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TE10 Subset1: Conditional joint deblocking-debanding filter
(JCTVC-C091/ m18114)

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Summary

- Banding-noise in video coding

- Conditional joint deblocking-debanding filter
  - Implementation on the top of TMuC deblocking filter

- Simulation results
  - Significant banding-noise reduction in Kimono sequence
  - Negligible impacts on BD-Rate/PSNR values
    - Intra: HCE 0.14% (-0.01dB) and LC 0.16%(-0.04dB)
    - Random access: HCE 0.05%(-0.00dB) and LC 0.24%(-0.00dB)
    - Low delay: HCE 0.03%(-0.00dB) and LC 0.10%(-0.00dB)
  - Negligible impacts on encoding and decoding times
    - Encoding time increase: up to 5%.
    - Decoding time increase: up to 1%.

Banding-noise in video coding

Banding-noise

- One of the signal-dependent noises
- Noticeable in areas of low detail with subtle pixel-intensity changes even when input video is encoded at high rates

Solutions

- Encode input video with higher sample bit-depth
- Mask it with signal independent noise by in-loop debanding and/or post debanding

Banding-noise example: Kimono1 144th frame (1/4)

Original image

Banding-noise example: Kimono1 144th frame (2/4)

Cropped and zoomed original image

Banding-noise example: Kimono1 144th frame (3/4)

(Color enhanced) Cropped and zoomed original image

Banding-noise example: Kimono1 144th frame (4/4)

(Color enhanced) TMuC HCE Random Access Anchor QP=22

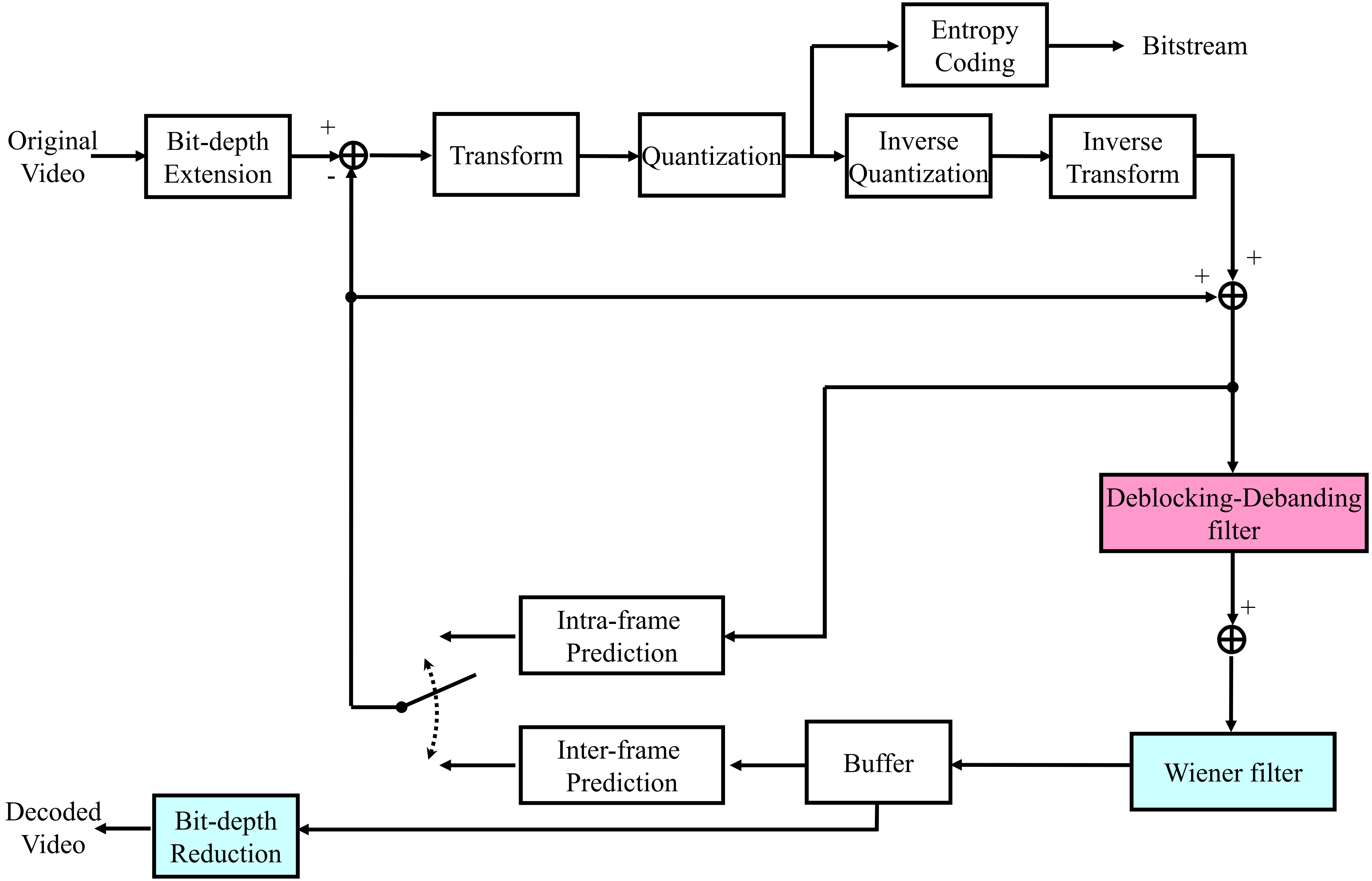
Conditional joint deblocking-debanding filter (JCT-VC B056)

- In-loop debanding
  - Integrate the comfort noise injection into conditional deblocking filter
  - Several advantages over post debanding as:
    - Content providers can guarantee video quality
    - No need for an extra frame buffer in the decoder
    - Efficient detection of areas where banding-noise typically appears is possible by using coded information

- Parallel processing conscious
  - Non-recursive processing
  - Pseudo-noise is loaded from LUT in a pixel-position associated manner.

