for Class B sequences

AHG7-8bit sequences

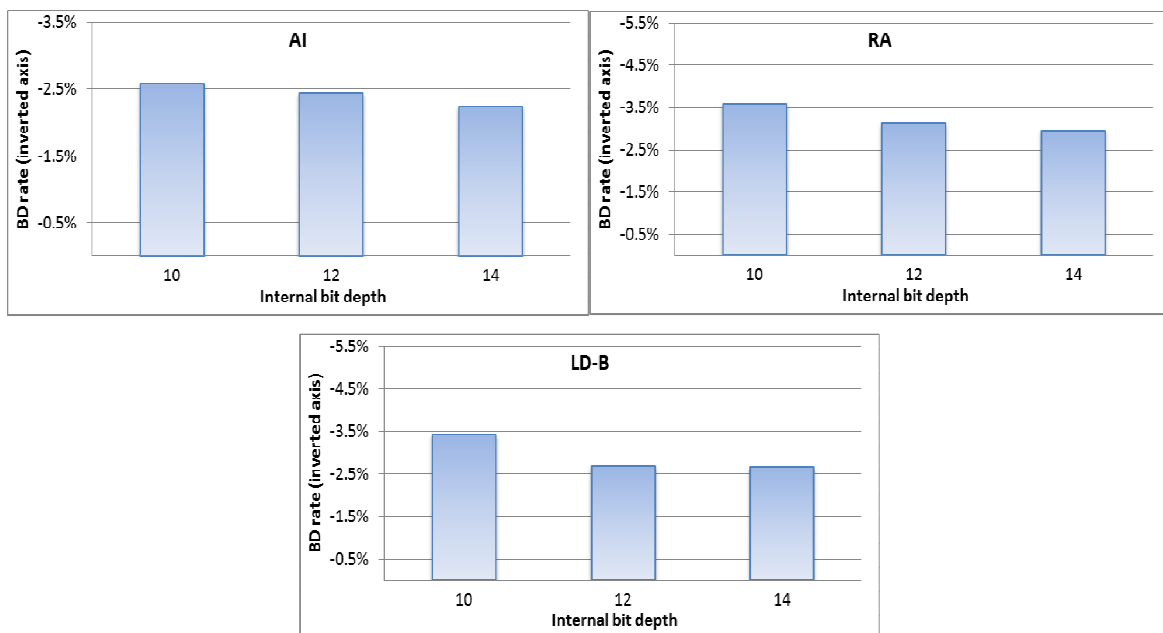


Figure 2: BD rate gain plots for AHG7-8bit sequences

All configurations above show BD-rate losses with the increase of internal bit depth contrary to the expected behaviour. The performances for Chroma components also largely follow a similar pattern.

AHG7-10bit sequences

The experimental results in Table 2 shows that both high internal bit depth cases provide a BD rate loss compared to the baseline case of 10 bit.

AHG7-12bit sequences

For these sequences there is a small performance loss in AI configuration, and small improvements in RA and LD.

4 Discussion

Further study is suggested to establish the cause of this behaviour. It could potentially have been caused by one or more bugs in the codec implementation, or undesirable interactions of the existing tools.

As a potential example of the latter, the contribution from the SAO tool in each of the above test scenarios was investigated, and while not conclusive, a number of interesting observations were made:

- Disabling the SAO created a coding efficiency loss in most test cases, as expected
- However, the effects of higher internal bit depth appeared more logical with no SAO; i.e. the coding efficiency increases at higher bit depths.

The experimental results with SAO disabled (keeping all remaining test conditions identical as above) are shown in Table 3 below.

