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| *Title:* | **RCE1: Summary report on HEVC Range Extensions Core Experiment 1 (RCE1) on high bit rate coding at high bit depths** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Report | | |
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| *Source:* | CE coordinators | | |

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# Introduction

This is a summary report on HEVC Range Extensions Core Experiment 1 on high bit rate coding at high bit depths. The core experiment investigated techniques for reducing the number of context-coded bins and for coding bypass bins as raw and their combinations. Performance of the proposed methods was evaluated primarily under AHG18 conditions. Performance was also evaluated under AHG5 and AHG8 (lossless) test conditions to analyze the methods at normal bit-depths.

# Document List

## Subtest A

* JCTVC-P0073, “RCE1: Results for subtest A” R. Joshi, J. Sole, and Marta Karczewicz (Qualcomm)
  + Crosscheck: subtest A1, JCTVC-P0247 (Mediatek)
  + Crosscheck: subtest A2, JCTVC-P0194 (Samsung)Crosscheck: subtest A4, JCTVC-P0220 (Canon)

## Subtest B

* JCTVC-P0060, “RCE1: Results for tests B1, B2 and B3a” K. Sharman, N. Saunders, J. Gamei (Sony)
  + Crosscheck: subtest B1, JCTVC-P0077 (Qualcomm)
* JCTVC-P0074, “RCE1: Results for subtests B5, B6, B7” R. Joshi, J. Sole, and Marta Karczewicz (Qualcomm)
  + Crosscheck: subtest B5, JCTVC-P0221 (Canon)
  + Crosscheck: subtest B6, JCTVC-P0195 (Samsung)
  + Crosscheck: subtest B7, JCTVC-P0245 (Sharp)

## Non-CE contributions

* JCTVC-P0075, “non-[RCE1, RCE2]: Combination of RCE1 subtests B5 and B6 with RCE2 subtest A1” R. Joshi, L. Guo, J. Sole, and Marta Karczewicz (Qualcomm)

# Tested Methods

The CE was set up to explore combinations of alignment mechanisms with alignment conditions and change of the point in the entropy coder where the bypass bins are used.

Two alignment mechanisms for bypass bins were tested:

**Method 1** [M0178, N0190, O0046, O0207]**:** Alignment to 256. This can be expressed as:

ivlCurrRange = 256

Following this stage all subsequent EP bins can be interpreted as raw binary data.

**Method 2** [M0178, N0190, O0046]: Alignment to 384. This can be expressed as:

if (ivlCurrRange >= 384)

if (ivlOffset < 256) nextEPBitIsZero = true

else ivlOffset -= 128

ivlCurrRange = 256

Following this stage all subsequent EP bins can be interpreted as raw binary data.

## Bypass of context coded bins for coefficient coding (subtest A)

In this subtest, various positions for switching to bypass in transform coefficient coding were explored.

**Subtest A.1** [O0208, Qualcomm]: Bypass after the significance map if the Golomb Rice parameter value at the end of the previous 4×4 subblock is greater than or equal to 4.

**Subtest A.2** [O0209, Qualcomm]: Bypass all the context-coded flags for the current 4×4 subblock (coded subblock flags, significance flags, greater than 1 flags and greater than 2 flags) if the Golomb Rice parameter value at the end of the previous 4×4 subblock is greater than or equal to 4.

**Subtest A.3** [O0209 (ext.), Qualcomm]: Bypass all the context-coded flags in a transform block if the Golomb Rice parameter value at the end of the previous 4×4 subblock is greater than or equal to 4. In that case, the last significant coefficient position was sent as (blkSizeX – lastX, blkSizeY – lastY).

**Subtest A.4** [meeting discussion]: All the bins (for coefficients as well as other syntax elements) are coded as raw. Residual data is modified according to subtest A.3.

## Combinations (subtest B)

**Subtest B.1** [M0178]: Always apply method 1 before any bypass bins in a 4×4 subblock.

**Subtest B.2** [M0178]: Always apply method 2 before any bypass bins in a 4×4 subblock.

**Subtest B.3.a** [O0046]: Method 1 before sign coding if any coeff\_abs\_level\_rem syntax elements are present for the 4x4 subblock.

**Subtest B.3.b** [O0207]: Method 1 based on sign data hiding condition for a 4×4 subblock.

**Subtest B.5**: Method 1 + A.1

**Subtest B.6**: Method 1 + A.2

**Subtest B.7**: Method 1 + A.3

# Summary of results

## BD-rate comparisons



## Average bin count statistics



# Summary of bin counts and throughput analysis

The table below indicates the worst cases bin numbers.



Note that with the ‘GolombRiceGroupAdaptation’ disabled, the above 647s would all become 698. The worst-case bound considering two 4×4 subblocks is a non-tight upper bound. As an example, for subtest A1, if the 2nd 4x4 has the worst-case bypass bins, the 3rd subblock would also have 16 context-coded bins in the worst case, resulting in an average of 19.

# References

[1] R. Joshi and K. Sharman, “HEVC Range Extensions Core Experiment 1 (RCE1): High bit rate coding at high bit depths” JCTVC-O1121, Geneva, CH, October 2013.