- Systematic noise-shaping mechanism with the help of IBDI and Wiener filter

JCTVC-B056 block diagram



Conditional joint deblocking-debanding filter

(Step1) Load pseudo-noise from LUT

(Step2) Apply strong filtering

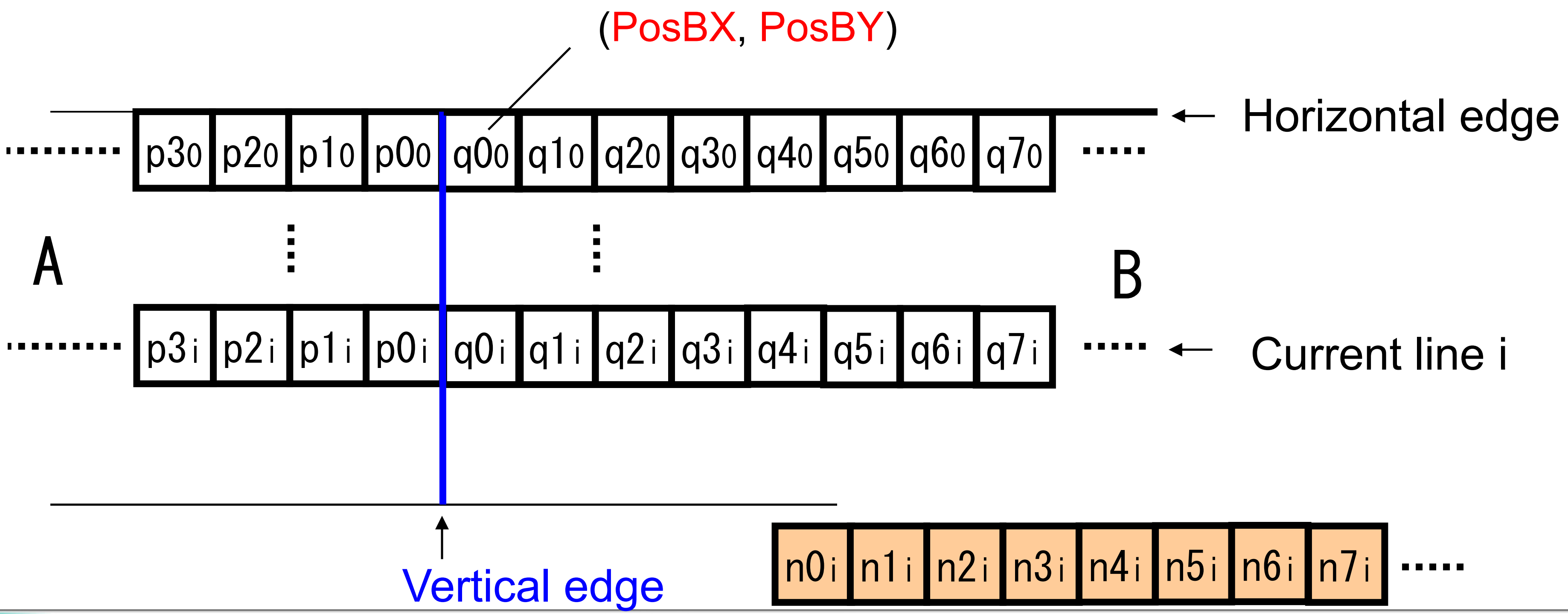
(Step3) Conditionally inject pseudo-noise

Note that two modifications were introduced into (Step3) of JCT-VC B056.

(Step1) Load pseudo-noise from LUT

- Pseudo-noise is associated with its pixel position.

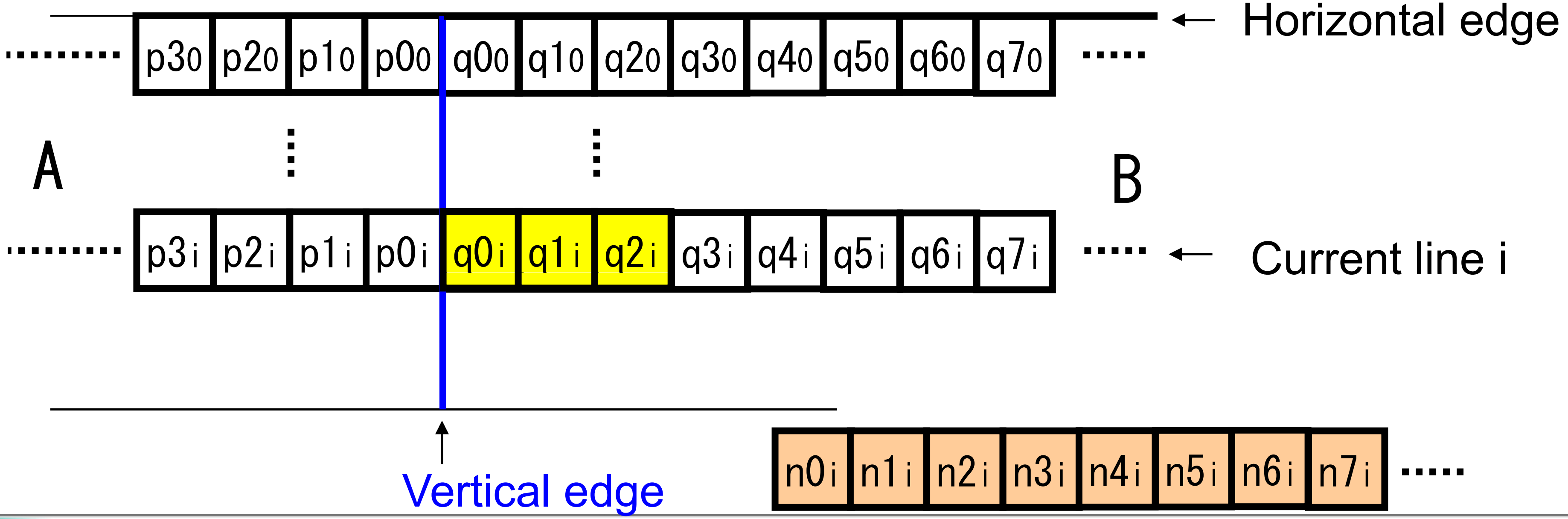
nj_i =LUT [(idxOffset + (i<<4) + j) & 4095];
idxOffset = ((PosBY + (PosBX<<4)) & 4095);



(Step2) Strong filtering

- Boundary three pixels are filtered by conventional filters as in TMuC

q0i=(p1i + 2*p0i + 2*q0i + 2*q1i + q2i + 4)>>3;
q1i=(p0i + q0i + q1i + q2i +2)>>2;
q2i=(p0i + q0i + q1i + 3*q2i + 2*q3i + 4)>>3;



(Step3) Conditional pseudo-noise injection

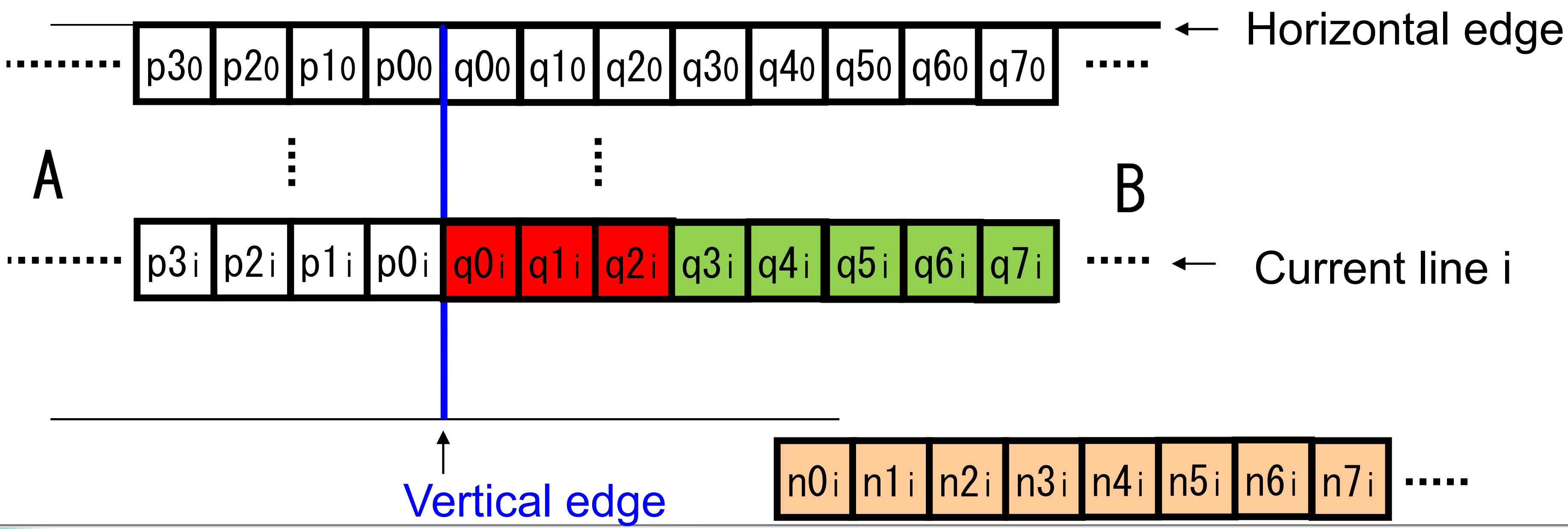
- Add pseudo-noise if the area is supposed to be very smooth.

