

JCTVC-R0139
Modulation channel information SEI

18th JCTVC Meeting: Sapporo, June-July 2014

technicolor



Purpose of the proposal

New SEI message aiming at using a modulation channel in combination with a limited bit-depth channel

Primary intent:

- High bit-depth video coding while re-using existing limited bit-depth HEVC implementations (typically of 8 or 10 bits)
- Can even deal with floating-point format signals (e.g. EXR)

Difference with JCTVC-N0142/-O0090/-P0162/-P0173:

- Use of a multiplicative approach based on modulation instead of an additive approach of 2 layers

Mechanism having similarities with alpha channel

Purpose of the proposal



HBD picture 16b 4:4:4



Modulation picture 10b 4:0:0



LBD picture 10b 4:2:0

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Purpose of the proposal



HBD picture 16b 4:4:4



Modulation picture 10b 4:0:0



LBD picture 10b 4:2:0

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Process description

Encoding side : Demodulation

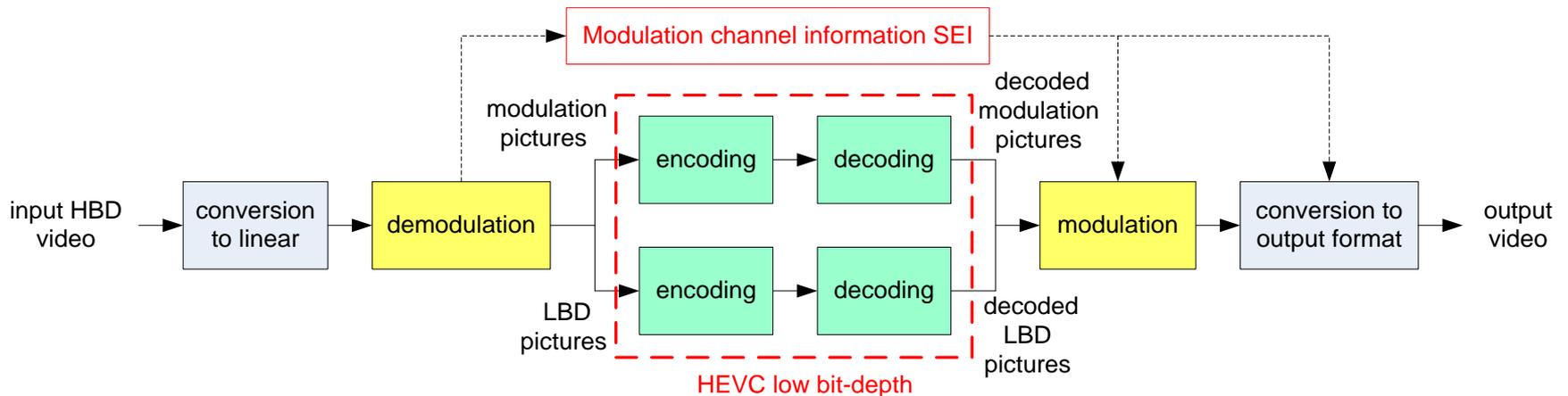
- Input picture split into 1 modulation picture + 1 LBD picture

Decoding side : Modulation

- Decoded modulation and LBD signals recomposed into Target HBD output signal
- Output format indicated in the SEI

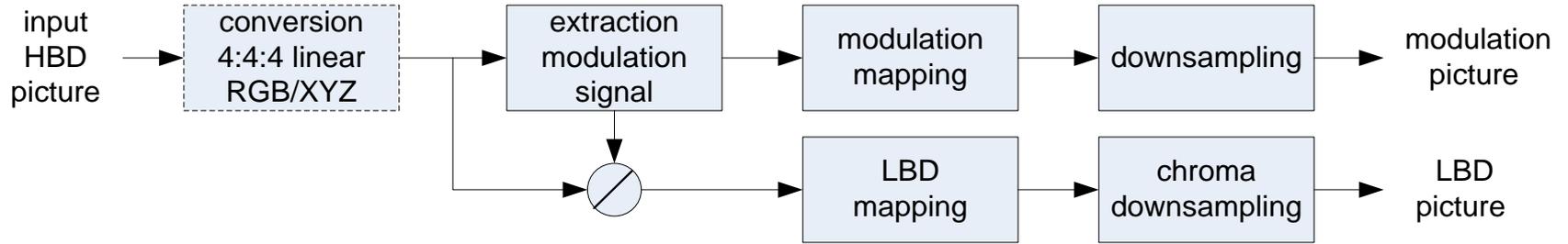
Modulation channel info SEI:

