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| *Title:* | **AHG13: On signalling of MSB cycle for long-term reference pictures** | | |
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| *Author(s) or Contact(s):* | Adarsh K. Ramasubramonian Rajan Joshi Ye-Kui Wang  5775 Morehouse Drive San Diego, CA 92121-1714 USA | Tel: Email: | 1-858-658-5804 [aramasub@qualcomm.com](mailto:aramasub@qualcomm.com)  1-858-658-4511 [rajanj@qualcomm.com](mailto:rajanj@qualcomm.com)  1-858-651-8345 [yekuiw@qualcomm.com](mailto:yekuiw@qualcomm.com) |
| *Source:* | Qualcomm Incorporated | | |

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# Abstract

This document proposes changes to the semantics of the syntax elements poc\_lsb\_lt[ i ], delta\_poc\_msb\_present\_flag[ i ], and delta\_poc\_msb\_cycle\_lt[ i ] to improve the efficiency of signalling the MSB cycle for long-term reference pictures in the slice header. In alignment with the proposed changes to the semantics, changes to the RPS derivation process are also proposed, including swapping of the order of STRP and LTRP subset derivations, such that the STRP subset is derived first.

If the proposal in JCTVC-J0115 is adopted, then this proposal is claimed to become irrelevant and should be ignored.

Revision 1 of JCTVC-J0118 includes a different change to the RPS derivation process.

# Introduction

The current semantics of poc\_lsb\_lt[ i ], delta\_poc\_msb\_present\_flag[ i ], and delta\_poc\_msb\_cycle\_lt[ i ] in the slice header are as follows.

**poc\_lsb\_lt**[ i ] specifies the value of the least significant bits of the picture order count value of the i-th long-term reference picture that is included in the long-term reference picture set of the current picture. The length of the poc\_lsb\_lt[ i ] syntax element is log2\_max\_pic\_order\_cnt\_lsb\_minus4 + 4 bits. For any values of j and k in the range of 0 to num\_long\_term\_pics – 1, inclusive, if j is less than k, poc\_lsb\_lt[ j ] shall not be less than poc\_lsb\_lt[ k ].

**delta\_poc\_msb\_present\_flag[ i ]** equal to 1 specifies that delta\_poc\_msb\_cycle\_lt[ i ] is present. delta\_poc\_msb\_present\_flag[ i ]equal to 0 specifies that delta\_poc\_msb\_cycle\_lt[ i ] is not present. delta\_poc\_msb\_present\_flag[ i ] shall be equal to 1 when there is more than one reference picture in the decoded picture buffer with the least significant bits of the picture order count value equal to poc\_lsb\_lt[ i ].

**delta\_poc\_msb\_cycle\_lt**[ i ]is used to determine the value of the most significant bits of the picture order count value of the i-th long-term reference picture that is included in the long-term reference picture set of the current picture.

The variable DeltaPocMSBCycleLt[ i ] is derived as follows.

if( i = = 0 | | poc\_lsb\_lt[ i − 1 ] ! = poc\_lsb\_lt[ i ] )   
 DeltaPocMSBCycleLt[ i ] = delta\_poc\_msb\_cycle\_lt[ i ]   
 else (7‑43)  
 DeltaPocMSBCycleLt[ i ] = delta\_poc\_msb\_cycle\_lt[ i ] + DeltaPocMSBCycleLt[ i − 1 ]

The value of DeltaPocMSBCycleLt[ i ] \* MaxPicOrderCntLsb + pic\_order\_cnt\_lsb – poc\_lsb\_lt[ i ] shall be in the range of 1 to 224 – 1, inclusive.

The semantics have the following deficiencies.

