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| **Joint Collaborative Team on Video Coding (JCT-VC)**  **of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29/WG 11**  12th Meeting: Geneva, CH, 14–23 Jan. 2013 | Document: JCTVC-L0023r1 |

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| *Title:* | **TE3: Summary Report of Tool Experiment on Combined Prediction in SHVC** | | |
| *Status:* | TE report input to JCT-VC | | |
| *Purpose:* | TE report | | |
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| *Source:* | TE coordinators | | |

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# Abstract

This document reports tool experiment activities of combined prediction in SHVC (TE3) between the 11th JCT-VC meeting in Shanghai, China (10–19 October 2012) and 12th JCT-VC meeting in Geneva, Switzerland (14–23 Jan. 2013).

# Introduction

Combined prediction techniques for SHVC are studied in this TE according to [1].

# Document list

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| --- | --- | --- | --- |
| Test | Subtests | Proposals and short descriptions | Crosschecking documents |
| 4.1 Intra prediction based on reconstructed base layer | 4.1.2 | JCTVC-L0036 (Nokia)  dc\_delta is added to the Intra Prediction block when size >= 8x8. dc\_delta = (DC of BL Pred block) - (DC of EL Pred block). | JCTVC-L0235 (Qualcomm) |
| 4.1.3 | JCTVC-L0099 (LG)  Unavailable ref samples for Intra Prediction at EL are replaced by collocated BL samples. | JCTVC-L0270 (Sharp) |
| 4.2 Intra prediction based on differential picture | 4.2.1 | JCTVC-L0037 (Nokia)  Intra horizontal and vertical prediction modes at EL are replaced by new modes which combine EL and BL layer as Pred\_el = Ref\_el + Rec\_bl - Ref\_bl. No additional Signaling. | JCTVC-L0342 (MediaTek) |
| 4.2.2 | JCTVC-L0222 (Qualcomm)  CU level Diff domain Intra Prediction. MDIS is disabled in Diff Mode. Planar Mode is modified to set all the pixels in the bottom-right portion ((x + y) >= N-1) to zero in diff mode. | JCTVC-L0079 (Samsung)  JCTVC-L0253 (Gent) |
| 4.2.3 | JCTVC-L0135 (LG)  CU Level Diff Domain Intra Prediction. Diff signal is clipped to [-128,127] | JCTVC-L0237 (Qualcomm) |
| 4.2.4 | JCTVC-L0183 (Vidyo/Samsung)  CU level Diff Intra Prediction. Offset 128 is added to diff signal to keep the dynamic range of [0, 255] | JCTVC-L0217 (MediaTek) |
| 4.3 Inter prediction based on reconstructed base layer | 4.3.1 | JCTVC-L0072 (MediaTek)  Rec\_el=Clip((Pred\_el+Rec\_bl)/2+Residue\_el). CU level signaling. | JCTVC-L0354 (TI) |
| 4.4 Inter prediction based on differential picture | 4.4.1 | JCTVC-L0136 (LG)  CU level diff-inter prediction. Diff signal is clipped to [-128, 127] | JCTVC-L0081 (Qualcomm) |
| 4.4.2 | JCTVC-L0184 (Vidyo/Samsung)  CU level diff-inter prediction. Offset 128 was added to diff signal to keep the dynamic range of [0, 255]. Bi-linear interpolation for sub-pel diff blocks. Deblocking BS=1 for the diff/non-diff boundary. | JCTVC-L0218 (MediaTek) |
| 4.5 SVC style residual prediction | 4.5.1 | JCTVC-L0286 (Intel)  SVC style residual prediction. The signaling is at CU level for intra while PU level for inter. Base residues are bi-linearly up-sampled. | JCTVC-L0343 (MediaTek) |
| 4.6 Generalized residual prediction | 4.6.1 | JCTVC-L0100 (Canon)  CU level signaling. Pred\_el=Ref\_el+Rec\_bl-Ref\_bl. This method does not apply to skip mode. | JCTVC-L0095 (Samsung) |
| 4.6.2.1 | JCTVC-L0078 (Qualcomm)  CU level signaling. Pred\_el=Ref\_el + w\*(Rec\_bl-Ref\_bl), w= 0.5, 1. Interpolation directly on differential block for sub-pel positions. Fast GRP mode selection method (encoder only). Additional options: 4-tap up-sampling filter. Additional motion estimation in differential pictures (encoder only).  Test 1: GRP (0.5)  Test 2: GRP (0.5, 1) + Fast GRP mode selection  Test 3: GRP (0.5, 1) + Fast GRP mode selection + 4-tap up-sampling filter for GRP mode  Test 4 (recently released): Test 1 + additional motion estimation  Test 5 (recently released): Test 2 + additional motion estimation | JCTVC-L0141 (LG)  JCTVC-L0063 (ETRI) |
| 4.6.2.2 | JCTVC-L0206 (Qualcomm)  Combined prediction of base and enhancement layer. Rec\_el=Clip(Pred\_el+Rec\_bl+1)/2+Residue\_el) | JCTVC-L0064 (ETRI) |
| 4.6.3 | JCTVC-L0038 (Nokia)  PU level signaling. Pred\_el=Ref\_el + w\*(Rec\_bl-Ref\_bl), w=0.5, 1 | JCTVC-L0082 (Qualcomm)  JCTVC-L0080 (Samsung) |