If all of the following conditions are true,

- q_0 is an intra block with TUsizeB >= 16x16
- $| p_1 - q_0 | <= 1$
- $| q_0 - q_7 | <= 1$

the pseudo-noise is added as

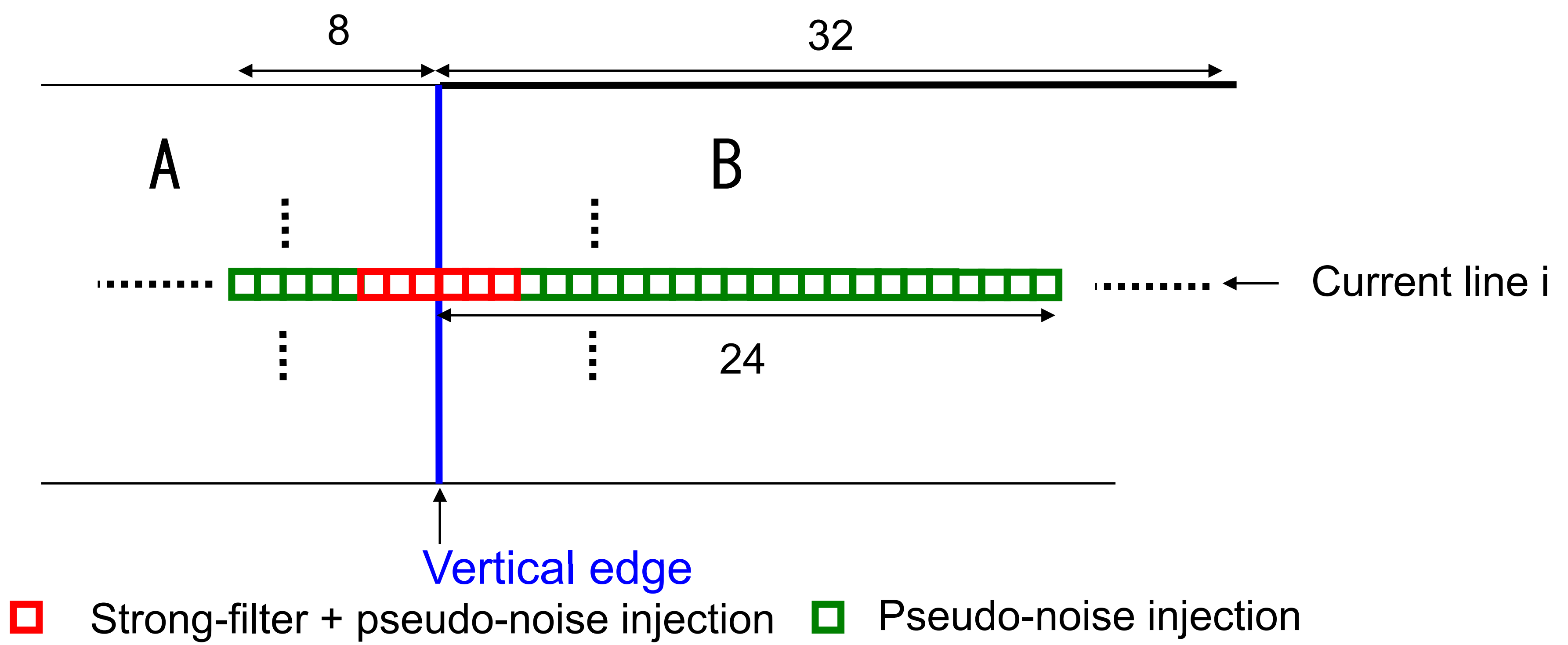
$qj_i = Clip_{0-255}(qj_i + nj_i);$ for j=0, … max(3, TUWidthB-9)



Two modifications in Step 3

Maximum TU size conscious modification:

- Pseudo-noise injection is conducted in an asymmetric way so that the number of processed A images is limited to 8.
- Limit the number of reference lines used for filtering horizontal edges up to 8 for any LCU sizes

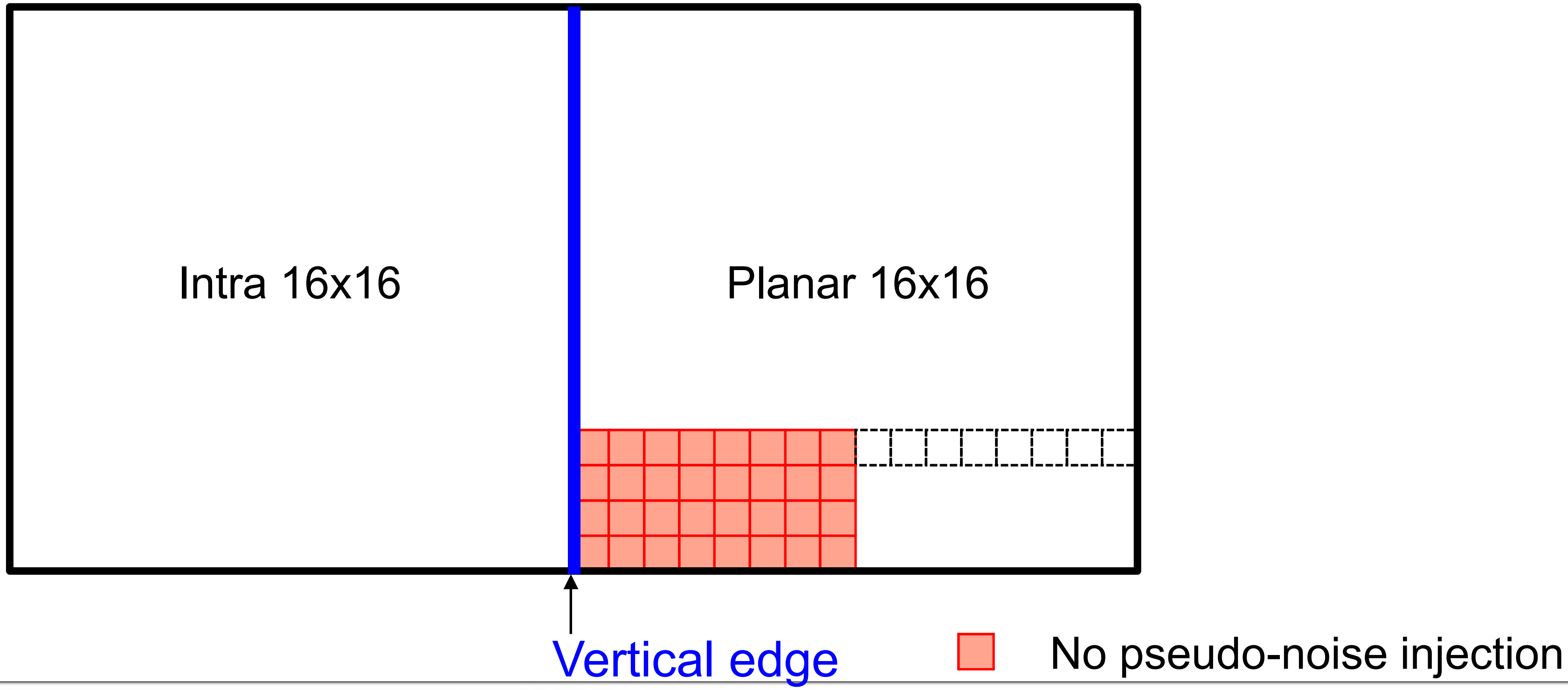


Two modifications in Step 3 (Cont.)