- Contains the parameters useful for the recomposing (modulation) process

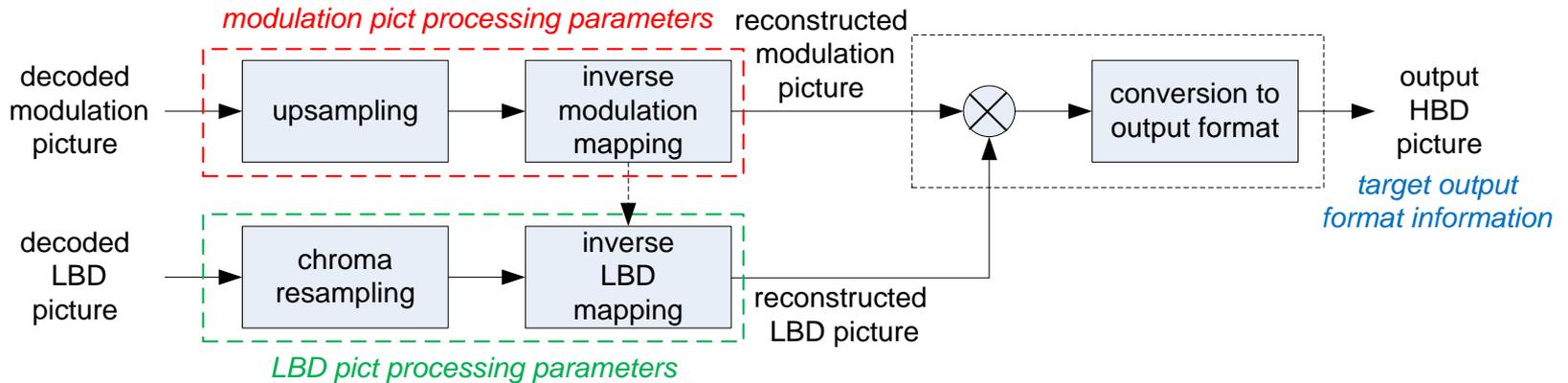


Demodulation / Modulation

Encoding side: demodulation



Decoding side: modulation



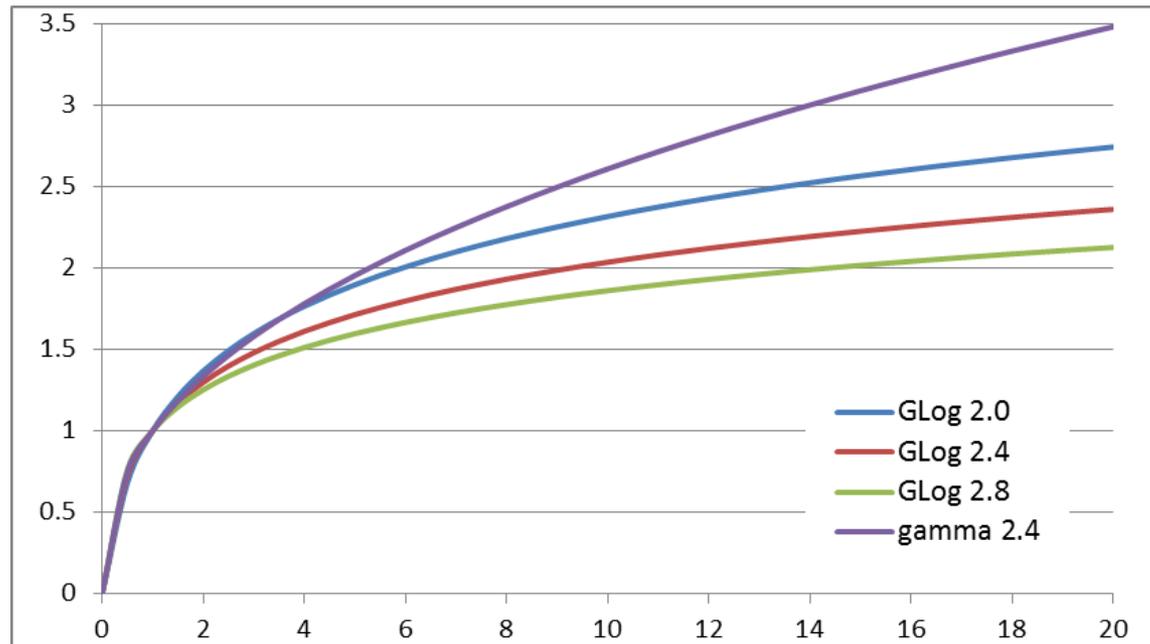
SEI embeds

- **modulation pict processing parameters**
- **LBD pict processing parameters**
- **target output format information**

Mapping function applied to LBD signal

Transfer function defined as a log-like correction (noted GLog):

- $GLog(x) = a_0 * \ln(x + b_0) + c_0$
- parameters a_0 , b_0 , c_0 determined such that 0 and 1 are invariant ($GLog(0) = 0$ and $GLog(1) = 1$) - the derivative in 1 defined as $GLog'(1) = \gamma$
- Enables to lower high lights more aggressively than usual gamma, while preserving black lights as usual gamma



Modulation

2 functional modes considered

- YCbCr mode
 - Decoded LBD channel is ‘compatible’ with Rec.709 or Rec.2020
 - Can be directly rendered on displays conform to Rec.709 or Rec.2020
- Lab mode
 - Works in a perceptual color space (derived from CIE Lab color space)
 - No viewability on Rec.709 or Rec.2020 displays without adaptation
