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| *Title:* | **AHG19: A QP-based enabling method for lossless coding in HEVC** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

Lossless coding can be used in many practical applications, such as medical imaging, remote desktop sharing, online gaming, etc. In this contribution, we propose a method that enables lossless coding in HEVC without change to the HEVC syntax specification. This is done by using QP to signal a HEVC video codec whether a CU employs lossless coding. Specifically, if QP is equal to the smallest QP value (e.g. QP=0 for the 8-bit bit-depth case) for a CU, lossless coding is applied, i.e., inverse quantization, inverse transform, de-blocking filter, SAO and ALF are all bypassed for this coding unit (JCTVC-G664). Furthermore, the sample-based intra prediction method (SAP), as proposed in JCTVC-H083 for lossless coding, can be used to replace the existing intra prediction method and signaled by this proposal as well. With this signaling method, the lossless coding mode can be applied to the entire picture or to individual CUs conveniently. The HM5.0 software has been modified to incorporate this signaling method. Test results are shown to demonstrate the effectiveness of this signaling method.

# Introduction

In recent years, we observe more and more usage of lossless coding in real-world applications, such as medical imaging, remote desktop sharing, online gaming, etc. It's highly desirable to incorporate a lossless coding mode in the current HEVC working draft.

To achieve lossless coding, the transform and quantization and their inverse operations are bypassed in the encoder and decoder since the existing HEVC transforms are not reversible in general. Without transform operation, sample based intra predictions, as proposed in [1][2], become possible. In lossless coding, no distortion is introduced in reconstructed CUs. Thus, all the in-loop filtering operations including deblocking filter, SAO and ALF should be bypassed.

To avoid the potential coding performance loss for the lossy case and to minimize the necessary changes to the HEVC specification, we propose not to add any additional flag and instead to use QP to indicate the lossless coding mode. Using this method, the lossless coding mode can be conveniently applied to the entire picture or at CU level.

To demonstrate the effectiveness of the software, we have modified the HM5.0 software to incorporate the QP signaling which enables the lossless coding mode at picture level and CU level by bypassing the transform, quantization, deblocking filter, SAO and ALF operations, The software also includes the SAP method proposed in [2] which is also enabled by the proposed QP signaling method. The corresponding test results are also provided in this contribution.

# Mechanism to indicate the lossless coding mode

As mentioned above, to allow a decoder to decode HEVC bit stream correctly, we propose to indicate lossless coding of a coding unit (CU) by setting its quantization parameter QP’Y equals 0, where QP’Y = QPY + QpBdOffsetY as defined in the WD (JCTVC-G1103\_d9). For those CUs using lossless coding mode, the internal bit depth is set to the input bit depth and the de-blocking filter, SAO and ALF are all disabled.

We use two examples to illustrate the usage of this signaling mechanism. The main motivation of using the existing quantization parameter (QP’Y = 0) to indicate the lossless mode is that no new syntax element is introduced to the bit stream, and as a result, the coding performance of HEVC for the lossy mode would not be impacted or compromised by adding this new mode. In addition, using QP’Y also brings us the flexibility in the sense that this lossless mode can be used not only for the entire picture or a slice but also for the individual CUs as well.

In the first example, to indicate the lossless coding for a video picture, we can simply set the following syntax elements in the bit stream

* Set pic\_init\_qp\_minus26=-26 in picture parameter set (PPS)
* Set max\_cu\_qp\_delta\_depth=0 in picture parameter set (PPS)
* Set slice\_qp\_delta = 0 in slice header.

Based on this setting, QP’Y=0 will be used for all CUs in the video picture thus indicating lossless coding for the whole picture. Note the above syntax element settings are based on JCTVC\_G1103\_d9.

In another example, to enforce lossless compression on any individual CUs in a video picture whenever necessary, we can set following syntax elements in the bit stream.

* Set pic\_init\_qp\_minus26 as usual for lossy coding
* Set max\_cu\_qp\_delta\_depth and slice\_qp\_delta as usual for lossy coding
* Set cu\_qp\_delta in a CU to a value such that the derived QP’Y equal to 0 thus indicating lossless coding for the CU.

Based on this setting, QP’Y is set to zero for those CUs using the lossless coding mode. Note the above syntax element settings are based on JCTVC\_G1103\_d9.

To demonstrate the benefit of applying lossless coding on individual CUs, we have encoded the SlideEditing sequence in ClassF using (1). fixed QP=37 and (2). QP=37 mixed with several lossless coded LCUs that are in the second LCU row. The results are shown below, where LCU [1, 1], [1, 11], [1, 12], [1, 14], [1, 15], [1, 16], [1, 17], [1, 18], and [1, 19] were encoded using the proposed lossless mode in Figure 2.