Notations: Rec\_bl and Rec\_el denote the reconstruction of base layer and enhancement layer, Pred\_el indicates the prediction of enhancement layer, Ref\_bl and Ref\_el are up-sampled reference picture of base layer and enhancement layer (for intra blocks, Ref\_bl/Ref\_el represents the intra prediction in base/enhancement layer), and Residue\_el is the residue of enhancement layer.

# Summary of Results

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Subtests | Proposal | Test case | Results (BD-rate reduction of EL+BL) | | | | | Average of Coding Gain and Geometry Mean of Coding Time | | | | |
| Y | U | V | EncT | DecT | Y | U | V | EncT | DecT |
| 4.1 Intra prediction based on reconstructed base layer | 4.1.2 | AI-2x | -0.2% | -0.1% | 0.0% | 105% | 99% | -0.2% | 0.0% | 0.0% | 105% | 100% |
| AI-1.5x | -0.1% | 0.0% | 0.0% | 105% | 101% |
| 4.1.3  (Inter results are not mandatory) | AI-2x | -0.2% | -0.1% | -0.1% | 102% | 101% | -0.1% | -0.1% | -0.1% | 102% | 101% |
| AI-1.5x | -0.1% | 0.0% | -0.1% | 102% | 101% |
| RA-2x | -0.1% | -0.1% | -0.1% | 100% | 100% | 0.0% | -0.1% | -0.1% | 100% | 100% |
| RA-1.5x | 0.0% | -0.1% | -0.1% | 100% | 100% |
| RA-SNR | 0.0% | 0.0% | 0.0% | 102% | 102% |
| LDP-2x | 0.0% | -0.1% | -0.1% | 100% | 99% |
| LDP-1.5x | 0.0% | -0.1% | -0.1% | 101% | 100% |
| LDP-SNR | 0.0% | -0.1% | -0.1% | 99% | 99% |
| 4.2 Intra prediction based on differential picture | 4.2.1 | AI-2x | -0.3% | -0.1% | -0.2% | 101% | 99% | -0.3% | -0.1% | -0.1% | 100% | 99% |
| AI-1.5x | -0.2% | 0.0% | -0.1% | 99% | 100% |
| 4.2.1 + 4.1.2 | AI-2x | -0.4% | -0.2% | -0.2% | 105% | 99% | -0.4% | -0.1% | -0.2% | 104% | 100% |
| AI-1.5x | -0.3% | 0.0% | -0.1% | 104% | 101% |
| 4.2.2 | AI-2x | -1.1% | -0.3% | -0.5% | 160% | 109% | -0.9% | 0.0% | -0.2% | 156% | 108% |
| AI-1.5x | -0.8% | 0.2% | 0.0% | 151% | 107% |
| 4.2.3 | AI-2x | -0.9% | -0.4% | -0.6% | 163% | 110% | -0.8% | -0.1% | -0.3% | 159% | 109% |
| AI-1.5x | -0.6% | 0.1% | 0.0% | 154% | 109% |
| 4.2.4 | AI-2x | -0.9% | -0.5% | -0.7% | 177% | 141% | -0.8% | -0.2% | -0.4% | 171% | 142% |
| AI-1.5x | -0.6% | 0.0% | -0.2% | 166% | 143% |
| 4.3 Inter prediction based on reconstructed base layer | 4.3.1 | RA-2x | -0.4% | -1.7% | -1.9% | 105% | 101% | -1.2% | -3.3% | -3.8% | 104% | 100% |
| RA-1.5x | -0.6% | -2.3% | -2.7% | 103% | 100% |
| RA-SNR | -0.8% | -3.3% | -3.9% | 103% | 100% |
| LDP-2x | -1.2% | -2.6% | -3.0% | 105% | 100% |
| LDP-1.5x | -1.5% | -4.1% | -4.7% | 103% | 99% |
| LDP-SNR | -2.4% | -6.0% | -7.0% | 104% | 100% |
| 4.4 Inter prediction based on differential picture | 4.4.1 | RA-2x | -1.8% | -3.3% | -3.3% | 165% | 104% | -2.0% | -3.5% | -3.7% | 153% | 103% |
| RA-1.5x | -2.4% | -4.3% | -4.5% | 154% | 101% |
| RA-SNR | -1.5% | -3.5% | -3.7% | 145% | 105% |
| LDP-2x | -2.0% | -2.9% | -3.0% | 161% | 106% |
| LDP-1.5x | -2.8% | -4.2% | -4.3% | 149% | 101% |
| LDP-SNR | -1.5% | -3.0% | -3.1% | 143% | 105% |
| 4.4.2 | RA-2x | -1.7% | -2.6% | -2.6% | 182% | 137% | -2.4% | -3.7% | -3.7% | 168% | 131% |
| RA-1.5x | -2.1% | -3.8% | -3.9% | 170% | 138% |
| RA-SNR | -1.7% | -3.7% | -4.0% | 157% | 115% |
| LDP-2x | -2.7% | -2.9% | -2.5% | 179% | 139% |
| LDP-1.5x | -3.3% | -4.5% | -4.4% | 165% | 140% |
| LDP-SNR | -2.7% | -4.9% | -5.2% | 155% | 118% |