 - Optimal coding efficiency

Modulation YCbCr mode

Modulation channel inverse mapping

- Corresponds mathematically to an inverse log transfer function

YCbCr LBD channel inverse mapping

- Color space conversion from YCbCr to RGB
- Inverse transfer function: $s_{tf} = \text{LumaFact} * \text{GLog}^{-1}(s * \text{Scal})$
- Color space conversion from RGB to XYZ

Modulation

- $X_{\text{HBD}} = X_{\text{tf}} * \text{mod}_{\text{rec}}$ $Y_{\text{HBD}} = Y_{\text{tf}} * \text{mod}_{\text{rec}}$ $Z_{\text{HBD}} = Z_{\text{tf}} * \text{mod}_{\text{rec}}$

Modulation Lab mode

Modulation channel inverse mapping

- Corresponds mathematically to an inverse log transfer function

Lab LBD channel inverse mapping

- Rescaling depending on local modulation value m

$$L_1 = L / \text{scal}(m) \quad a_1 = a / \text{scal}(m) \quad b_1 = b / \text{scal}(m)$$

- Inverse transform from locally perceptual color space

$$\hat{C}^2 = a_1^2 + b_1^2 \quad C = (\exp(k * \hat{C}) - 1) / k$$

$$a_2 = a_1 * C / \hat{C} \quad b_2 = b_1 * C / \hat{C}$$

Note: quantization $\tilde{a}=a\hat{C}/C$ and $\tilde{b}=b\hat{C}/C$ aims at preserving the perceptual distance in Lab94 space