AI

	class B			AHG7 - 8 bit			AHG7 - 10 bit			AHG7 - 12 bit		
	Y	Cb	Cr	Y	Cb	Cr	Y	Cb	Cr	Y	Cb	Cr
10bit	-1.4%	-2.8%	-3.3%	-3.0%	-2.9%	-2.4%						
12bit	-1.5%	-2.9%	-3.4%	-3.2%	-3.1%	-2.6%	-0.1%	-0.1%	-0.2%			
14bit	-1.5%	-2.9%	-3.5%	-3.2%	-3.1%	-2.6%	-0.1%	-0.2%	-0.2%	0.0%	0.0%	0.0%

RA

	class B			AHG7 - 8 bit			AHG7 - 10 bit			AHG7 - 12 bit		
	Y	Cb	Cr	Y	Cb	Cr	Y	Cb	Cr	Y	Cb	Cr
10bit	-2.8%	-6.8%	-7.6%	-3.9%	-3.4%	-2.8%						
12bit	-3.0%	-7.2%	-7.9%	-4.1%	-3.7%	-2.9%	-0.2%	-0.3%	-0.4%			
14bit	-3.0%	-7.0%	-8.0%	-4.1%	-3.6%	-2.9%	-0.3%	-0.3%	-0.5%	0.0%	0.0%	0.0%

LD-B

	class B			AHG7 - 8 bit			AHG7 - 10 bit			AHG7 - 12 bit		
	Y	Cb	Cr	Y	Cb	Cr	Y	Cb	Cr	Y	Cb	Cr
10bit	-3.3%	-9.0%	-10.9%	-4.4%	-3.2%	-2.4%						
12bit	-3.5%	-9.0%	-10.1%	-4.6%	-3.3%	-2.5%	-0.3%	-0.6%	-0.9%			
14bit	-3.5%	-8.7%	-9.2%	-4.6%	-3.3%	-2.5%	-0.4%	-0.5%	-0.8%	0.0%	0.0%	0.0%

Table 3 Experimental results with SAO disabled

The relevant BD-rate plots for class B and AHG7 sequences are shown in Figure 3 and Figure 4.