1. In the latest semantics as described in HEVC WD7, it is given that *“delta\_poc\_msb\_present\_flag[ i ] shall be equal to 1 when there is more than one reference picture in the decoded picture buffer with the least significant bits of the picture order count value equal to poc\_lsb\_lt[ i ].”* The value of delta\_poc\_msb\_present\_flag[ i ] thus depends on the reference pictures in the DPB. If there are reference pictures in the DPB that are marked as “unused for reference”, the value of delta\_poc\_msb\_present\_flag[ i ] will depend on those pictures too. This is not desirable as the pictures in DPB that are marked “unused for reference” are present only waiting to be output and whether such pictures are present in the DPB depends on the decoder output schedule. Given a bitstream, systems and applications may apply different output schedules based on the delay requirement and the available memory that can be used to store decoded pictures, by setting appropriate values for picture output times. Thus, counting such pictures may not only unnecessarily increase the chance of requiring the value of delta\_poc\_msb\_present\_flag[ i ] to be 1, thus requiring more bits, it may also introduce bitstream conformance and interoperability problems, e.g., when a decoder actually uses more DPB memory than the minimum required, a conforming bitstream may appear not conforming to the decoder as more pictures only waiting to be output may be present in the DPB (compared to a decoder that uses exactly the minimum required DPB memory) and thus the decoder may even not be able to correctly decode the bitstream.
2. When there are more than one reference picture in the DPB that has the same LSB as that of the LTRP signalled, it is mandated that the delta\_poc\_msb\_present\_flag[ i ] is set to 1. However, if there is a picture in the DPB that is marked as a short-term reference picture (STRP) by the current picture, then including it in the candidate set of LTRPs may end up signalling more MSB bits than needed. Consider the example where log2\_max\_pic\_order\_cnt\_lsb\_minus4 equals 4, and hence eight bits will be used to represent the POC LSB of the picture in the slice header. Furthermore, consider that only pictures with POC 0 and 256 are present in the DPB with POC LSB equal to 0, and that picture 0 is an LTRP and picture 256 is an STRP for the current picture. As per the current syntax, because picture 256 is also present in the DPB, delta\_poc\_msb\_present\_flag[ i ] will be 1 for LTRP 0 and hence the MSB cycle for picture 0 has to be sent. However, if the decoder knows that the picture 256 is an STRP for the current picture, which it would know from the short-term reference picture signalling, then picture 0 can be identified uniquely even without sending the MSB cycle.
3. If there are two LTRPs with different LSB values, but both have delta\_poc\_msb\_cycle\_lt[ i ] signalled, the current syntax would signal the delta\_poc\_msb\_cycle\_lt[ i ] as such. Signalling the difference for one of the pictures would be more efficient.

# Proposal

We propose the changes below to the semantics of poc\_lsb\_lt[ i ], delta\_poc\_msb\_present\_flag[ i ], and delta\_poc\_msb\_cycle\_lt[ i ], and the derivation process of reference picture sets to solve the above problems. As can be seen, the equation for derivation of the variable DeltaPocMSBCycleLt[ i ] has been simplified with less condition check.

In alignment with the changes to the semantics, slight changes to the RPS derivation process are also proposed, including swapping of the order of STRP and LTRP subset derivations, such that the STRP subset is derived first.

Parts to be changed are highlighted and parts to be removed are strikethrough.

## Slice header semantics

**poc\_lsb\_lt[** i **]** specifies the value of the least significant bits of the picture order count value of the i-th long-term reference picture that is included in the long-term reference picture set of the current picture. The length of the poc\_lsb\_lt[ i ] syntax element is log2\_max\_pic\_order\_cnt\_lsb\_minus4 + 4 bits. ~~For any values of j and k in the range of 0 to num\_long\_term\_pics – 1, inclusive, if j is less than k, poc\_lsb\_lt[ j ] shall not be less than poc\_lsb\_lt[ k ].~~

**delta\_poc\_msb\_present\_flag[** i **]** equal to 1 specifies that delta\_poc\_msb\_cycle\_lt[ i ] is present. delta\_poc\_msb\_present\_flag[ i ] equal to 0 specifies that delta\_poc\_msb\_cycle\_lt[ i ] is not present. delta\_poc\_msb\_present\_flag[ i ] shall be equal to 1 when there is more than one picture that is marked as "used for reference" in the decoded picture buffer, excluding those pictures that is included in the short-term reference picture set of the current picture, with the least significant bits of the picture order count value equal to poc\_lsb\_lt[ i ].

**delta\_poc\_msb\_cycle\_lt**[ i ]is used to determine the value of the most significant bits of the picture order count value of the i-th long-term reference picture that is included in the long-term reference picture set of the current picture. When not present, the value of delta\_poc\_msb\_cycle\_lt[ i ] is inferred to be equal to 0.

The variable DeltaPocMSBCycleLt[ i ] is derived as follows.

DeltaPocMSBCycleLt[ i ] = delta\_poc\_msb\_cycle\_lt[ i ]  
 if( i != 0 ) (7‑37)  
 DeltaPocMSBCycleLt[ i ] += DeltaPocMSBCycleLt[ i − 1 ]

[Note that the above is equivalent to the following, but the above is in a more compact form:

if( i = = 0 )  
 DeltaPocMSBCycleLt[ i ] = delta\_poc\_msb\_cycle\_lt[ i ]  
 else (7‑37)  
 DeltaPocMSBCycleLt[ i ] = delta\_poc\_msb\_cycle\_lt[ i ] + DeltaPocMSBCycleLt[ i − 1 ]

]

The value of DeltaPocMSBCycleLt[ i ] \* MaxPicOrderCntLsb + pic\_order\_cnt\_lsb – poc\_lsb\_lt[ i ] shall be in the range of 1 to 224 – 1, inclusive.

