



# AHG5: Modified SAO for Range Extensions

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# Overall Summary

- **Objective**

Improve the SAO tool for different sample bit depths, coding bitrates and picture sampling formats

- **Proposed Method**

Add a new set of syntax elements for adapting the SAO tool

- **Features**

Compatible to HEVC with the default syntax values

- **Overall BD rate savings**

	Y	U	V
AI Main-tier	-0.2%	-0.3%	-0.5%
RA Main-tier	-0.4%	-1.6%	-0.7%
LD Main-tier	-0.7%	-1.5%	-1.0%

# New Syntax `sao_sign_thre` for EO Sample Classification

- HEVC

- $cat\_idx = \text{sign}(c-c_1) + \text{sign}(c-c_{-1}) + 2$

- $$\text{sign}(x) = \begin{cases} 1 & \text{if } x > 0 \\ 0 & \text{if } x = 0 \\ -1 & \text{if } x < 0 \end{cases}$$

- Proposal

- $cat\_idx = \text{sao\_sign}(c-c_1) + \text{sao\_sign}(c-c_{-1}) + 2$

- $$\text{sao\_sign}(x) = \begin{cases} 1 & \text{if } x \geq T \\ 0 & \text{if } |x| < T \\ -1 & \text{if } x \leq -T \end{cases}$$

- **T is set to the new slice header syntax `sao_sign_thre`**

- Compatible to HEVC by setting  $T = 1$  while allowing scaling with the bit depth

- Improving coding efficiency for high sample bit depth

# New Syntax `sao_bit_shift` for Deriving Offset Values

- HEVC
  - Offset value is derived by

$$\text{SaoOffsetVal} = \text{offsetSign} * \text{sao\_offset\_abs} \ll (\text{bitDepth} - \text{Min}(\text{bitDepth}, 10))$$

- Proposal
  - Offset value is derived by

$$\text{SaoOffsetVal} = \text{offsetSign} * (\text{sao\_offset\_abs} \ll \text{saoBitShift})$$

- `saoBitShift` set to the new slice header syntax `sao_bit_shift`
- Improving coding efficiency for high sample bit depth

# New Syntax `sao_eo_offset_max` for Entropy Coding

- HEVC

- Syntax `sao_offset_abs` is coded using truncated Rice (TR) binarization process with the parameters given by

$$\begin{aligned} cMax &= ( 1 \ll ( \text{Min}( \text{bitDepth}, 10 ) - 5 ) ) - 1, \\ cRiceParam &= 0 \end{aligned}$$

- Proposal

- Syntax `sao_offset_abs` is coded using truncated Rice (TR) binarization process with the parameters given by

$$\begin{aligned} cMax &= \text{saoOffsetMax}, \\ cRiceParam &= 0 \end{aligned}$$

- `saoOffsetMax` is set to the current HEVC `cMax` parameter for BO and set to `sao_eo_offset_max` for EO
- `sao_eo_offset_max` is separately coded for each color component and for each EO offset index in a slice

# New SPS Syntax Elements

- New SPS syntax elements to indicate if the new SAO syntax elements present in the slice segment header
- If not present, their values are set to the pre-defined values of the related HEVC parameters and the proposal is compatible to the current HEVC standard.

	Descriptor
seq_parameter_set_rbsp() {	
.....	
<b>amp_enabled_flag</b>	u(1)
<b>sample_adaptive_offset_enabled_flag</b>	u(1)
if (sample_adaptive_offset_enabled_flag && general_profile_idc == 4) {	
<b>adaptive_sao_params_active_flag</b>	u(1)
if (adaptive_sao_params_active_flag) {	
<b>adaptive_sao_bit_shift_active_flag</b>	u(1)
<b>adaptive_sao_sign_thre_active_flag</b>	u(1)
<b>adaptive_sao_eo_offset_max_active_flag</b>	u(1)
}	
}	
<b>pcm_enabled_flag</b>	u(1)
.....	
}	