| 4.5 SVC style residual prediction | 4.5.1 | AI-2x | -0.1% | -0.1% | -0.1% | 172% | 109% | -0.1% | 0.0% | 0.0% | 167% | 109% |
| AI-1.5x | 0.0% | 0.0% | 0.0% | 163% | 109% |
| RA-2x | -0.3% | -0.8% | -0.9% | 103% | 112% | -0.4% | -0.9% | -1.0% | 103% | 110% |
| RA-1.5x | -0.5% | -1.1% | -1.3% | 103% | 114% |
| RA-SNR | -0.3% | -0.8% | -0.9% | 103% | 100% |
| LDP-2x | -0.1% | -0.6% | -0.7% | 103% | 115% |
| LDP-1.5x | -0.6% | -1.3% | -1.4% | 103% | 117% |
| LDP-SNR | -0.3% | -0.7% | -0.7% | 103% | 102% |
| 4.6 Generalized residual prediction | 4.6.1 | RA-2x | -1.5% | -2.5% | -2.5% | 155% | 85% | -1.6% | -2.8% | -2.9% | 143% | 83% |
| RA-1.5x | -1.8% | -3.2% | -3.3% | 143% | 80% |
| RA-SNR | -1.1% | -2.7% | -2.9% | 132% | 80% |
| LDP-2x | -1.8% | -2.5% | -2.5% | 154% | 81% |
| LDP-1.5x | -2.3% | -3.5% | -3.5% | 142% | 87% |
| LDP-SNR | -1.3% | -2.4% | -2.6% | 133% | 87% |
| 4.6.2.1  Test1 | RA-2x | -1.5% | -2.9% | -3.0% | 121% | 108% | -2.4% | -3.0% | -2.8% | 118% | 107% |
| RA-1.5x | -2.3% | -3.7% | -4.0% | 116% | 107% |
| RA-SNR | -1.7% | -3.6% | -3.9% | 114% | 110% |
| LDP-2x | -2.4% | -2.2% | -1.7% | 122% | 105% |
| LDP-1.5x | -3.4% | -2.6% | -1.5% | 117% | 105% |
| LDP-SNR | -3.2% | -3.1% | -2.6% | 116% | 106% |
| 4.6.2.1  Test2 | RA-2x | -1.9% | -4.0% | -4.2% | 119% | 105% | -2.8% | -4.3% | -4.2% | 116% | 104% |
| RA-1.5x | -2.8% | -5.2% | -5.6% | 111% | 103% |
| RA-SNR | -2.1% | -4.7% | -5.2% | 114% | 107% |
| LDP-2x | -2.7% | -3.4% | -3.0% | 124% | 102% |
| LDP-1.5x | -3.9% | -4.3% | -3.5% | 113% | 101% |
| LDP-SNR | -3.4% | -4.2% | -3.8% | 118% | 105% |
| 4.6.2.1  Test3 | RA-2x | -2.3% | -3.4% | -3.6% | 119% | 125% | -3.5% | -3.7% | -3.8% | 116% | 129% |
| RA-1.5x | -3.0% | -4.1% | -4.6% | 111% | 125% |
| RA-SNR | -2.8% | -4.3% | -4.8% | 113% | 141% |
| LDP-2x | -3.4% | -3.1% | -2.7% | 123% | 124% |
| LDP-1.5x | -4.5% | -3.6% | -3.0% | 113% | 123% |
| LDP-SNR | -4.8% | -4.0% | -3.8% | 117% | 141% |
| 4.6.2.1  Test4 (**recently released**) | RA-2x | -2.0% | -3.6% | -3.6% | 171% | 110% | -3.1% | -3.7% | -3.4% | 159% | 109% |
| RA-1.5x | -2.7% | -4.1% | -4.4% | 160% | 109% |
| RA-SNR | -2.4% | -4.5% | -4.8% | 149% | 113% |
| LDP-2x | -3.0% | -2.9% | -2.3% | 168% | 107% |
| LDP-1.5x | -4.1% | -3.0% | -2.0% | 158% | 106% |
| LDP-SNR | -4.2% | -4.0% | -3.5% | 148% | 109% |
| 4.6.2.1  Test5  (**recently released**) | RA-2x | -2.4% | -4.5% | -4.5% | 156% | 105% | -3.4% | -4.8% | -4.7% | 148% | 105% |
| RA-1.5x | -3.2% | -5.5% | -5.8% | 140% | 105% |
| RA-SNR | -2.6% | -5.4% | -5.8% | 139% | 108% |
| LDP-2x | -3.4% | -4.0% | -3.5% | 162% | 103% |
| LDP-1.5x | -4.7% | -4.8% | -4.0% | 143% | 101% |
| LDP-SNR | -4.3% | -4.9% | -4.5% | 146% | 106% |
| 4.6.2.2 | RA-2x | -0.4% | -1.9% | -2.1% | 122% | 103% | -1.2% | -3.6% | -4.2% | 116% | 100% |
| RA-1.5x | -0.6% | -2.5% | -3.0% | 114% | 99% |
| RA-SNR | -0.8% | -3.5% | -4.1% | 113% | 102% |
| LDP-2x | -1.2% | -2.9% | -3.3% | 118% | 97% |
| LDP-1.5x | -1.5% | -4.6% | -5.3% | 113% | 98% |
| LDP-SNR | -2.5% | -6.4% | -7.5% | 115% | 101% |
| 4.6.3 | RA-2x | -1.7% | -3.6% | -3.8% | 122% | 103% | -2.4% | -3.8% | -4.0% | 115% | 104% |
| RA-1.5x | -2.5% | -4.5% | -4.9% | 113% | 110% |
| RA-SNR | -1.6% | -4.2% | -4.7% | 114% | 104% |
| LDP-2x | -2.3% | -2.9% | -2.8% | 117% | 103% |
| LDP-1.5x | -3.4% | -3.8% | -3.6% | 109% | 100% |
| LDP-SNR | -2.9% | -3.8% | -4.2% | 114% | 103% |