## Decoding process of reference picture set

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The derivation process for the reference picture set and picture marking are performed according to the following ordered steps, where DPB refers to the decoded picture buffer as described in Annex C:

1. The following applies:

for( i = 0; i < NumPocLtCurr; i++ ) {  
 if( !delta\_poc\_msb\_present\_flag[ i ] ) {  
 if( there is a long-term reference picture picX in the DPB [Ed. (JB): Should be made more precise.]  
 with pic\_order\_cnt\_lsb equal to PocLtCurr[ i ] )  
 RefPicSetLtCurr[ i ] = picX  
 else if( there is a short-term reference picture picY in the DPB   
 with pic\_order\_cnt\_lsb equal to PocLtCurr[ i ]  
 and with PicOrderCntVal not included in any of  
 PocStCurrBefore[ ], PocStCurrAfter[ ], and PocStFoll[ ] )  
 RefPicSetLtCurr[ i ] = picY  
 else   
 RefPicSetLtCurr[ i ] = "no reference picture"  
 } else {   
 if( there is a long-term reference picture picX in the DPB  
 with PicOrderCntVal equal to PocLtCurr[ i ] )  
 RefPicSetLtCurr[ i ] = picX  
 else if( there is a short-term reference picture picY in the DPB  
 with PicOrderCntVal equal to PocLtCurr[ i ] )  
 RefPicSetLtCurr[ i ] = picY  
 else   
 RefPicSetLtCurr[ i ] = "no reference picture"  
 }  
} (8‑6)

for( i = 0; i < NumPocLtFoll; i++ ) {  
 if( !delta\_poc\_msb\_present\_flag[ i ] ) {  
 if( there is a long-term reference picture picX in the DPB  
 with pic\_order\_cnt\_lsb equal to PocLtFoll[ i ] )  
 RefPicSetLtFoll[ i ] = picX  
 else if( there is a short-term reference picture picY in the DPB  
 with pic\_order\_cnt\_lsb equal to PocLtFoll[ i ]  
 and with PicOrderCntVal not included in any of   
 PocStCurrBefore[ ], PocStCurrAfter[ ], and PocStFoll[ ] )  
 RefPicSetLtFoll[ i ] = picY  
 else   
 RefPicSetLtFoll[ i ] = "no reference picture"  
 } else {  
 if( there is a long-term reference picture picX in the DPB  
 with PicOrderCntVal to PocLtFoll[ i ] )  
 RefPicSetLtFoll[ i ] = picX  
 else if( there is a short-term reference picture picY in the DPB  
 with PicOrderCntVal equal to PocLtFoll[ i ] )  
 RefPicSetLtFoll[ i ] = picY  
 else  
 RefPicSetLtFoll[ i ] = "no reference picture"  
 }  
}

1. All reference pictures included in RefPicSetLtCurr and RefPicSetLtFoll are marked as "used for long-term reference"
2. The following applies:

for( i = 0; i < NumPocStCurrBefore; i++ )  
 if( there is a short-term reference picture picX in the DPB  
 with PicOrderCntVal equal to PocStCurrBefore[ i ])  
 RefPicSetStCurrBefore[ i ] = picX  
 else  
 RefPicSetStCurrBefore[ i ] = "no reference picture"

for( i = 0; i < NumPocStCurrAfter; i++ )  
 if( there is a short-term reference picture picX in the DPB  
 with PicOrderCntVal equal to PocStCurrAfter[ i ])  
 RefPicSetStCurrAfter[ i ] = picX  
 else  
 RefPicSetStCurrAfter[ i ] = "no reference picture" (8‑7)

for( i = 0; i < NumPocStFoll; i++ )  
 if( there is a short-term reference picture picX in the DPB  
 with PicOrderCntVal equal to PocStFoll[ i ])  
 RefPicSetStFoll[ i ] = picX  
 else  
 RefPicSetStFoll[ i ] = "no reference picture"

1. All reference pictures included in RefPicSetStCurrBefore, RefPicSetStCurrAfter and RefPicSetStFoll are marked as "used for short-term reference".
2. All reference pictures in the decoded picture buffer that are not included in RefPicSetLtCurr, RefPicSetLtFoll, RefPicSetStCurrBefore, RefPicSetStCurrAfter or RefPicSetStFoll are marked as "unused for reference".

NOTE 4 – There may be one or more reference pictures that are included in the reference picture set but not present in the decoded picture buffer. Entries in RefPicSetStFoll or RefPicSetLtFoll that are equal to "no reference picture" should be ignored. Unless either of the following two conditions is true, an unintentional picture loss should be inferred for each entry in RefPicSetStCurrBefore, RefPicSetStCurrAfter and RefPicSetLtCurr that is equal to "no reference picture": a) the first coded picture in the bitstream is a CRA picture and the current coded picture is a TFD picture associated with the first coded picture in the bitstream; b) the previous RAP picture preceding the current coded picture in decoding order is a BLA picture and the current coded picture is a TFD picture associated with the BLA picture.

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# Patent rights declaration(s)

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