Planar mode filter conscious modification:

- No pseudo-noise injection is applied to images which can be processed by Planar mode filtering.
- No influence to Planar mode filtering results.

Example)



Simulation results

- Coding conditions
  - TE10 compliant
  - Software: TMuC0.7 (with BUGFIXTMP50 for encoder crash cases)

- Computing platform

Computing platform	Usage
Windows 7 64-bit Professional Core i7 2.8GHz and Memory 12GB	Anchor and Proposal encoding Class A, B, C, and D. Up to 8 encodings ran at the same time.
Windows XP 32-bit Professional Xeon 3.33GHz and Memory 3GB	Anchor and Proposal encoding Class E. Up to 8 encodings ran at the same time.
Windows XP 64-bit Professional Opteron 2.60GHz and Memory 32GB	Anchor and Proposal decoding all Classes.

Note that encoding-time was varied due to automated CPU over-clocking.

Simulation results (Cont.)

- Coding results
  - High Coding Efficiency (HCE) All Intra, Random Access, and Low Delay.
  - Low Complexity (LC) All Intra, Random Access, and Low Delay. (LC is optional in TE10 Subset1)

- Coding efficiency relative to Anchor
  - BD-PSNR, BD-Rate, and, enc. and dec. time increases.

- Debanding examples in Kimono and Vidyo3

Impacts on coding efficiency in HCE case

Results for High Coding Efficiency All Intra

	BD-PSNR dB	BD-Rate %	Enc. Time %	Dec. Time %
Class A	0.00	0.0	109	101
Class B	0.00	0.1	102	101
Class C	0.00	0.0	104	100
Class D	0.00	0.0	102	100
Class E	-0.02	0.4	99	103
Total	-0.01	0.1	102	101

Results for High Coding Efficiency Random Access

	BD-PSNR dB	BD-Rate %	Enc. Time %	Dec. Time %
Class A	0.00	0.0	107	100
Class B	0.00	0.1	102	100
Class C	0.00	0.0	101	100
Class D	0.00	0.0	94	100
Total	0.00	0.0	100	100

Results for High Coding Efficiency Low Delay

	BD-PSNR dB	BD-Rate %	Enc. Time %	Dec. Time %
Class B	0.00	0.0	99	100
Class C	0.00	0.0	104	100
Class D	0.00	0.0	100	99
Class E	-0.01	0.2	100	101
Total	0.00	0.0	101	100

Impacts on coding efficiency in LC case

Results for Low Complexity All Intra

	BD-PSNR dB	BD-Rate %	Enc. Time %	Dec. Time %
Class A	-0.02	0.4	106	100
Class B	-0.04	1.0	104	101
Class C	-0.01	0.2	107	101
Class D	-0.01	0.1	104	99
Class E	-0.14	2.6	99	102
Total	-0.04	1.2	104	101

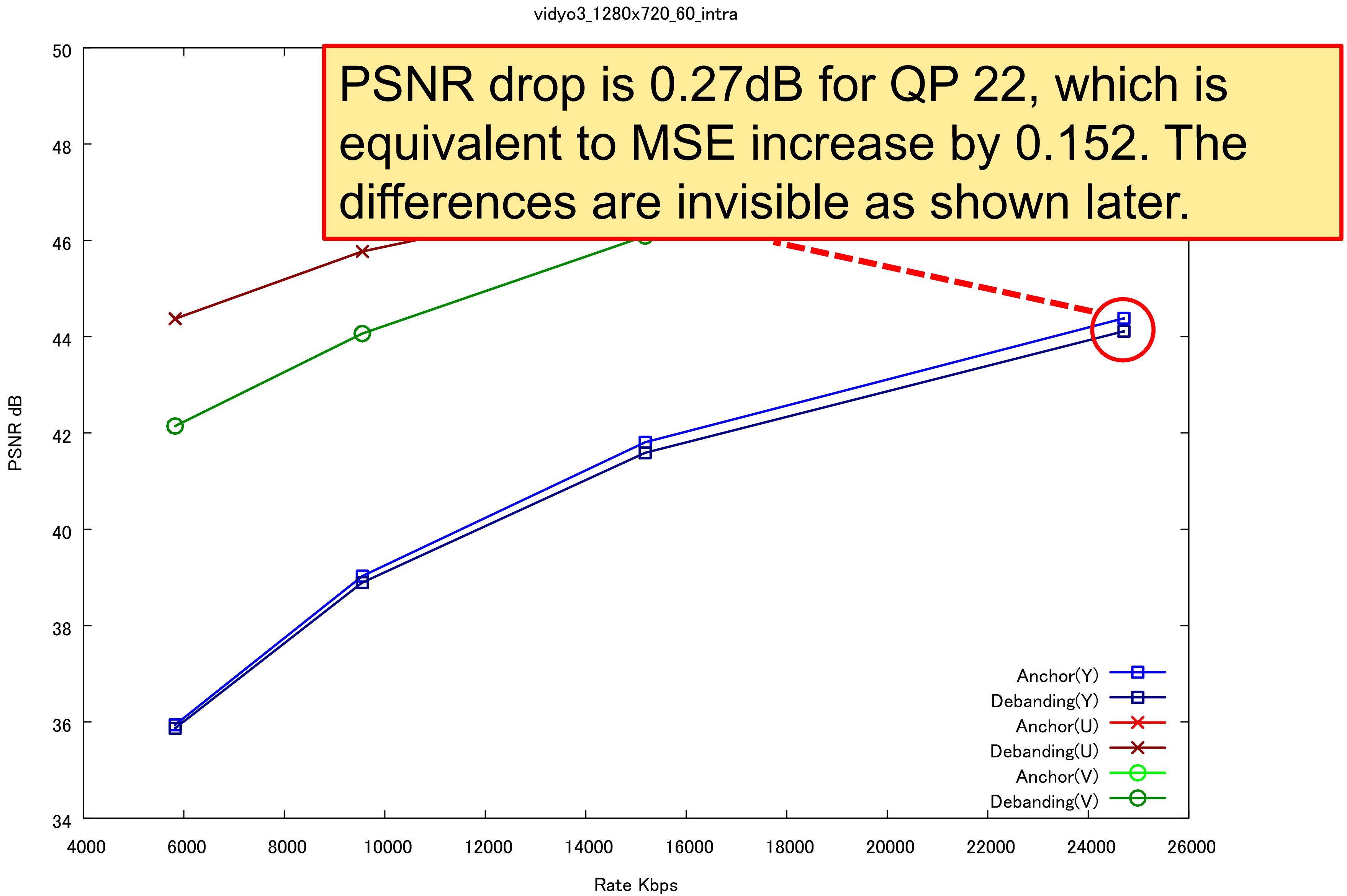
Results for Low Complexity Random Access

	BD-PSNR dB	BD-Rate %	Enc. Time %	Dec. Time %
Class A	-0.01	0.2	104	101
Class B	-0.01	0.3	106	100
Class C	0.00	0.1	107	101
Class D	0.00	0.0	107	100
Total	0.00	0.2	106	101