# Recommendations

It is recommended to discuss all the proposals in JCT-VC meeting and adopt promising one(s).

# References

1. X. Li, E. Francois, P. Lai, D. Kwon, A. Saxena, “Description of Tool Experiment B3: Combined Prediction in SHVC”, doc. JCTVC-K1103, 11th Meeting of Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, Shanghai, China, 10–19 Oct. 2012.

# Appendix – list of related non-TE proposals

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| --- | --- | --- |
| Proposals | Title | Crosschecking documents |
| JCTVC-L0074 (MediaTek) | Non-TE3: Adaptive predictor compensation with generalized residual prediction | JCTVC-L0196 (Qualcomm) |
| JCTVC-L0084 (Samsung) | Non TEB3: Bi-directional optical flow for inter-layer texture prediction | JCTVC-L0243 (LG) |
| JCTVC-L0104 (Canon) | Non-TE3: Simplification of Generalized Residual Inter-Layer Prediction (GRILP) in SHVC | JCTVC-L0383 (Qualcomm) |
| JCTVC-L0140 (LG) | Non-TE3: Modifications on inter-layer texture, DC, planar predictions | JCTVC-L0312 (Intel) |
| JCTVC-L0190 (Qualcomm) | Non-TE3: Extension of Test 4.6.2.1 on Generalized Residual Prediction | JCTVC-L0327 (I2R) |
| JCTVC-L0193 (Technicolor) | Base Layer residue upsampling and skip mode |  |
| JCTVC-L0211 (Qualcomm) | NonTE3/4: Combination of TE-B4 4.2.1 Adaptive Up-sampling Filter and TE3 4.6.2.1 Generalized Residual Prediction | JCTVC-L0314 (Intel) |
| JCTVC-L0215 (Sony) | Non-TE3: Cross-checking and simplification of intra residual planar prediction in TE3-4.2.2 |  |
| JCTVC-L0265 (Sony) | On interpolation filter for Generalized Residual Prediction |  |
| JCTVC-L0267 (Sharp) | Hybrid Intra and Inter-layer Prediction | JCTVC-L0273 (Samsung) |
| JCTVC-L0278 (Sony) | On Inter-layer Prediction | JCTVC-L0326 (Sharp)  JCTVC-L0337 (JVC Kenwood) |
| JCTVC-L0294 (Qualcomm) | Non-TE3 : Simplification of Difference Intra Prediction In SHVC | JCTVC-L0329 (LG) JCTVC-L0384 (Qualcomm) |
| JCTVC-L0412 (Samsung) | Non-TE 3: On estimation theoretic prediction for enhancement layer residual in scalable video coding |  |