JCTVC-T0112: On escape pixel coding for palette mode

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JCTVC-T0112: On escape pixel coding for palette

- Problem 1 with the current SCM3.0
  - Max quantized value calculation cMax for truncated binary code
  - Division and floating point operations invoked at the decoder

Floating point operation

- A quantization step size parameter qStep is derived as follows:
    qStep = (qP==0) ? Round($2^{(qP-4)/6}$) : 1

Division operation

- A maximum possible quantized value maxValue is derived as follows:
    maxValue = ((1<<bitDepth) − 1) / Qstep

- The number of bins numBins to represent maxValue is derived as follows
    while(maxValue) {
        maxValue = maxValue >> 1
        numBins++
    }

- The maximum parameter cMax for the truncated binary codeword is derived as follows
    cMax = clip3(0, $2^{numBins}$-1, ((1<<bitDepth) − 1) *quantScale +rightShiftOffset) >> rightShiftParam)

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- Solution 1: using a lookup table of 6 elements
  - Scaled integer and shift operation to calculate cMax

cMax = ((1<<bitDepth) − 1) * quantScale + rightShiftOffset) >> rightShiftParam

quantScale = g_quantScales[qP%6], where g_quantScales = {26214, 23302, 20560, 18396, 16384, 14564 }

rightShiftParam = 14 + (qP/6)

rightShiftOffset = 1 << (rightShiftParam -1)

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- Solution 2: using a lookup table of 52 elements
  - cMax lookup table for each QP

qP	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
cMax	255	255	255	255	255	227	202	180	161	143	128	114	101	90	80

qP	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
cMax	72	64	57	51	45	40	36	32	28	25	23	20	18	16	14

qP	30	31	32	32	34	35	36	37	38	39	40	41	42	43	44
cMax	13	11	10	9	8	7	6	6	5	4	4	4	3	3	3

qP	45	46	47	48	49	50	51
cMax	2	2	2	2	1	1	1

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- Solution 3: using a fixed length codeword
  - Approximate the quantization step size by power of 2
    - quantBits = (qP < 4) ? 0: (qP – 4) / 6
  - Calculate remaining bits to represent quantized escape
    - maxBit = bitDepth – quantBits
  - Use fixed length codeword
  - Use left shift to reconstruct the escape pixel
    - recSample = (palette_escape_val << quantBits)

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- Solution 4: using remaining coefficient codeword
  - Golomb rice parameter 3
  - Independent of cMax

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- ## Problem 2 with the current SCM3.0

  - Undefined negative right shift operations when QPper >=6

Right shift could be negative

```
Int InvquantiserRightShift = (IQUANT_SHIFT - iQPper);

Int iAdd = InvquantiserRightShift == 0 ? 0 : 1 <<(InvquantiserRightShift - 1);

iValue = ((pPixelValue[uiIdx]*g_invQuantScales[iQPrem] + iAdd)>>InvquantiserRightShift);
```

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- ■ Solution for undefined operation
  - ▪ Same operation as coefficient dequantization
  - ▪ Differentiate right shift and left according QP

invQuantRightShift = 6 – qPper
addOffset = invQuantRightShift <= ? 0: 1<< (invQuantRightShift - 1)

If invQuantRightShift is larger than 0, the following procedure is applied

deQuantEspValue = (EspValue * invQuantScale[qPrem] + addOffset)>>invQuantRightShift

Otherwise, (invQuantRightShift is 0 or negative), the following procedure is applied

invQuantLeftShift = - invQuantRightShift
deQuantEspValue = (EspValue * invQuantScale[qPrem]) << invQuantLeftShift

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Simulation Results – Solution 1

- Anchor: SCM3.0 CTC
- Tested: Solution 1 - using a look up table of 6 elements for cMax

	All Intra			Random Access			Low delay B		
	G/Y	B/U	R/V	G/Y	B/U	R/V	G/Y	B/U	R/V
RGB, text & graphics with motion, 1080p & 720p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
RGB, mixed content, 1440p & 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
RGB, Animation, 720p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
RGB, camera captured, 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YUV, text & graphics with motion, 1080p & 720p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YUV, mixed content, 1440p & 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YUV, Animation, 720p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YUV, camera captured, 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Enc Time[%]	97%			99%			100%		
Dec Time[%]	96%			101%			103%		