- Inverse transform from the CIE Lab-like space

$$Y' = L_1 / 116 \quad X' = a_2 / 500 + Y' \quad Z' = b_2 / 500 + Y'$$

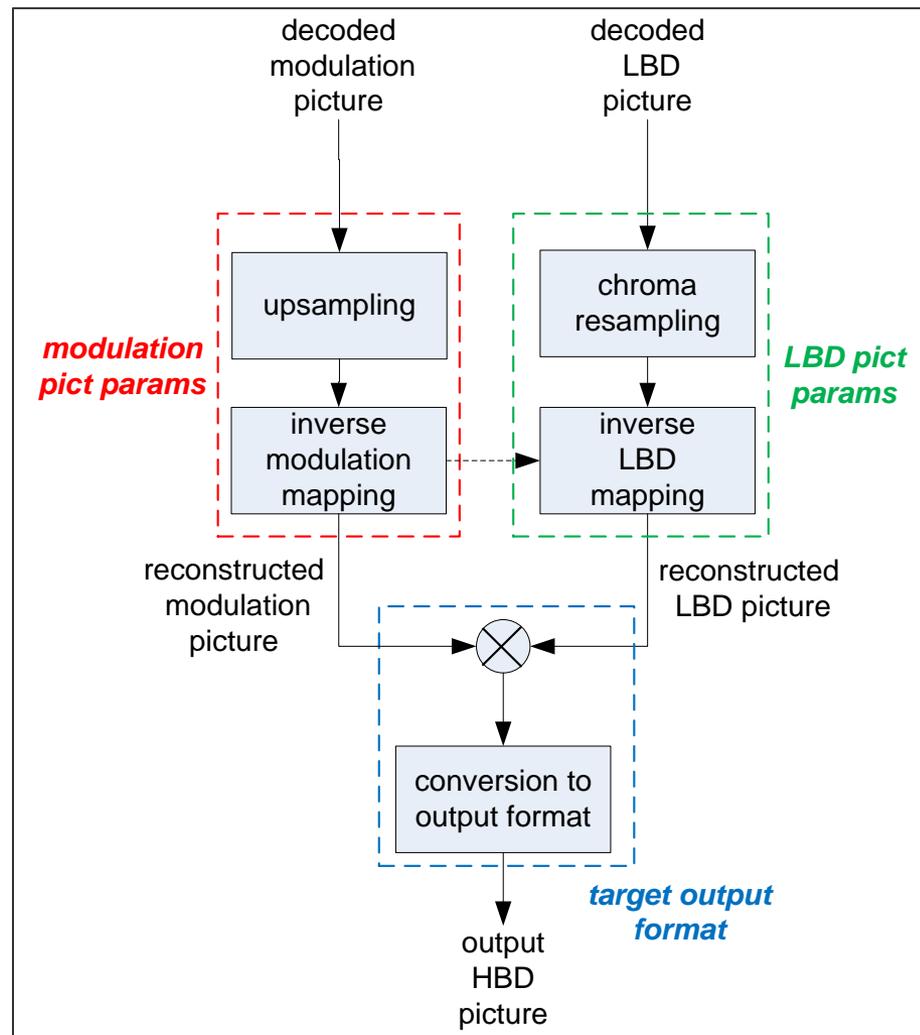
- Inverse TF (applies to each X, Y and Z sample) $s_{\text{tf}} = \text{GLog}^{-1}(s)$

Modulation

- $X_{\text{HBD}} = X_{\text{tf}} * 0.9505 * \text{mod}_{\text{rec}}$ $Y_{\text{HBD}} = Y_{\text{tf}} * \text{mod}_{\text{rec}}$ $Z_{\text{HBD}} = Z_{\text{tf}} * 1.0890 * \text{mod}_{\text{rec}}$

Syntax of Modulation channel information SEI

| modulation_channel_info(payloadSize) { | Descriptor | |
|--|------------|---|
| mod_channel_cancel_flag | u(1) | related to the output signal format |
| if (!mod_channel_cancel_flag) { | | |
| mod_chroma_format_idc | ue(v) | |
| mod_sample_format_idc | ue(v) | |
| if(mod_sample_format_idc == 1) { | | |
| mod_bit_depth_luma_minus8 | u(3) | |
| mod_bit_depth_chroma_minus8 | u(3) | |
| } | | |
| mod_video_full_range_flag | u(1) | |
| mod_colour_primaries | u(8) | |
| mod_transfer_characteristics | u(8) | related to the modulation picture processing |
| mod_matrix_coeffs | u(8) | |
| mod_modpic_bit_depth_minus8 | u(3) | |
| mod_lbd_bit_depth_luma_minus8 | u(3) | related to the LBD picture processing |
| mod_lbd_bit_depth_chroma_minus8 | u(3) | |
| mod_lbd_format | u(2) | |
| if((mod_lbd_format == 1) (mod_lbd_format == 2)) { | | |
| lbd_glog_a0 | u(15) | |
| lbd_glog_b0 | u(14) | |
| lbd_glog_c0 | u(10) | |
| lbd_scaling_factor | u(10) | |
| lbd_luminance_balance_factor | u(10) | |
| } | | |
| } | | |
| mod_channel_persistence_flag | u(1) | |
| } | | |



