

HW Cost for Deriving iScale

- JCTVC-J0155v2 with TB&TD range equal to [-32,31] versus HM-7.0 with TB&TD range equal to [-128,127]
 - **54.7% increase** in gate count; HM has much lower cost
- JCTVC-J0155v2 with TB&TD range equal to [-32,31] versus HM-7.0 with TB&TD range equal to [-32,31]
 - **168.5% increase** in gate count; HM has much lower cost

	HM-7.0, clip TB and TD to [-128, 127]		J0155v2 (clip TB and TD to [-32, 31])		HM-7.0, clip TB and TD to [-32, 31]	
step	Operation	HW impl.	Operation	HW impl.	Operation	HW impl.
1	Clip TB and TD to [-128, 127]		Clip TB and TD to [-32, 31]		Clip TB and TD to [-32, 31]	
2	$iX = (2^{14} + (\text{Abs}(\text{TD}) \gg 1)) / \text{TD}$	256x16b LUT	$i\text{Scale} = ((\text{TB} \ll 9) + \text{Sign2}(\text{TB}) * \text{Abs}(\text{TD})) / (\text{TD} \ll 1)$	32x32x16b LUT	$iX = (2^{14} + (\text{Abs}(\text{TD}) \gg 1)) / \text{TD}$	64x16b LUT
3	$i\text{Scale} = (iX * \text{TB} + 32) \gg 6$	16bx8b multiplier			$i\text{Scale} = (iX * \text{TB} + 32) \gg 6$	16bx6b multiplier
4	Clip iScale to [-4096, 4095]		Clip iScale to [-4096, 4095]		Clip iScale to [-4096, 4095]	
Gate count		1492		2309		860

HW Cost for the Entire MV Scaling

- JCTVC-J0155v2 with TB&TD range equal to [-32,31] versus HM-7.0 with TB&TD range equal to [-128,127]
 - **20.5% increase** in gate count; HM has much lower cost
- JCTVC-J0155v2 with TB&TD range equal to [-32,31] versus HM-7.0 with TB&TD range equal to [-32,31]
 - **43.3% increase** in gate count; HM has much lower cost

	HM-7.0, clip TB and TD to [-128, 127]		J0155r1		HM-7.0, clip TB and TD to [-32, 31]	
step	Operation	HW impl.	Operation	HW impl.	Operation	HW impl.
1	Clip TB and TD to [-128, 127]		Clip TB and TD to [-32, 31]		Clip TB and TD to [-32, 31]	
2	$iX = (2^{14} + (\text{Abs}(TD) \gg 1)) / TD$	256x16b LUT	$iScale = ((TB \ll 9) + \text{Sign2}(TB) * \text{Abs}(TD)) / (TD \ll 1)$	32x32x1 6b LUT	$iX = (2^{14} + (\text{Abs}(TD) \gg 1)) / TD$	64x16b LUT
3	$iScale = (iX \times TB + 32) \gg 6$	16bx8b multiplier			$iScale = (iX \times TB + 32) \gg 6$	16bx6b multiplier
4	Clip iScale to [-4096, 4095]		Clip iScale to [-4096, 4095]		Clip iScale to [-4096, 4095]	
5	$MV2 = \text{Sign}(iScale \times MV1) \times ((iScale \times MV1 + 127) \gg 8)$	16bx13b multiplier	$MV2 = \text{Sign}(iScale \times MV1) \times ((iScale \times MV1 + 127) \gg 8)$	16bx13b multiplier	$MV2 = \text{Sign}(iScale \times MV1) \times ((iScale \times MV1 + 127) \gg 8)$	16bx13b multiplier
6	Clip MV2 to [-32768, 32767]		Clip MV2 to [-32768, 32767]		Clip MV2 to [-32768, 32767]	
Gate count		3979		4796		3347

Conclusion

- JCTVC-J0155 might slightly reduce software instructions (cannot measure any run time difference) but would significantly increase hardware gate count
- It is suggested to keep the current MV scaling in HM and HEVC text specification

HW Cost for the Entire MV Scaling

- JCTVC-J0155v1 with TB&TD range equal to [-128,127] versus HM-7.0 with TB&TD range equal to [-128,127]
 - 86.9% increase** in gate count; HM has much lower cost

	HM-7.0, clip TB and TD to [-128, 127]		J0155v1-opt1		J0155v1-opt2		J0155v1-combined	
step	Operation	HW impl.	Operation	HW impl.	Operation	HW impl.	Operation	HW impl.
1	Clip TB and TD to [-128, 127]		Clip TB and TD to [-127, 127]		Clip TB and TD to [-128, 127]		Clip TB and TD to [-127, 127]	
2	$iX = (2^{14} + (\text{Abs}(\text{TD}) \gg 1)) / \text{TD}$	256x16b LUT	$iX = (2^{14} + (\text{Abs}(\text{TD}) \gg 1)) / \text{TD}$	256x16b LUT	$i\text{Scale} = ((\text{TB} \ll 9) + \text{TD}) / (\text{TD} \ll 1)$	256x25b LUT + 25b x 17b multiplier	$i\text{Scale} = ((\text{TB} \ll 9) + \text{TD}) / (\text{TD} \ll 1)$	256x25b LUT + 25b x 17b multiplier
3	$i\text{Scale} = (iX \times \text{TB} + 32) \gg 6$	16b x 8b multiplier	$i\text{Scale} = (iX \times \text{TB} + 32) \gg 6$	16b x 8b multiplier				
4	Clip iScale to [-4096, 4095]				Clip iScale to [-4096, 4095]			
5	$\text{MV2} = \text{Sign}(i\text{Scale} \times \text{MV1}) \times ((i\text{Scale} \times \text{MV1} + 127) \gg 8)$	16b x 13b multiplier	$\text{MV2} = \text{Sign}(i\text{Scale} \times \text{MV1}) \times ((i\text{Scale} \times \text{MV1} + 127) \gg 8)$	16b x 16b multiplier	$\text{MV2} = \text{Sign}(i\text{Scale} \times \text{MV1}) \times ((i\text{Scale} \times \text{MV1} + 127) \gg 8)$	16b x 13b multiplier	$\text{MV2} = \text{Sign}(i\text{Scale} \times \text{MV1}) \times ((i\text{Scale} \times \text{MV1} + 127) \gg 8)$	16b x 16b multiplier
6	Clip MV2 to [-32768, 32767]		Clip MV2 to [-32768, 32767]		Clip MV2 to [-32768, 32767]		Clip MV2 to [-32768, 32767]	
Gate count		3979		4988		6409		7415