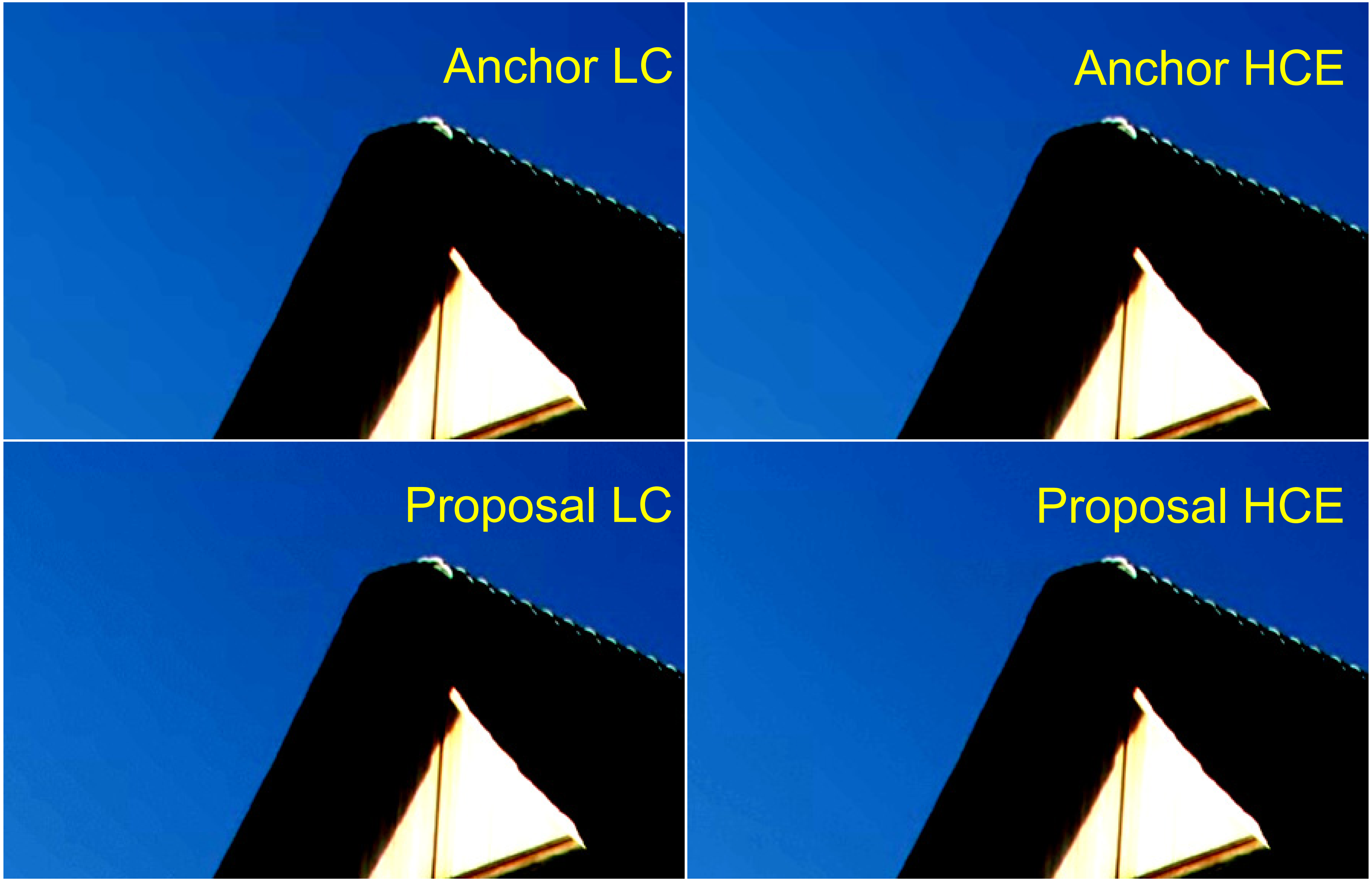
Results for Low Complexity Low Delay

	BD-PSNR dB	BD-Rate %	Enc. Time %	Dec. Time %
Class B	0.00	0.1	104.00	101.00
Class C	0.00	0.0	108.00	100.00
Class D	0.00	0.0	109.00	98.00
Class E	-0.01	0.3	99.00	99.00
Total	0.00	0.1	105.00	100.00

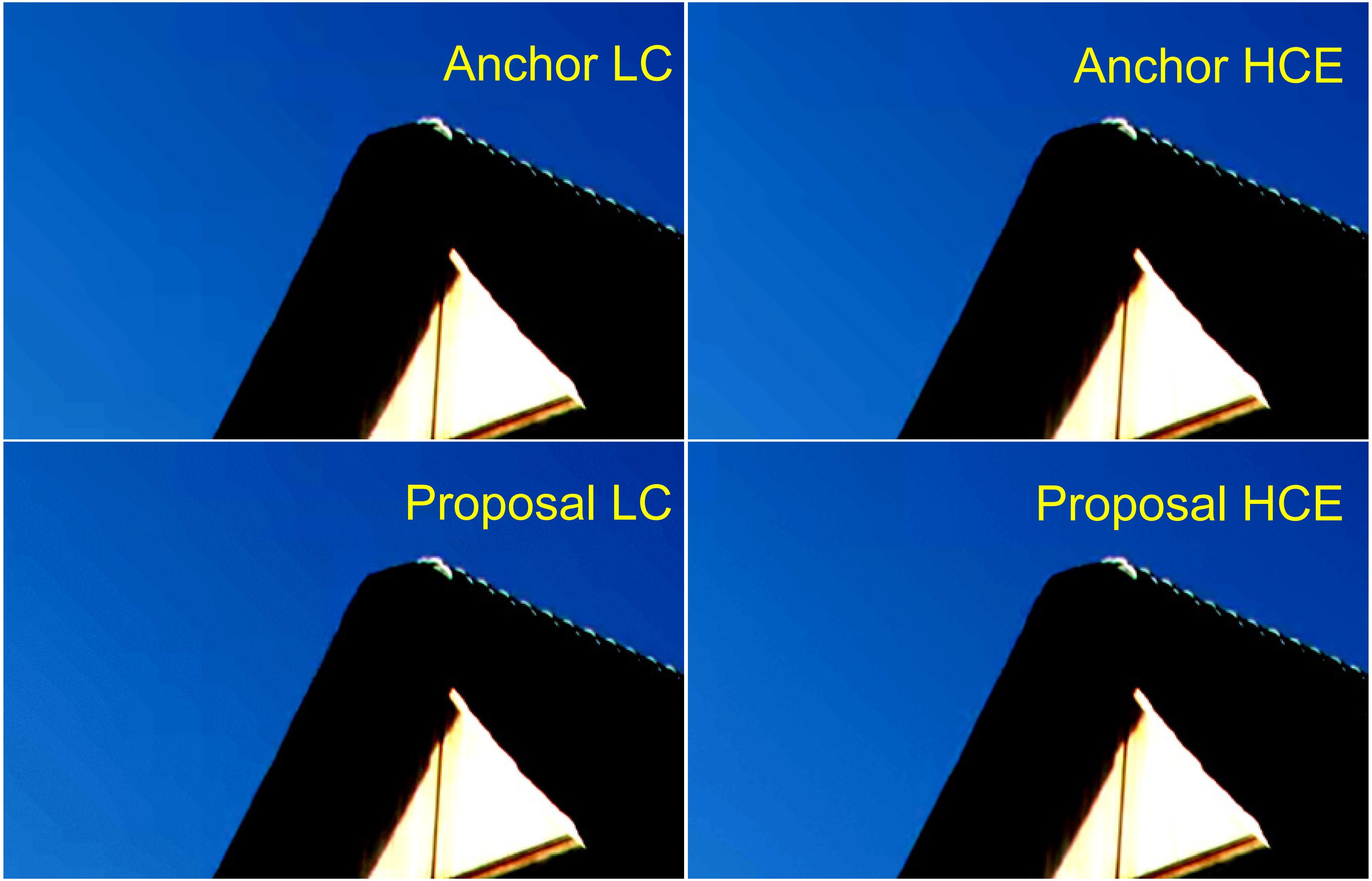
R-D Curve of Vidyo3 Low Complexity All Intra