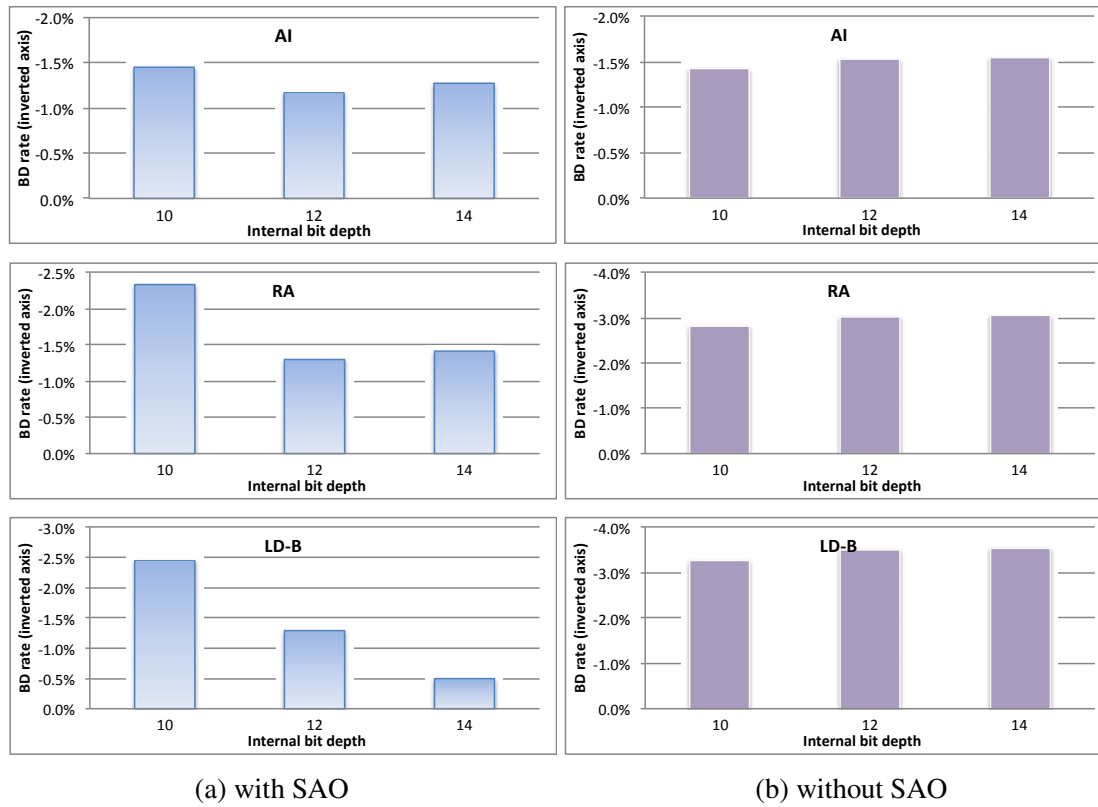


Figure 3: BD rate gain plots for Class B sequences, with and without SAO

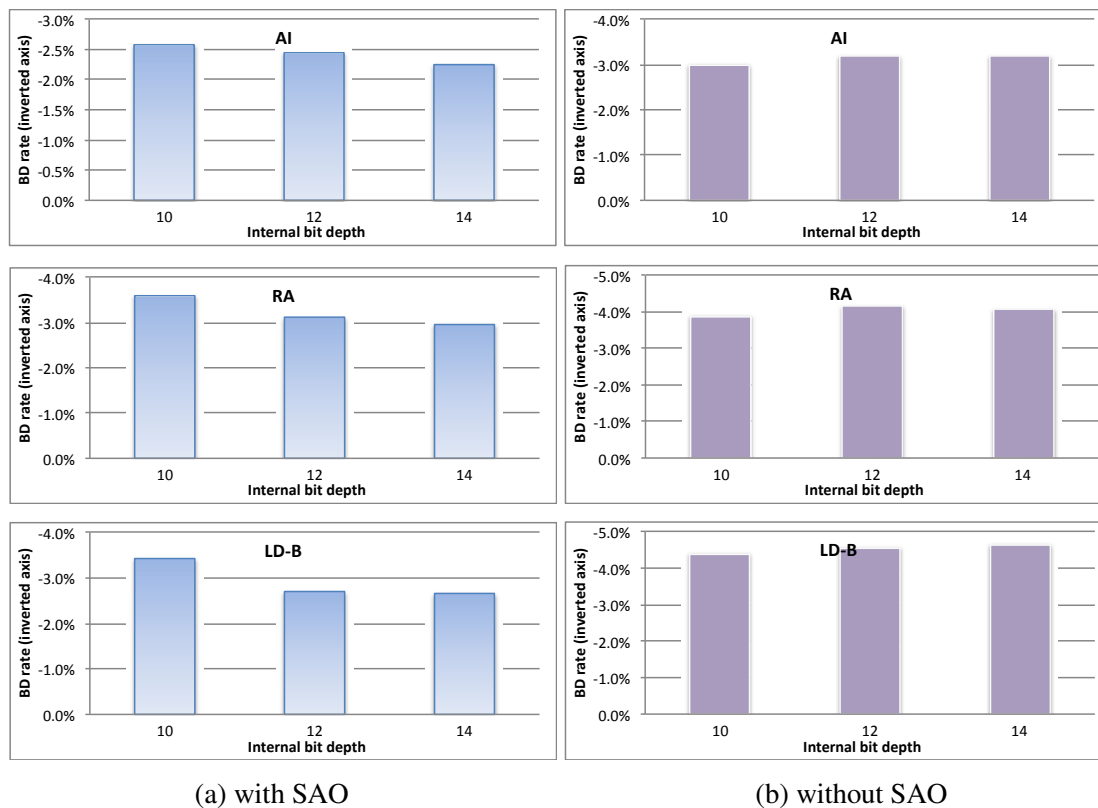


Figure 4: BD rate gain plots for AHG7 8 bit sequences, with and without SAO

While this does not suggest a bug in SAO code, a study of the interactions of these and other potentially related tools is expected to be useful.

5 References

- [1] T. Chujoh, R. Noda, “Internal bit depth increase for coding efficiency,” ITU-T SG16 Q.6 Document, VCEG-AE13, Marrakech, Jan. 2007.
- [2] F. Bossen, “HM 8 Common Test Conditions and Software Reference Configurations”, JCTVC-K1100, 11th meeting, Shanghai, CN, Oct. 2012.
- [3] D. Flynn, “Common Test Conditions and software reference configurations for HEVC range extensions”, JCTVC-K1006, 11th meeting, Shanghai, CN, Oct. 2012.