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Simulation Results – Solution 2

- Anchor: SCM3.0 CTC
- Tested: Solution 2 - using a look up table of 52 elements for cMax

	All Intra			Random Access			Low delay B		
	G/Y	B/U	R/V	G/Y	B/U	R/V	G/Y	B/U	R/V
RGB, text & graphics with motion, 1080p & 720p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
RGB, mixed content, 1440p & 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
RGB, Animation, 720p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
RGB, camera captured, 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YUV, text & graphics with motion, 1080p & 720p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YUV, mixed content, 1440p & 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YUV, Animation, 720p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YUV, camera captured, 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Enc Time[%]	98%			99%			100%		
Dec Time[%]	99%			102%			106%		

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Simulation Results – Solution 3

- Anchor: SCM3.0 CTC
- Tested: Solution 3 – using fixed length codeword

	All Intra			Random Access			Low delay B		
	G/Y	B/U	R/V	G/Y	B/U	R/V	G/Y	B/U	R/V
RGB, text & graphics with motion, 1080p & 720p	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%
RGB, mixed content, 1440p & 1080p	-0.2%	0.0%	0.0%	-0.4%	-0.3%	-0.2%	-0.3%	0.0%	-0.2%
RGB, Animation, 720p	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%	-0.1%
RGB, camera captured, 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YUV, text & graphics with motion, 1080p & 720p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	-0.1%	-0.1%
YUV, mixed content, 1440p & 1080p	0.0%	0.0%	0.0%	0.0%	-0.1%	-0.1%	-0.1%	-0.4%	0.1%
YUV, Animation, 720p	0.0%	0.0%	0.0%	0.0%	0.1%	0.2%	-0.1%	0.2%	-0.1%
YUV, camera captured, 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Enc Time[%]	98%			101%			99%		
Dec Time[%]	100%			100%			102%		

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Simulation Results – Solution 4

- Anchor: SCM3.0 CTC
- Tested: Solution 4 – using remaining coefficient codeword

	All Intra			Random Access			Low delay B		
	G/Y	B/U	R/V	G/Y	B/U	R/V	G/Y	B/U	R/V
RGB, text & graphics with motion, 1080p & 720p	0.1%	0.2%	0.2%	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%
RGB, mixed content, 1440p & 1080p	0.1%	0.1%	0.1%	0.1%	0.1%	0.1%	0.0%	0.2%	-0.1%
RGB, Animation, 720p	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.1%	-0.1%
RGB, camera captured, 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YUV, text & graphics with motion, 1080p & 720p	0.1%	0.1%	0.1%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%
YUV, mixed content, 1440p & 1080p	0.0%	0.0%	0.0%	0.0%	-0.1%	-0.1%	-0.1%	-0.4%	-0.3%
YUV, Animation, 720p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.2%
YUV, camera captured, 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Enc Time[%]	99%			99%			100%		
Dec Time[%]	98%			102%			106%		

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Simulation Results – Solution for defined process

- Anchor: SCM3.0 in high QP range {42, 43, 44, 45}
- Tested: fix of undefined operations (no effect on CTC)

	All Intra			Random Access			Low delay B		
	G/Y	B/U	R/V	G/Y	B/U	R/V	G/Y	B/U	R/V
RGB, text & graphics with motion, 1080p & 720p	-0.3%	-0.4%	-0.5%	-0.2%	-0.3%	-0.3%	-0.2%	-2.7%	-0.3%
RGB, mixed content, 1440p & 1080p	-0.1%	-0.4%	-0.5%	-0.1%	-0.5%	-0.4%	0.2%	-0.2%	-0.4%
RGB, Animation, 720p	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%
RGB, camera captured, 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
YUV, text & graphics with motion, 1080p & 720p	0.0%	-0.1%	0.3%	-0.1%	0.0%	0.0%	0.1%	-0.1%	-0.1%
YUV, mixed content, 1440p & 1080p	0.0%	0.0%	0.0%	0.1%	0.2%	0.4%	-0.2%	0.2%	1.1%
YUV, Animation, 720p	0.0%	0.0%	0.0%	0.0%	0.1%	0.1%	0.0%	0.0%	0.0%
YUV, camera captured, 1080p	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Enc Time[%]	99%			100%			99%		
Dec Time[%]	101%			103%			101%		

- Thanks

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