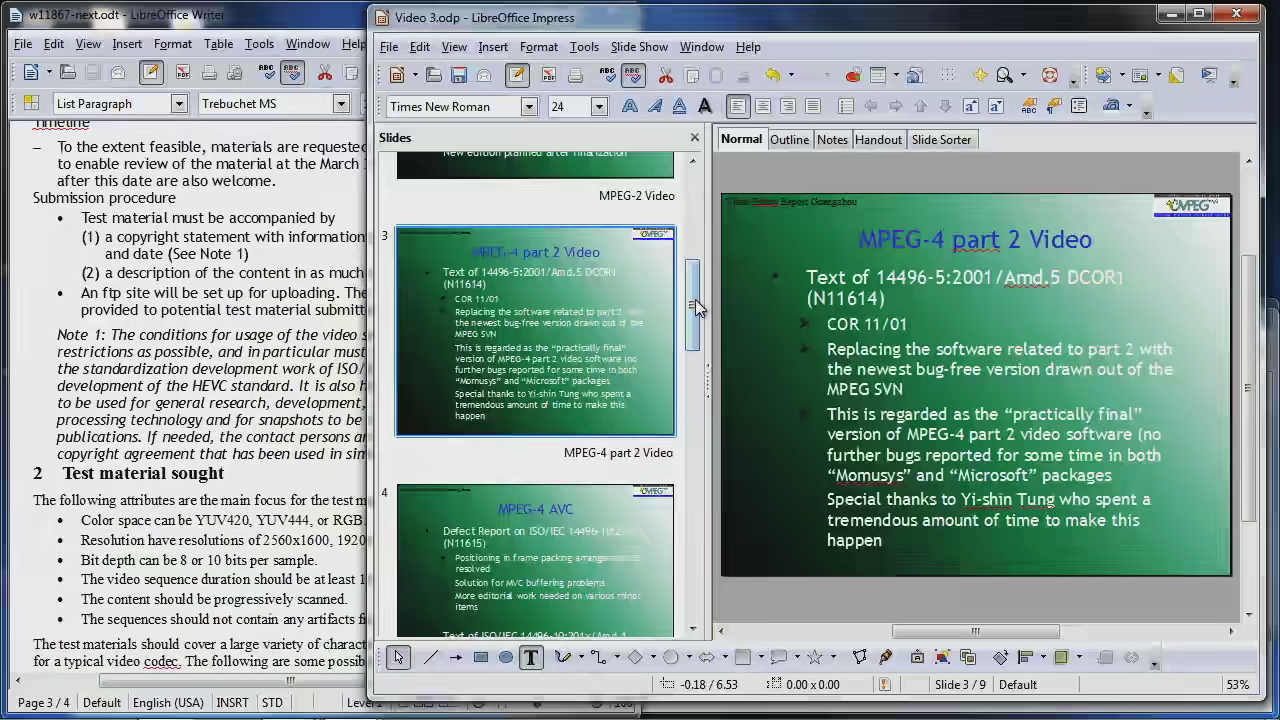


Figure 1. HM5 with fixed QP=37

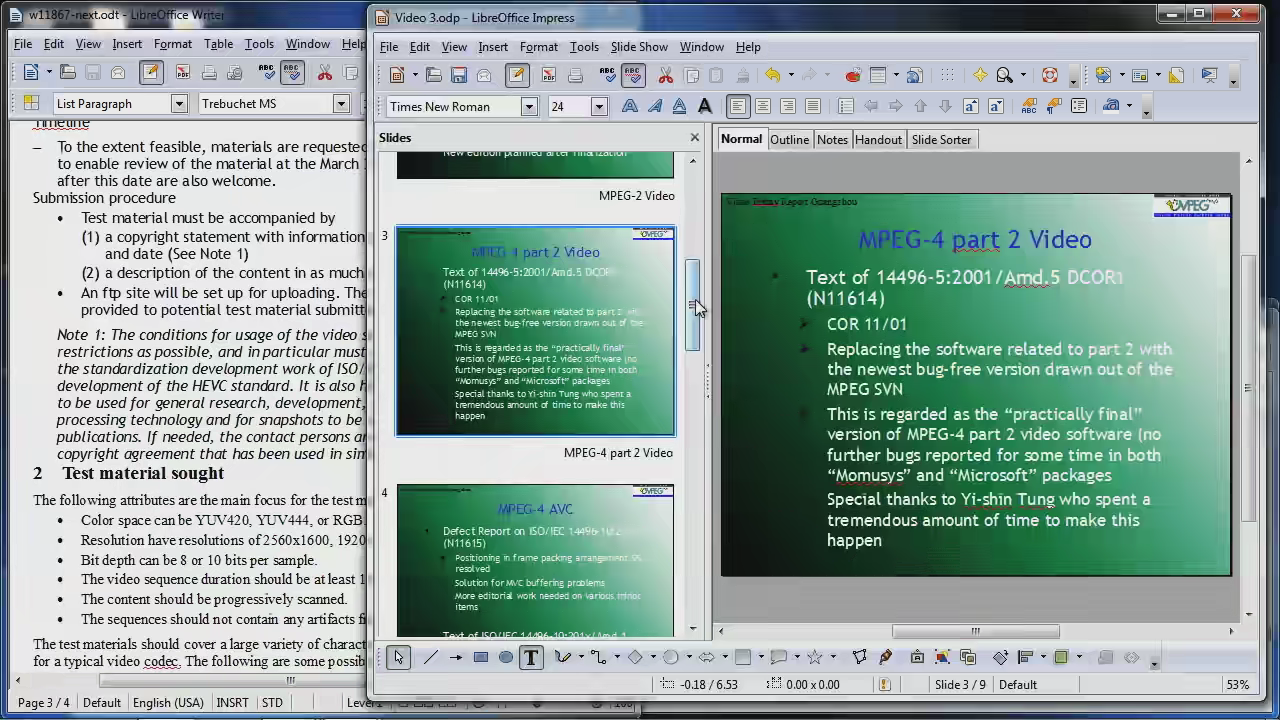


Figure 2. HM5 QP=37 mixed with several lossless coded LCUs that are in the second LCU row".

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# Test Settings and Conditions

The modified HM5.0 software is used for the simulations of this document. The software was developed by adding the proposed signaling method in the software used in H0083 while maintaining its sample-based intra prediction method. The simulation platform is 64-bit Windows 7 based machines equipped with Intel(R) Core i7 operating at 3.47 GHz and 18GB memory. In the simulations, RDOQ, deblocking filter, SAO and ALF are also configured to be on but are disabled when lossless coding mode is used. The internal bit depth is always set to the input bit depth.

# Experimental results

In Table 1 and Figure 3, results of three tests are compared using a ClassF sequence, SlideEdting, as the test sequence and AI-HE test condition.

(1) In the first test, the HM5.0 software (HM-5.0-bugfix) with QP=0 and QP=5 are used as anchors [3].

(2) In the second test, denoted as HM5.0 lossless coding, the modified HM5.0 software is used with the following setting;

* QP set to 0 in the configuration file
* Delta QP is disabled by setting MaxDeltaQP=0 and MaxCuDQPDepth=0 to achieve picture level lossless coding.

(3) In the third test, denoted as HM5.0 mixed coding, the modified HM5.0 software is used with the following Setting:

* QP is configured to 5;
* CU-level delta QP is enabled by setting MaxDeltaQP=1 and MaxCuDQPDepth=2;
* Encoder RDO process is modified to allow the encoder choose between QP’Y=0 (lossless coding) and QP’Y=5 (HM5.0 lossy coding). Thus mixed coding is achieved.

As shown in Table 1 and Figure 3, the bit rate of the HM5.0 anchor, QP=0 and QP=5, is larger than the HM5.0 lossless coding and the HM5.0 mixed coding, while also resulting in lower PSNR value. The HM5.0 lossless test achieves Y-PSNR 99.99 dB, indicating no distortion between the input video and the reconstructed video, i.e., lossless coding. One important observation is that the