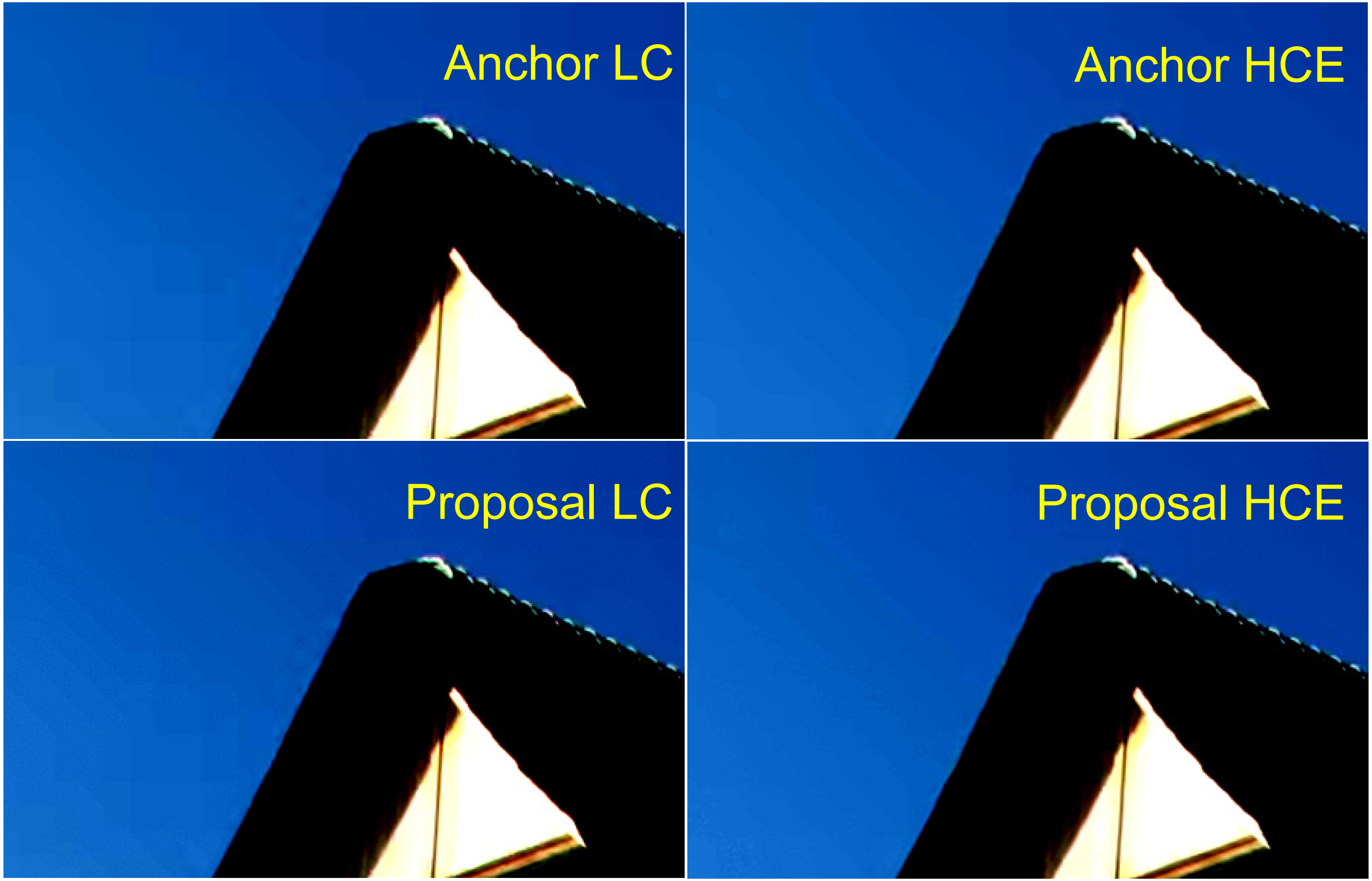
Compressed Kimono with QP=22 (Color enhanced)



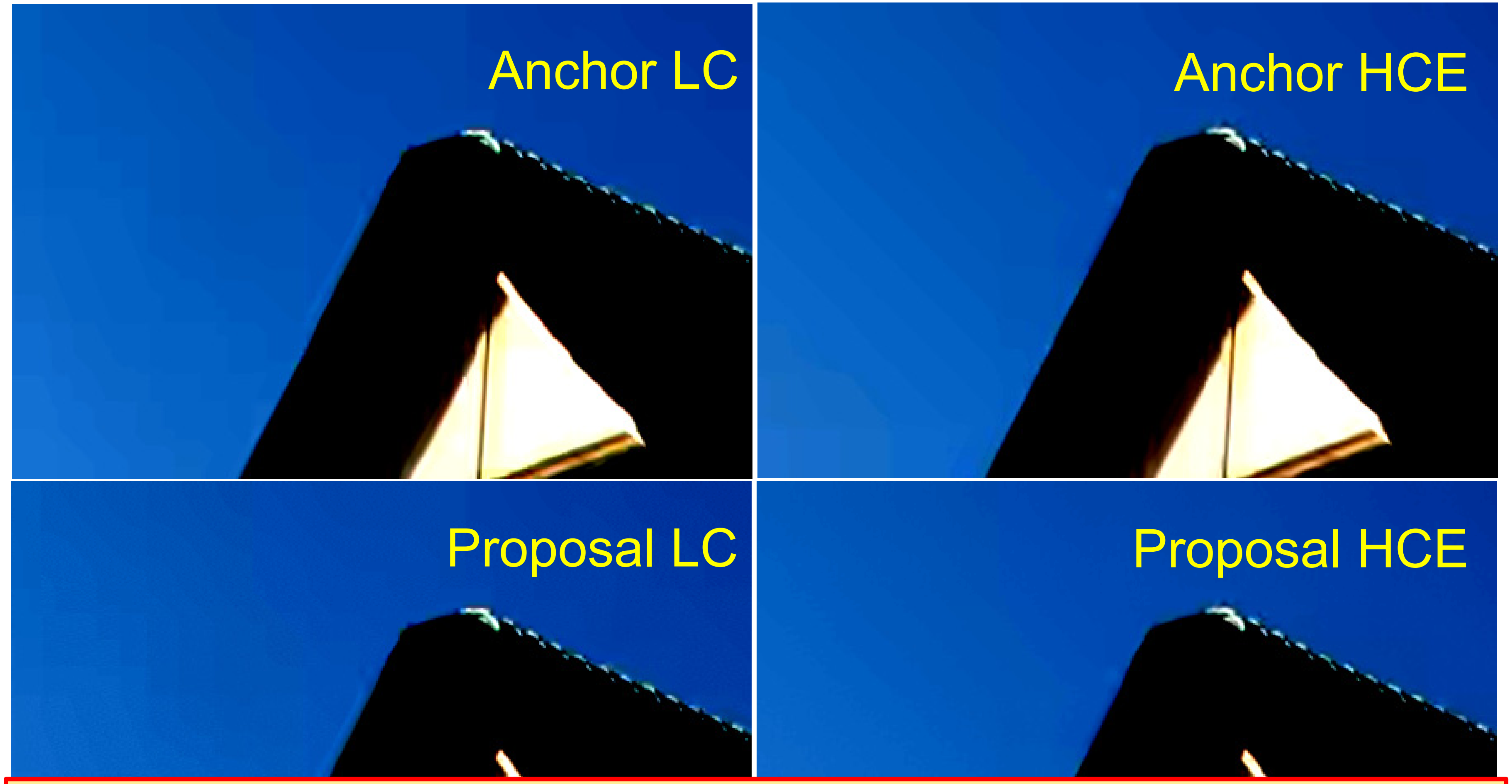
Compressed Kimono with QP=27 (Color enhanced)