# Results under CTCs (JCTVC-L1006)

	All Intra Main-tier			All Intra High-tier			All Intra Super-High-tier		
	Y	U	V	Y	U	V	Y	U	V
RGB 4:4:4	-0.3%	-0.2%	-0.3%	-0.2%	-0.1%	-0.2%	-0.1%	-0.1%	-0.1%
YCbCr 4:4:4	-0.3%	-0.3%	-0.4%	-0.2%	-0.2%	-0.3%	-0.2%	-0.2%	-0.2%
YCbCr 4:2:2	-0.1%	-0.6%	-0.9%	-0.1%	-0.2%	-0.4%	-0.1%	-0.1%	-0.2%
<b>Overall</b>	-0.2%	-0.3%	-0.5%	-0.2%	-0.2%	-0.3%	-0.1%	-0.1%	-0.2%
	-0.2%	-0.3%	-0.5%	-0.2%	-0.2%	-0.3%	-0.1%	-0.1%	-0.2%
Enc Time[%]		106%			105%			105%	
Dec Time[%]		104%			103%			103%	

	Random Access Main-tier			Random Access High-tier		
	Y	U	V	Y	U	V
RGB 4:4:4	-0.7%	-1.2%	-0.6%	-0.6%	-0.9%	-0.5%
YCbCr 4:4:4	-0.4%	-2.3%	-0.2%	-0.5%	-1.6%	0.0%
YCbCr 4:2:2	-0.2%	-1.3%	-1.4%	-0.3%	-1.1%	-0.7%
<b>Overall</b>	-0.4%	-1.6%	-0.7%	-0.5%	-1.2%	-0.4%
	-0.4%	-2.6%	-0.8%	-0.5%	2.6%	-0.4%
Enc Time[%]		102%			102%	
Dec Time[%]		102%			103%	

	Low delay B Main-tier			Low delay B High-tier		
	Y	U	V	Y	U	V
RGB 4:4:4	-0.9%	-1.2%	-1.1%	-0.6%	-0.8%	-0.7%
YCbCr 4:4:4	-0.9%	-2.0%	-0.6%	-0.8%	-1.4%	-0.4%
YCbCr 4:2:2	-0.3%	-1.3%	-1.3%	-0.3%	-0.8%	-0.7%
<b>Overall</b>	-0.7%	-1.5%	-1.0%	-0.6%	-1.0%	-0.6%
	-0.7%	-3.1%	-0.9%	-0.6%	-0.3%	-0.6%
Enc Time[%]		101%			101%	
Dec Time[%]		99%			101%	

\* Thank Samsung for the cross check (JCTVC-N0331)

# Results with Internal Bit Depth Increase (IBDI) by 2 Bits

	All Intra Main-tier			All Intra High-tier			All Intra Super-High-tier		
	Y	U	V	Y	U	V	Y	U	V
RGB 4:4:4	-0.3%	-0.2%	-0.3%	-0.2%	-0.1%	-0.2%	-0.2%	-0.1%	-0.2%
YCbCr 4:4:4	-0.3%	-0.3%	-0.4%	-0.2%	-0.2%	-0.3%	-0.2%	-0.3%	-0.4%
YCbCr 4:2:2	-0.1%	-0.6%	-1.0%	-0.1%	-0.2%	-0.4%	-0.1%	-0.1%	-0.2%
<b>Overall</b>	-0.2%	-0.4%	-0.6%	-0.2%	-0.2%	-0.3%	-0.2%	-0.2%	-0.3%
	-0.2%	-0.3%	-0.6%	-0.2%	-0.2%	-0.3%	-0.1%	-0.2%	-0.3%
Enc Time[%]	108%			107%			106%		
Dec Time[%]	102%			102%			102%		

	Random Access Main-tier			Random Access High-tier		
	Y	U	V	Y	U	V
RGB 4:4:4	-0.7%	-1.3%	-0.7%	-0.6%	-1.0%	-0.5%
YCbCr 4:4:4	-0.4%	-2.6%	-0.4%	-0.6%	-2.1%	-0.4%
YCbCr 4:2:2	-0.3%	-1.5%	-1.4%	-0.3%	-1.3%	-0.9%
<b>Overall</b>	-0.5%	-1.8%	-0.8%	-0.5%	-1.4%	-0.6%
	-0.4%	-2.6%	-0.8%	-0.5%	2.9%	-0.6%
Enc Time[%]	103%			103%		
Dec Time[%]	102%			102%		

