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| **Joint Collaborative Team on Video Coding (JCT-VC)**  **of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11**  8th Meeting: San José, CA, USA, 1–10 February, 2012 | Document: JCTVC-H0490 |

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| *Title:* | **Non-CE6a: Reduce the look-up table entries for LM mode calculation** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

This contribution proposes to reduce the look-up table used in LM mode calculation from 63 entries to 56 entries or further to 32 entries. It can be derived that the entries from 1~7 are theoretically not used for the calculation of alpha. And the entries from 1~31 are seldom used in all testing sequences. Simulations reported that the performances are the same as the HM5.0 anchor in all intra high efficiency tests.

# Introduction

For chroma blocks, the current design of High Efficiency Video Coding (HEVC) has a chroma from luma intra prediction mode, which is also referred as LM mode, in addition to the directional modes and the DC mode.

According to the HEVC working draft [1] and the HM-5.0 software, the current design of LM mode uses reconstructed luma samples to generate chroma samples. The values of the prediction are derived as the following ordered steps [1]:

1. Variable k3 and the sample array pY’ are derived as:

k3 = Max( 0, BitDepthC + log2( nS ) – 14 ) (1)

pY’[ x, y ] = ( recSamplesL[ 2x-1, 2y+1 ] +   
2\*recSamplesL[ 2x, 2y+1 ] + recSamplesL[ 2x+1, 2y+1 ] + 2 ) >> 2, with x=0..nS-1, y = -1 (2)

pY’[ x, y ] = ( recSamplesL[ 2x, 2y ] + recSamplesL[ 2x, 2y+1 ] ) >> 1, with x=-1..nS-1, y = 0..nS-1 (3)

1. Variables L, C, LL, LC and k2 are derived as follows:

L =  (4)

C =  (5)

LL =  (6)

LC =  (7)

k2 = log2( (2\*nS) >> k3 ) (8)

1. Variables a, b and k are derived as:

a1 = ( LC << k2 ) – L\*C (9)  
a2 = ( LL << k2 ) – L\*L (10)  
k1 = Max( 0, log2( abs( a2 ) ) – 5 ) – Max( 0, log2( abs( a1 ) ) – 14 ) + 2 (11)  
a1s = a1 >> Max(0, log2( abs( a1 ) ) – 14 ) (12)  
a2s = abs( a2 >> Max(0, log2( abs( a2 ) ) – 5 ) ) (13)  
a3 = a2s < 1 ? 0 : Clip3( -215, 215-1, a1s\*lmDiv + ( 1 << ( k1 – 1 ) ) >> k1 ) (14)

alpha = a3 >> Max( 0, log2( abs( a3 ) ) – 6 ) (15)  
k = 13 – Max( 0, log2( abs( alpha ) ) – 6 ) (16)

beta = ( L – ( ( alpha \* C ) >> k1 ) + ( 1 << ( k2 – 1 ) ) ) >> k2 (17)

where *lmDiv* is specified in a look-up table [1] with the input a2s.

1. The values of the prediction samples predSamples[ x, y ] are derived as:

predSamples[ x, y ] = Clip1C( ( ( pY’[ x, y ] \* alpha ) >> k ) + beta ), with x, y = 0..nS-1 (18)

The *lmDiv* calculation of (14) in current LM mode is base a 63-entry look-up table, where each entry is defined as:

UInt *lmDiv* [ 63 ];

for( Int i = 1; i < 64; i++ )

lmDiv [i-1] = ( (1 << 15) + i/2 ) / i; (19)

After a2s is calculated from (10) and (13), it is used as the index of (19) to get the value of *lmDiv*.

# Reducing the number of entries

Set

 (20)

 (21)

where *avgY’* means the average value of all the luma prediction samples,

From (4), (6), (8) and (10) we have,

a2 = ( LL << k2 ) – L\*L







 (22)

Because nS≥4, and BitDepthCis in the range of 8 to 10, from (1) we can see k3=0. So we have:

a2 (23)

If the luma references are not all equal, (23) means the actual value of a2 is always equal or larger than 8.

According to (13), we can see that if a2≥32, then a2s≥32. The *lmDiv* entries that are really used is in the range of [8, 63] if the luma references are not all equal.

Furthermore, if one of the item ΔpY’ in (23) is equal or larger than 2, a2 will equal or larger than 32 accordingly. In this condition, lmDiv table can be reduced to 32 entries.

