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| *Title:* | **Core Experiment on Entropy Coding for High Bit Depth and High Bit Rate Coding** | | |
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| *Purpose:* | Core Experiment description | | |
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| *Source:* | CE coordinators | | |

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# Abstract

The goal of this Core Experiment (CE) is to conduct a study of coding tools for High Bitdepth and High Bitrate coding proposed at V meeting of JVET.

The software basis for this CE is VTM-13.0. For the test sequences, configurations and test conditions, the High Bit-depth CTC described in JVET-U2018 is used, unless otherwise specified in the CE description.

# Participants

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# Test conditions and evaluation criteria

The proposals will be tested under the High Bit-Depth CTC specified in [1] in both lossy and lossless configurations. Simulation results in Low QP, Normal QP configurations as well as in lossless configuration to be reported for all tests.

Planned tests in the CE shall be implemented on, and compared with, VTM-13.0 with the modification described in CTC [1] to enable high bit depth processing. Configuration files provided with VTM-13.0 reflect HBD-ralated adoptions from JVET V meeting.

In LowQP configuration, extended precision processing will be enabled (parameter ExtendedPrecision is set equal to 1), and all results will be compared with an anchor with the same setting.

For Normal QP configuration (12 bits 4:2:0 PQ/HLG test sequences), extended precision will be disabled (parameter ExtendedPrecision is set equal to 0) and the results will be compared with an anchor with extended precision disabled.

Adaptive transform precision tests (i.e. CE-2) will also report results for extended precision processing being disabled for 12 bits data (HDR PQ/HLG and SVT12) in LowQP configuration for both, the anchor and the test. Proponents of CE-2 tests to provide anchor simulation results in the aforementioned configuration. Cross-checkers of CE-2 to report on the anchor results cross-check as well.

For tests targeting high throughput profile ( i.e. ,CE-3), HM configured in HEVC high throughput profile as an additional reference point to be used. The latest version of HM (HM-16.23) will be used for high throughout profile. In HM-16.23, the High Throughput 4:4:4 16 Intra profile can be enabled using encoder\_intra\_high\_throughput\_rext.cfg. Proponents of CE-3 tests to provide the HM anchor simulation results in the aforementioned configuration. Cross-checkers of CE-3.x to report on the HM anchor results cross-check as well.

Proposals will be compared with respect to bit rate, objective quality, and complexity. To provide an indication of complexity, comparative run-times for encoding and decoding as well as assessed increase in memory requirements and number of additional operations will be used. In addition, throughput issues should be considered, in particular any change to the bin to bit ratio will be reported for CE-3 tests.

If a proposal changes coding for 8 or 10 bit sources, additional VVC 10 bit CTC results shall be provided.

# Proposals descriptions

The following contributions have been selected for CE study at the V meeting of JVET.

1. [JVET-V0121](https://jvet-experts.org/doc_end_user/current_document.php?id=10770) AHG8: On coding of last significant coefficient position for high bit depth and high bit rate extensions [F. Wang, L. Xu, Z. Xie, Y. Yu, H. Yu, D. Wang (OPPO)]

The proposal of JVET-V0121 proposes a modification to the derivation method of last significant coefficient position in regular residual coding (RRC). In the current VVC specification, the coordinate of last significant coefficient (LastSignificantCoeffX, LastSignificantCoeffY) is measured in reference to the top-left corner of a transform block (TB) and coded with syntax elements last\_sig\_coeff\_x\_prefix, last\_sig\_coeff\_y\_prefix, last\_sig\_coeff\_x\_suffix, and last\_sig\_coeff\_y\_suffix. It is observed that, when coding for high quality (or high bit-rate) with high bit-depth video, the number of significant coefficients become larger and the last significant coefficient often occur in the bottom-right portion of a TB. To accommodate this new distribution aspect, this contribution proposes to code the relative coordinates of last significant coefficient in reference to the bottom-right corner of a zero-out transform block. More specifically, the usage of the proposed alternative coordinates is signaled by a flag sh\_reverse\_last\_sig\_coeff\_flag in the slice header. When sh\_reverse\_last\_sig\_coeff\_flag is equal to 1, the last coefficient position is coded by using the proposed alternative coordinates for a whole slice. Otherwise, the current coordinates for the last coefficient position are used.

1. [JVET-V0133](https://jvet-experts.org/doc_end_user/current_document.php?id=10794) AHG8: Content Adaptive Transform Precision for High Bit Depth Coding [[K. Naser](mailto:karam.naser@interdigital.com), F. Galpin, F. Le Léannec, P. De Lagrange (InterDigital)]

The intermediate transform coefficient precision is fixed to 16 bit signed representation in VVC. Therefore, a pre-computed down-shift is performed after inverse quantization and inverse transform in order to avoid exceeding the 16 bit buffer. It is argued that this down-shift is too conservative as the prediction mechanism results in low magnitude residuals. For High Bit-Depth coding, the down-shift is increased to ensure 16 bit representation, which further decreases the quality of the inverse transformed coefficients. This contribution proposes to adaptively assign the down-shift according the contents.