Compressed Kimono with QP=32 (Color enhanced)

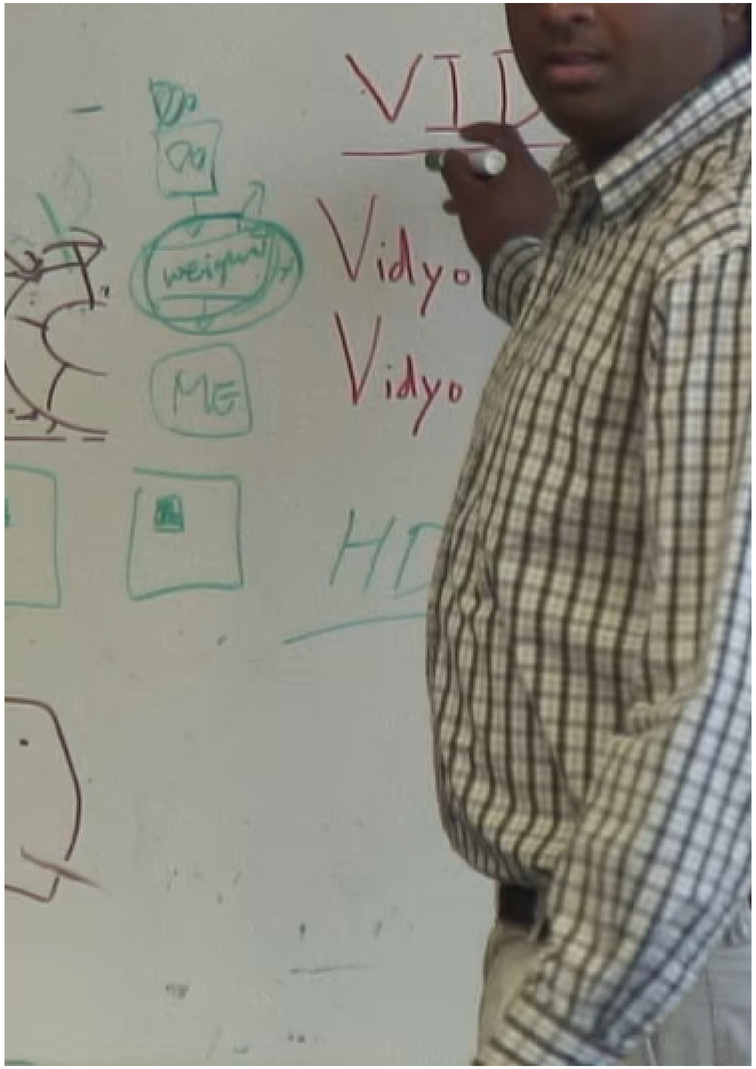


Compressed Kimono with QP=37 (Color enhanced)

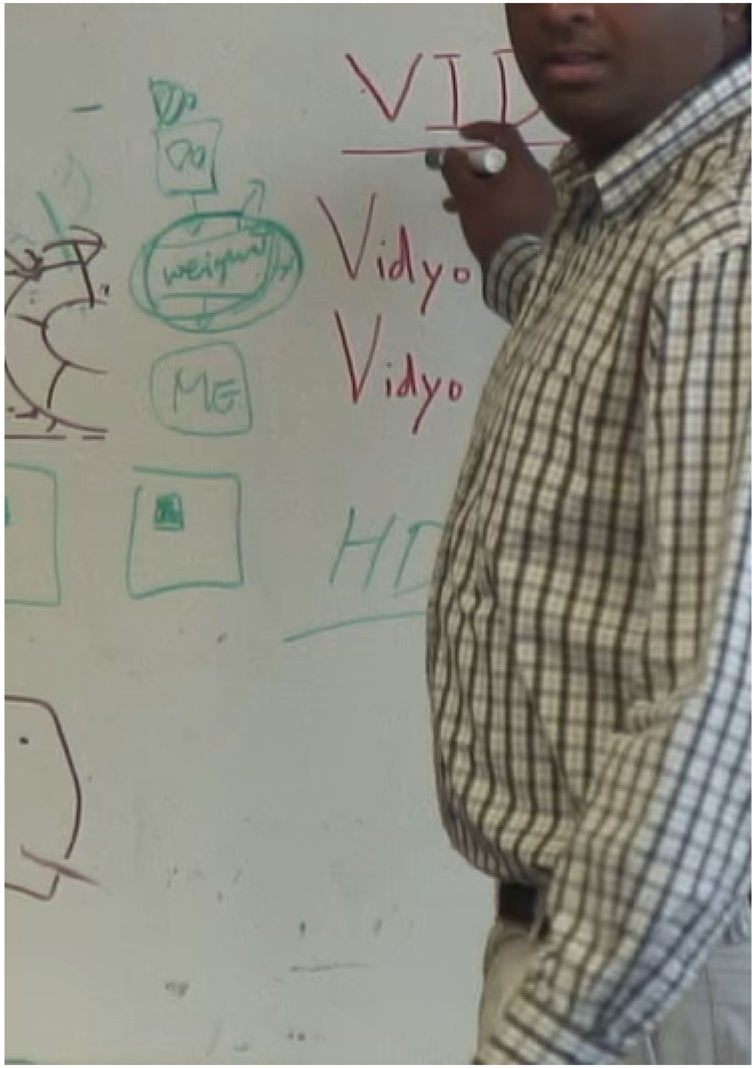


Significant banding-noise reduction by proposal, especially in HCE case. In Proposal HCE play-back video with QP=22, 27, and 32, banding-noise is not visible.