HM5.0 lossless coding still achieves lower bit rate than that from HM5.0 coding with QP=5 as well as that from HM5.0 mixed coding with QP=5, while maintaining perfect quality. Comparing the HM5.0 with QP=5 and the HM5.0 Mixed with QP=5, the mixed coding solution results in less bitrate and, in the meantime, higher PSNR. This clearly demonstrates the effectiveness of the QP signaling.

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|  | Bit Rate (kbps) | Y-PSNR (dB) |
| HM 5.0 with QP=0 | 129830.56 | 71.54 |
| HM 5.0 with QP=5 | 93718.39 | 60.30 |
| HM 5.0 Mixed QP=5 | 82934.91 | 98.13 |
| HM 5.0 Lossless | 82461.61 | 99.99 |

Table 1. Simulation results of the three tests

Figure 3. Graph of the simulation results of the three tests

In addition to the above tests, to confirm that the new software doesn’t break the existing quantization process, we have also performed the tests with QP=1, which results in the same results as obtained from the HM-5-bugfix software. The detailed test results are provided in the attached spreadsheet. Many thanks to I2R (Yih Han Tan Chou Han Yeo, and Zhengguo Li), they have cross-checked these tests as well as the software. The cross-check report is in H0673.

# Conclusion and recommendation

It is recommended to adopt this signaling method into HM test model and HEVC working draft to enable lossless coding mode at both picture and CU levels.

# References

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# Patent rights declaration(s)

**Huawei Technologies (USA) may have IPR relating to the technology described in this contribution and, conditioned on reciprocity, is prepared to grant licenses under reasonable and non-discriminatory terms as necessary for implementation of the resulting ITU-T Recommendation |ISO/IEC International Standard (per box 2 of the ITU-T/ITU-R/ISO/IEC patent statement and licensing declaration form).**

# WD text changes

The changes to the HEVC WD (JCTVC-G1103\_d9) and “Missing description about pcm\_sample\_loop\_filter\_disable\_flag for SAO” (WD Ticket #301) are given in details in the attachment of JCTVC-H0528-WD.doc and JCTVC-H0528-WD-supplement-SAO.doc.