It is proposed to adaptively assign the downshifts in the scaling process for transform coefficients (clause 8.7.3 of VVC) and in the transformation process for scaled transform coefficients (clause 8.7.4 of VVC) by examining the coefficients values of upon dequantization and inverse transform.

1. [JVET-V0178](https://jvet-experts.org/doc_end_user/current_document.php?id=10841) AHG8: a combination of JVET-V0059 option 2 and JVET-V0122 for high bit depth and high bit rate extensions [F. Wang, Z. Xie, Y. Yu, H. Yu, D. Wang (OPPO)] [late]

* JVET-V0059 AHG8: CABAC-bypass alignment for high bit-depth coding [M. G. Sarwer, J. Chen, Y. Ye, R. -L. Liao (Alibaba)]

This contribution proposed to enable CABAC bypass alignment method in VVC High Throughput 4:4:4 16 Intra Profile. Same as JVET-U0069, this contribution proposes two alignment options. In the first option, the bypass alignment is applied only to coefficient coding within a coefficient group (CG), without affecting the coding of sb\_coded\_flag of a transform block (TB). In the second option, in addition to CABAC bypass alignment, it is also proposed to switch to bypass coding of sb\_coded\_flag after the limit of context coded bins has been reached for the current TB. It is asserted that with the second option, alignment is needed only once after the limit of the context coded bins has been reached for the TB.

* JVET-V0122, “AHG8: a full-bypass mode in residual coding for high bit depth and high bit rate extensions”, F. Wang, Z. Xie, Y. Yu, H. Yu, D. Wang (OPPO)

This contribution proposes a full-bypass mode in residual coding for VVC version 2. It is proposed to add this new mode in both regular residual coding (RRC) and transform skip residual coding (TSRC). When enabled, this new mode will code coefficient or residual levels only through the bypass mode of the arithmetic coding engine without using any context-coded bin. This mode is primarily designed to improve the throughput of arithmetic coding for high quality applications with high bit-depth video signals, such as content capture, creation, and editing. It is observed that the simulation results showed over 15% reduction in average decoding time, even with a slight coding efficiency gain, from the 16-bit SVT sequences. The tests were conducted by using the CE anchor software and running the latest CTC in JVET-U2018.

JVET-V0178 proposes a combination of JVET-V0059 option 2 and JVET-V0122, in which all the syntax elements in residual coding, except for last significant coefficient position in RRC, are coded through bypass mode and alignment is needed only once after the last significant coefficient position in RRC and at the very beginning of a TB in TSRC.

An SPS level syntax element sps\_high\_throughput\_flag is used to enable/disable the proposed method. If sps\_high\_throughput\_flag is equal to 0, the current RRC and TSRC in VVC remains unchanged. If sps\_high\_throughput\_flag is equal to 1, the following aspects are changed:

1. The initial value of remBinsPass1 in RRC and RemCcbs in TSRC are set to 0, i.e. the maximum number of context coded bins is set to 0. As a result the coefficient or residual levels at all positions are coded only in the bypass mode.
2. The alignment happens before going into sub-block, i.e. after last\_sig\_coeff\_x\_prefix, last\_sig\_coeff\_y\_prefix, last\_sig\_coeff\_x\_suffix and last\_sig\_coeff\_y\_suffix if any of residual\_coding in RRC, and at the very beginning of residual\_ts\_coding in TSRC.
3. All the syntax elements of sb\_coded\_flag are always coded in bypass mode.

# Planned tests

## Coding of the last significant coefficient position

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| **Test** | **Proponent(s)** | **Cross-checker(s)** |
| *CE1.1* | OPPO | Qualcomm |

## CE1.1: Method of [JVET-V0121](https://jvet-experts.org/doc_end_user/current_document.php?id=10770)

In this test, the improvements of the proposed method will be tested. The encoding method described in the JVET-V0121 will be used to determine at encoder side the value of sh\_reverse\_last\_sig\_coeff\_flag for each slice.

## Adaptive Transform Precision

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| **Test** | **Proponent(s)** | **Cross-checker(s)** |
| CE2.1 | InterDigital | Sony |
| CE2.2 | InterDigital | Qualcomm |

## CE2.1: Method CATP0 of [JVET-V0133](https://jvet-experts.org/doc_end_user/current_document.php?id=10794)

In this test, the maximum dequantized coefficient value before applying the downshift is considered for computing the adaptive dequantization downshift. The susbsequent inverse transform shifts (horizontal and vertical) are modified accordingly.

