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# Abstract

This document is a description of the HEVC Range Extensions Core Experiment 3 on intra block copy refinement.

# Technical Description

This document defines HEVC Range Extensions Core Experiment 3 (RCE3) on intra block copy (IntraBC) refinement to be performed for the upcoming January 2014 JCT-VC meeting.

# List of Participants

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# Tools to be tested

The CE is set up to study intra block copying search area/performance trade-offs, technical modifications and explore combinations.

## Test A: Search Area vs. Performance

In this subtest, various search area sizes are tested. The anchor is current CTU + left CTU (64 columns).

### Subtest A.1 to A.4

1. Current CTU + 4 left columns
2. Current CTU + 8 left columns
3. Current CTU + 16 left columns
4. Current CTU + 32 left columns

### Subtest A.5

1. Current CTU + 4 left columns + 4 top rows [part of JCTVC-O0074]

## Test B: Block partitioning

In this subtest, various search area sizes will be tested, including the following

### Subtest B.1 - N×2N/2N×N Intra Block Copy [JCTVC-O0205]

JCTVC-O0205 introduces a PU-based IntraBC mode which relaxes the restriction that the basic unit for IntraBC must be 2N×2N. When put into use, this mode splits CUs of size 2N×2N into 2N×N and N×2N PUs, following the current inter split modes, and predicts each PU with IntraBC. This subtest is conducted with no reference to prior PUs within a CU.

### Subtest B.2 - TU-based process [JCTVC-O0183]

IntraBC is performed at CU level, which means that overlap between a current CU and its reference CU leads to failure of direct block copy. JCTVC-O0183 describes that IntraBC can be conducted at TU level because reconstruction can be done TU by TU in intra blocks. Performing IntraBC at TU level can reduce the unavailable area caused by the overlap between a block and its reference.

This subtest tests the performance of IntraBC at TU level, which may also include forced TU splitting to avoid overlap between a TU and its reference.

### Subtest B.3 - N×N PU

Currently, IntraBC is only performed at CU level. In this subtest, IntraBC is extended to N×N PU for the smallest CU. Following current split modes for intra, each PU has a block vector (BV). For each PU, the prior PUs with in a CU can be used as the reference.

### Subtest B.4 - Sample masking for intra block copy [JCTVC-O0351]

JCTVC-O0351 proposes to signal a mask for the CUs coded with IntraBC mode. The mask is covering a square area extending from one of the borders of the CU and having a width varying from 1 to 3 sample rows or columns. All the sample values in the masked area are substituted with a single sample value obtained from the middle sample of the inner boundary of the mask. The black samples in figure below illustrate the location of the sample which value is used in the substitution process



**Figure. Example of masks on different borders of the prediction block**

The interaction of sample masking is studied in combination with different tools in the RCE. Depending on the combination, signaling of the mask area can take place either at CU, PU or TU level. Also different configurations of the mask area and reference sample location can be tested depending on the tool combination.

## Test C: Padding/Unavailable samples pre-set

Tests in this category are also performed with relaxed vector restrictions for overlap area (but the search area does not go beyond current CTU + left CTU).

### Subtest C.1 - All unavailable samples pre-set to default value [JCTVC-O0074]

Currently, IntraBC vector shall refer only to the area which contains only already reconstructed samples, and shall not refer to area in a different slice or tile. Because of this requirement, the reference block cannot overlap with current CU. JCTVC-O0074 proposes to pre-set all not available samples for IntraBC samples with default value (mid grey) and so, relax vector restriction.

### Subtest C.2 - Padding CU horizontally [JCTVC-O0157]

Currently, for the CUs with IntraBC mode, all the samples in reference block need to be reconstructed samples. Because of this requirement, the reference block cannot overlap with current CU. JCTVC-O0157 proposes to extend IntraBC to the situation where the reference block is overlapped with current CU and the reference block is completed by horizontal padding. This subtest tests the performance of IntraBC with horizontal padding.

### Subtest C.3 - Padding CTU horizontally [JCTVC-O0157]

Similar to subtest C.2, but in this case, this subtest tests the performance of horizontal padding for the entire CTU before it is processed.

### Subtest C.4 - Padding horizontally or vertically [JCTVC-O0112]

When the current CU to be predicted by IntraBC overlaps the reference CU, the prediction samples in the overlapped region are generated by copying the available samples from either vertical or horizontal direction depending on relationship between BVx, BVy (horizontal and vertical components of the block vector, respectively), W, and H (width and height of the current CU, respectively). The proposed reference sample generation method is invoked only when the following condition is satisfied:

( –W < BVx ≤ 0 ) && ( –H < BVy ≤ 0 ).

When |BVy| > |BVx|, the reference samples are generated by copying the reference samples of the bottommost row of the above CU,



Otherwise, when |BVy| ≤ |BVx|, the reference samples are generated by copying the reference samples of the rightmost column of the left CU,



## Test D: Combinations

This section describes combinations of tests in the previous sections. Additional combinations might be considered after the assessment of the above tests.

### Subtest D.1

The subtest tests the combination of subtests B.1 (N×2N/2N×N IntraBC) and B.2 (TU Process). In this subtest, prior PUs within the current CU can be referenced.

### Subtest D.2

The subtest tests the combination of subtests B.1 (N×2N/2N×N IntraBC) and B.3 (IntraBC for N×N PU at the smallest CU size). In this subtest, prior PUs within the current CU cannot be referenced.

# List of Testers and Cross-checks

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| **Subtest** | **Method** | **Tester** | **Cross-checker** |
| A.1 … A.4 | Left search area | Qualcomm & Samsung | - |
| A.5 | CTU + 4 columns + 4 rows | Samsung | Canon |
| B.1 | N×2N/2N×N PU | NCTU/ITRI | Mediatek |
| B.2 | TU-based process | Microsoft | BBC |
| B.3 | N×N PU | Qualcomm | NCTU/ITRI |
| B.4 | Masking | Nokia | Sony |
| C.1 | Unavailable samples pre-set | Samsung | Qualcomm |
| C.2 | Padding CU horizontally | Qualcomm | Samsung |
| C.3 | Padding CTU horizontally | Qualcomm | Canon |
| C.4 | Padding horizontally/vertically | Samsung | Mitsubishi |
| D.1 | B.1 + B.2 | NCTU/ITRI | Samsung |
| D.2 | B.1 + B.3 | NCTU/ITRI | Mediatek |

# Test Conditions

RExt5.0 will be used for all experiments. The AHG8 test conditions will be used to evaluate the SCC lossy and lossless operating points.

# Evaluation of CE results

Results of the CE will be evaluated on the basis of BD-rate results and complexity. The complexity assessment will be performed on the basis of encoding/decoding complexity.

## Complexity

To measure software run times, range extension software with the provided configurations and the proposals implemented on range extension software shall be used. The computational time must be measured for each test sequence and test case for both anchor and proposals. Relative computational time calculated against the anchor must be presented.

Additional evaluation of the HW and SW complexity of the proposed tools for both encoder and decoder is encouraged.

# Timeline

* November 22nd, 2013: CE description finalized and uploaded.
* November 22nd, 2013: Test conditions are finalized with AHG8.
* November 22nd, 2013 (tentative): RExt5.0 software available.
* Range extension software availability date + 2 weeks: Cross-check begins. Proponents for tests A B and C provide software, draft specification text and results to CE participants.
* Range extension software availability date + 4 weeks: Proponents for tests D provide software, draft specification text and results to CE participants.
* January 3rd, 2014: Input documents and summary report uploaded.