	Low delay B Main-tier			Low delay B High-tier		
	Y	U	V	Y	U	V
RGB 4:4:4	-0.9%	-1.3%	-1.1%	-0.7%	-0.9%	-0.8%
YCbCr 4:4:4	-0.9%	-2.3%	-0.8%	-0.9%	-1.8%	-0.8%
YCbCr 4:2:2	-0.3%	-1.4%	-1.3%	-0.3%	-1.0%	-0.8%
<b>Overall</b>	-0.7%	-1.6%	-1.1%	-0.6%	-1.2%	-0.8%
	-0.7%	-3.3%	-1.0%	-0.7%	-0.2%	-0.8%
Enc Time[%]	102%			102%		
Dec Time[%]	100%			100%		

# Results with 8-bit Internal Bit Depth

	All Intra Main-tier			All Intra High-tier			All Intra Super-High-tier		
	Y	U	V	Y	U	V	Y	U	V
RGB 4:4:4	-0.2%	-0.1%	-0.2%	-0.1%	-0.1%	-0.1%	0.0%	0.0%	0.0%
YCbCr 4:4:4	-0.2%	-0.3%	-0.3%	-0.1%	-0.2%	-0.2%	-0.1%	-0.1%	-0.1%
YCbCr 4:2:2	-0.1%	-0.3%	-0.4%	-0.1%	-0.1%	-0.2%	0.0%	0.0%	-0.1%
<b>Overall</b>	-0.2%	-0.2%	-0.3%	-0.1%	-0.1%	-0.2%	0.0%	-0.1%	-0.1%
	-0.2%	-0.2%	-0.3%	-0.1%	-0.1%	-0.2%	0.0%	-0.1%	-0.1%
Enc Time[%]		102%			102%			101%	
Dec Time[%]		103%			103%			102%	

	Random Access Main-tier			Random Access High-tier		
	Y	U	V	Y	U	V
RGB 4:4:4	-0.4%	-0.6%	-0.3%	-0.4%	-0.4%	-0.3%
YCbCr 4:4:4	-0.3%	-1.7%	-0.1%	-0.4%	-1.4%	-0.4%
YCbCr 4:2:2	-0.1%	-0.6%	-0.8%	-0.3%	-0.8%	-0.7%
<b>Overall</b>	-0.3%	-1.0%	-0.4%	-0.4%	-0.8%	-0.4%
	-0.3%	-2.0%	-0.3%	-0.4%	2.5%	-0.4%
Enc Time[%]		101%			101%	
Dec Time[%]		102%			103%	

	Low delay B Main-tier			Low delay B High-tier		
	Y	U	V	Y	U	V
RGB 4:4:4	-0.4%	-0.5%	-0.4%	-0.3%	-0.3%	-0.3%
YCbCr 4:4:4	-0.5%	-1.8%	-0.7%	-0.6%	-1.4%	-0.8%
YCbCr 4:2:2	-0.2%	-0.7%	-0.8%	-0.3%	-0.8%	-0.7%
<b>Overall</b>	-0.4%	-1.0%	-0.6%	-0.4%	-0.8%	-0.6%
	-0.3%	-2.5%	-0.6%	-0.4%	-0.1%	-0.5%
Enc Time[%]		101%			101%	
Dec Time[%]		104%			104%	

# Conclusion

- Propose to add a new set of syntax elements to flexibly support replacing the pre-defined SAO parameters for different coding conditions
- Overall BD rate improvements for different sample bit depths over a wide bitrate range

	CTCs			IBDI by 2 bits			8-bit Internal Bit Depth		
	Y	U	V	Y	U	V	Y	U	V
<b>AI Main-tier</b>	-0.2%	-0.3%	-0.5%	-0.2%	-0.4%	-0.6%	-0.2%	-0.2%	-0.3%
<b>RA Main-tier</b>	-0.4%	-1.6%	-0.7%	-0.5%	-1.8%	-0.8%	-0.3%	-1.0%	-0.4%
<b>LD Main-tier</b>	-0.7%	-1.5%	-1.0%	-0.7%	-1.6%	-1.1%	-0.4%	-1.0%	-0.6%
<b>AI High-tier</b>	-0.2%	-0.2%	-0.3%	-0.2%	-0.2%	-0.3%	-0.1%	-0.1%	-0.2%
<b>RA High-tier</b>	-0.5%	-1.2%	-0.4%	-0.5%	-1.4%	-0.6%	-0.4%	-0.8%	-0.4%
<b>LD High-tier</b>	-0.6%	-1.0%	-0.6%	-0.6%	-1.2%	-0.8%	-0.4%	-0.8%	-0.6%

- Recommend to adopt the proposal into the range extensions draft or further study in RCE