Compressed Vidyo3 1st frames with QP=22

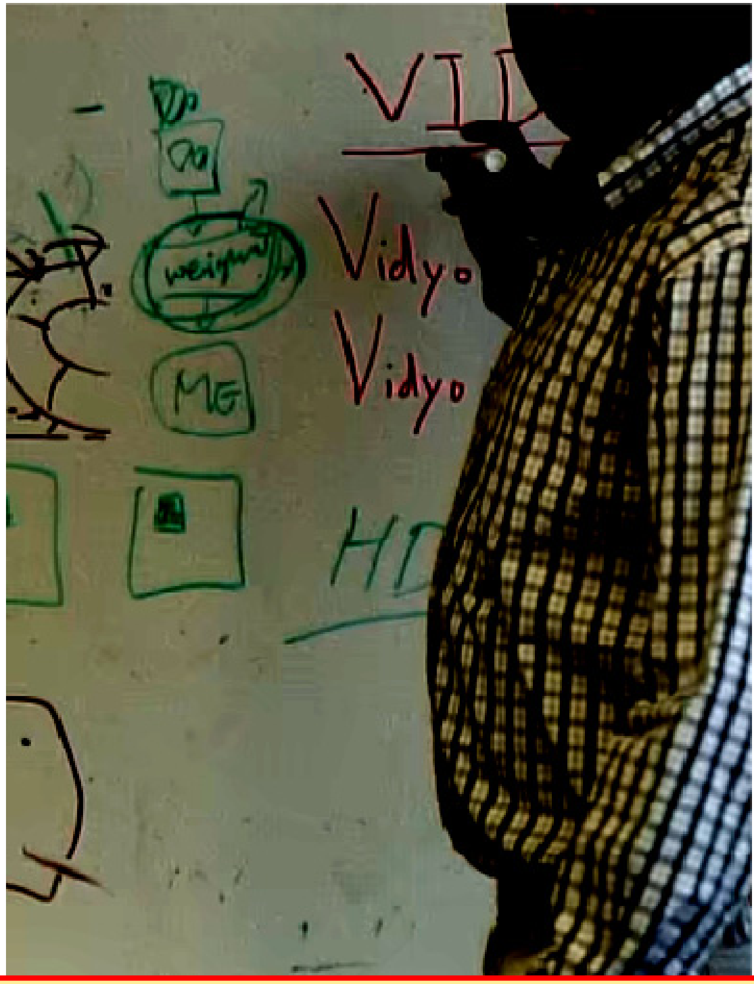


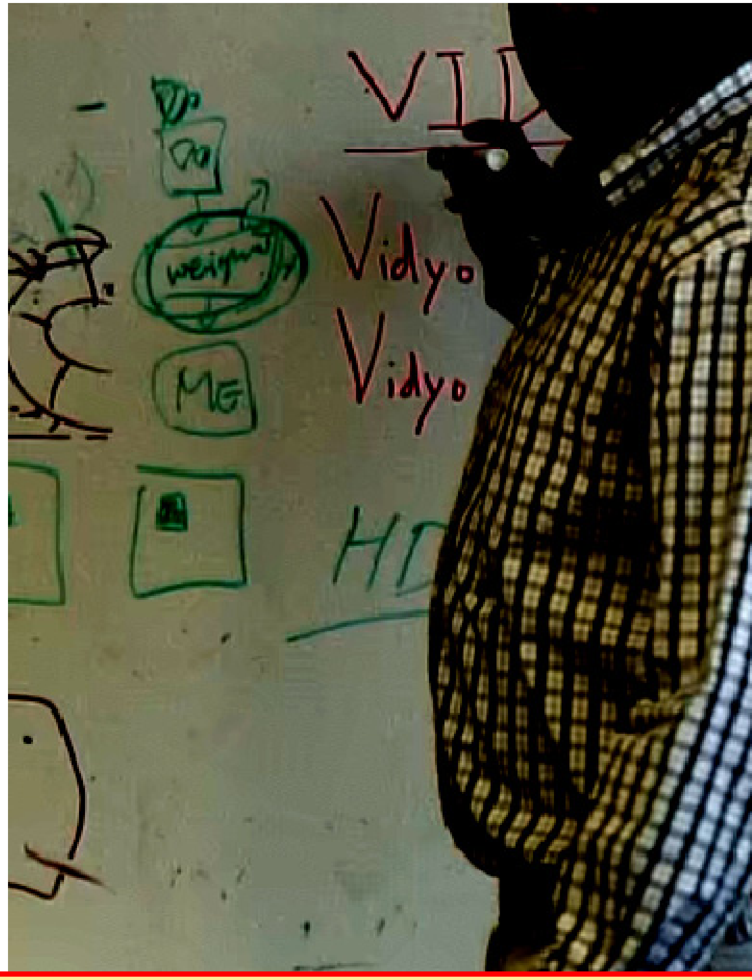
Anchor LC (42.8205 dB)



Proposal LC (42.6974dB)

Compressed Vidyo3 1st frames with QP=22(Color enhanced)





Debanding does not affect visual quality.

Anchor LC (42.8205 dB)

Proposal LC (42.6974dB)

Conclusions

• Banding-noise in video coding

• Debanding by a pseudo-noise based in-loop processing
  - Several advantages over post filtering
  - Significant banding-noise reduction with a negligible impact on coding efficiency including encoding and decoding times

• Recommend to adopt proposal into TMuC software and evaluate it with toolsets specified in HEVC Test Model
  - Its document and software are ready!

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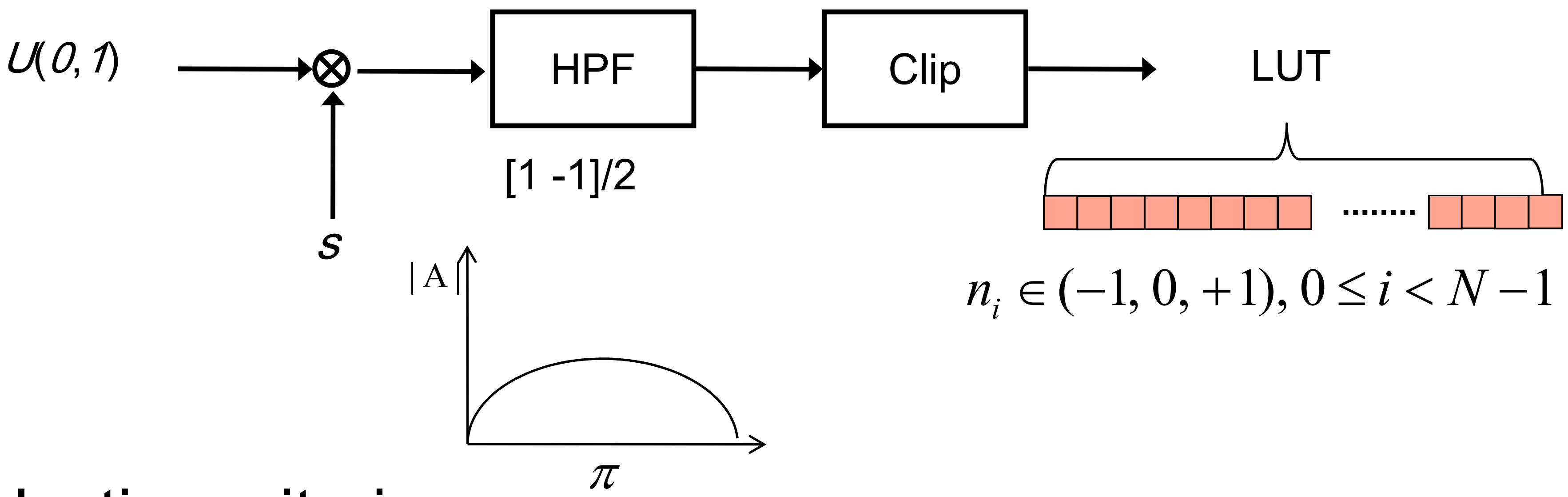
Pseudo-noise in LUT

Procedure



Selection criteria

$$N = 4096$$
$$P(+1) = 0.25$$
$$P(-1) = 0.25$$
$$P(0) = 0.50$$

The LUT size is about 1KB.
(= 2 * 4096 / 8)
The maximum MSE increase is 1.
(= 0.5 * 1 * 2)