# Simulation results

Reduce the number of entries to 56 is the same as 63 entries since they are equivalent.

Simulation has been performed to test the performance of reduce the number to 56 or 32, table 1 and 2 show the results compared with HM5.0 anchor:

Table 1. Testing results of 56 entries vs. HM5.0

|  |  |  |  |
| --- | --- | --- | --- |
|  | **All Intra HE** | | |
|  | Y | U | V |
| Class A (8bit) | 0.01% | -0.03% | 0.01% |
| Class B | 0.00% | -0.01% | 0.02% |
| Class C | 0.00% | -0.03% | -0.01% |
| Class D | 0.00% | 0.01% | 0.00% |
| Class E | 0.00% | 0.02% | 0.01% |
| **Overall** | 0.00% | -0.01% | 0.00% |
|  | 0.00% | -0.01% | 0.00% |
| Class F | 0.00% | -0.01% | 0.03% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 101% | | |

Table 2. Testing results of 32 entries vs. HM5.0

|  |  |  |  |
| --- | --- | --- | --- |
|  | **All Intra HE** | | |
|  | Y | U | V |
| Class A (8bit) | 0.01% | -0.03% | -0.03% |
| Class B | 0.00% | 0.00% | 0.01% |
| Class C | 0.00% | -0.01% | 0.00% |
| Class D | -0.01% | 0.01% | -0.04% |
| Class E | 0.00% | -0.01% | -0.01% |
| **Overall** | 0.00% | -0.01% | -0.01% |
|  | 0.00% | -0.01% | -0.01% |
| Class F | -0.01% | -0.01% | 0.00% |
| Enc Time[%] | 100% | | |
| Dec Time[%] | 99% | | |

The performance is almost the same for the two cases which also confirmed that the number of entries can be reduced.

# Conclusion

As observed in the simulation result, the reduction of the look-up table in LM mode intra prediction has no impact on BD-rate while reducing some storage. It is proposed to consider adopt the simplification of 32-entry look-up table.

# Reference

[1] Benjamin Bross, et. Al, “WD5: Working Draft 5 of High-Efficiency Video Coding”, ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, JCTVC-G1103

[2] Jianle Chen, et. Al, “Complexity reduction of chroma intra LM prediction mode”, ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, JCTVC-F494

[3] Frank Bossen, “Common HM test conditions and software reference configurations”, ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, JCTVC-G1200

# WD changes

## using 56 entries

Table 8‑9 – Specification of lmDiv

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **a2s** | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| **lmDiv** | 4096 | 3641 | 3277 | 2979 | 2731 | 2521 | 2341 | 2185 | 2048 | 1928 | 1820 | 1725 | 1638 |
| **a2s** | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 |
| **lmDiv** | 1560 | 1489 | 1425 | 1365 | 1311 | 1260 | 1214 | 1170 | 1130 | 1092 | 1057 | 1024 | 993 |
| **a2s** | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 |
| **lmDiv** | 964 | 936 | 910 | 886 | 862 | 840 | 819 | 799 | 780 | 762 | 745 | 728 | 712 |
| **a2s** | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 |
| **lmDiv** | 697 | 683 | 669 | 655 | 643 | 630 | 618 | 607 | 596 | 585 | 575 | 565 | 555 |
| **a2s** | 60 | 61 | 62 | 63 |  |  |  |  |  |  |  |  |  |
| **lmDiv** | 546 | 537 | 529 | 520 |  |  |  |  |  |  |  |  |  |

## using 32 entries

Table 8‑9 – Specification of lmDiv

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **a2s** | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 |
| **lmDiv** | 1024 | 993 | 964 | 936 | 910 | 886 | 862 | 840 | 819 | 799 | 780 | 762 | 745 |
| **a2s** | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 |
| **lmDiv** | 728 | 712 | 697 | 683 | 669 | 655 | 643 | 630 | 618 | 607 | 596 | 585 | 575 |
| **a2s** | 58 | 59 | 60 | 61 | 62 | 63 |  |  |  |  |  |  |  |
| **lmDiv** | 565 | 555 | 546 | 537 | 529 | 520 |  |  |  |  |  |  |  |

# Patent rights declaration(s)

**Hisilicon Technologies Co. Ltd and Santa Clara University and may have current or pending patent rights 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).**