## CE2.2: Method CATP1 of [JVET-V0133](https://jvet-experts.org/doc_end_user/current_document.php?id=10794)

In this test, in addition to CATP0 of CE2.1, the maximum coefficient value of the horizontal transform is determined for computing the inverse horizontal transform shift. The subsequent vertical transform shift is modified accordingly.

For tests in this category, simulation results for LowQP, normal QP as well as lossless coding configuration will be provided and compared agains the anchor in the same configuration.

Additional results will be provided for 12 bits data (HDR PQ/HLG and SVT12) in LowQP configuration with extended precission flag being disabled for both, the test and the VTM anchor.

Additional results will be provided for 16 bit data (SVT16) being coded in LowQP configuration with extended precission flag being enabled, and Log2TransformRange in the test being set equal to 16. Results will be compared against the VTM anchor coded in LowQP configuration with extended precission flag being enabled, and also against the same anchor with Log2TransformRange being set equal to 16.

## Bypass alignment and bypass coding

In this category, methods targeting high throughput profile and presented in JVET-V0059/JVET-V0178 are being tested.

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| **Test** | **Proponent(s)** | **Cross-checker(s)** |
| CE3.1 | Alibaba | Sony |
| CE3.2 | OPPO, Alibaba | InterDigital |

## Test 3.1: Option 2 described in JVET-V0059/JVET-V0178

In this test option 2 presented in JVET-V0059/JVET-V0178 will be tested. The CABAC bypass alignment will be done before bypass coding of each coefficient group. After reaching to the maximum number of context coded bins ( defined in existing VVC standard), the bypass alignment will be done only once for that transform block before CABAC engine switched to fully bypass coding of transform coefficients. If the remaining number of context coded bins < 4, sb\_coded\_flag (of both RRC and TSRC) will be context coded, Otherwise, sb\_coded\_flag (of both RRC and TSRC) will be bypasss coded.

## CE3.2: Method of JVET-V0178

In this test, the throughput benefits of the proposed method will be tested. When sps\_cabac\_bypass\_alignment\_enabled\_flag is equal to 1:

* the corresponding remBinsPass1 and RemCcbs are set to be 0;
* the coding of last\_sig\_coeff\_x\_prefix, last\_sig\_coeff\_y\_prefix, last\_sig\_coeff\_x\_suffix and last\_sig\_coeff\_y\_suffix remain the same (context coded);
* bypass alignment happens before the first bypass coded bin in both RRC and TSRC;
* all coefficient or residual levels are bypass coded with corresponding syntax elements for both RRC and TSRC;
* all sb\_coded\_flag are bypass coded as well.

In this test, the VTM throughput will be studied and tested in reference to HEVC. The measurements of bitrate, binrate, bin2bit ratio (weighted, unweighted, peak, average) and other relevant test results will be reported by using the templates in JVET-N0049 and JVET-V0150.

# Time-line and Responsibilities

T1: 2021-May-14: Version of CE description with final descriptions of tests is uploaded. Any changes of planned tests after this time need to be announced and discussed on the JVET reflector. Initially assigned description numbers shall not be changed later. If a test is skipped, it is to marked as "withdrawn".

T2: VTM 13.0 + 2 week (not later than 2021-June-04): Integration of initial CE test SW into a separate CE branch of the VTM is completed and initial study by cross-checkers begins.

T3: T2 + 2 (not later than 2021-June-18):

Final version of CE tests software and full results are provided, final cross-check begins.

T4: 2021-June-25: CE contribution documents including specification text and complete test results are uploaded to the JVET document repository. Work on CE report is starting.

# References

[1] A. Browne, T. Ikai, D.  Rusanovskyy, M.Sarwer, X. Xiu, “Common test conditions for high bit depth and high bit rate video coding”, JVET-U2018, JVET, 21th Meeting: by teleconference, 20-28 April. 2021

[2] AHG8: On coding of last significant coefficient position for high bit depth and high bit rate extensions, F. Wang, L. Xu, Z. Xie, Y. Yu, H. Yu, D. Wang (OPPO) JVET-V0121.

[3] AHG8: Content Adaptive Transform Precision for High Bit Depth Coding, K. Naser, F. Galpin, F. Le Léannec, P. De Lagrange (InterDigital), JVET-V0133.

[4] AHG8: CABAC-bypass alignment for high bit-depth coding, M. G. Sarwer, J. Chen, Y. Ye, R. -L. Liao (Alibaba), JVET-V0059.

[5] AHG8: a full-bypass mode in residual coding for high bit depth and high bit rate extensions, F. Wang, Z. Xie, Y. Yu, H. Yu, D. Wang (OPPO), JVET-V0122.

[6] AHG8: a combination of JVET-V0059 option 2 and JVET-V0122 for high bit depth and high bit rate extensions, F. Wang, Z. Xie, Y. Yu, H. Yu, D. Wang (OPPO), JVET-V0178