Possible containers for the Modulation channel

Several possible ways of conveying the modulation channel

- **Auxiliary picture**

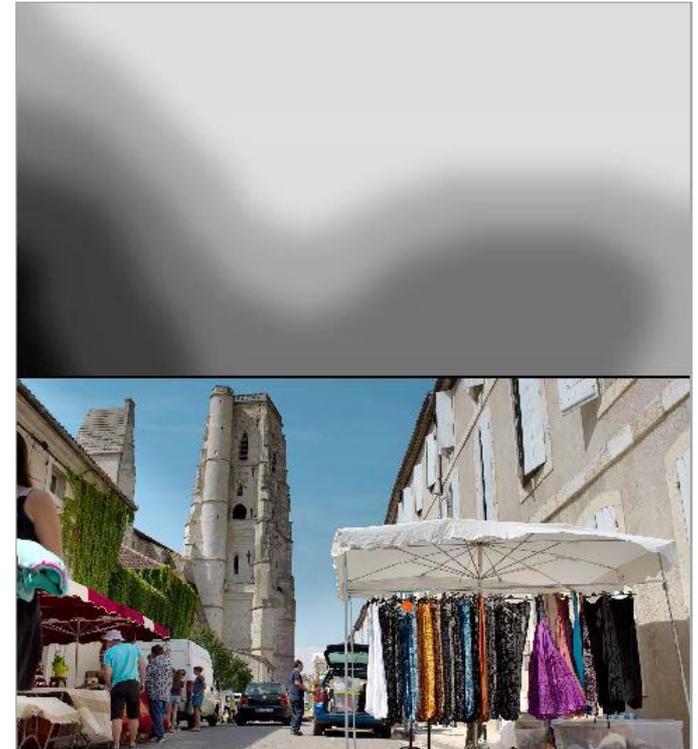
- close to the Alpha channel concept
- SHVC framework
- No synchro issue

- **Frame packing**

- already practically used for 3D/multiview services
- No synchro issue

- **Additional SEI message**

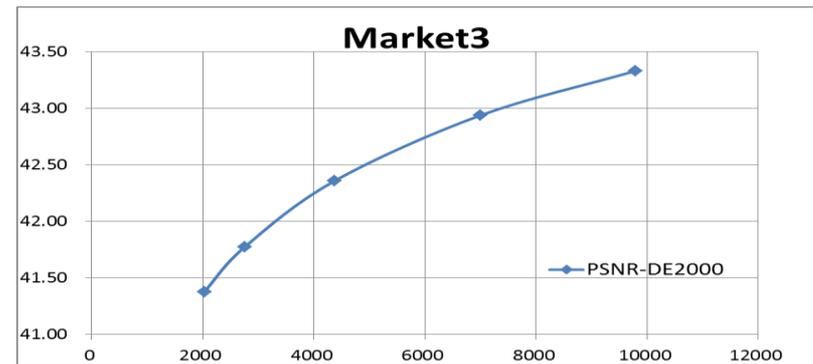
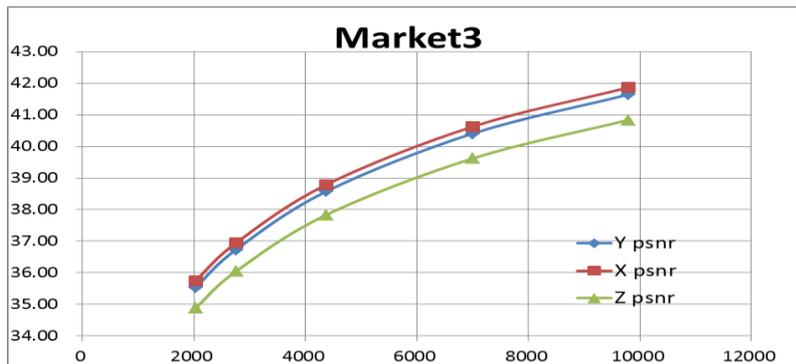
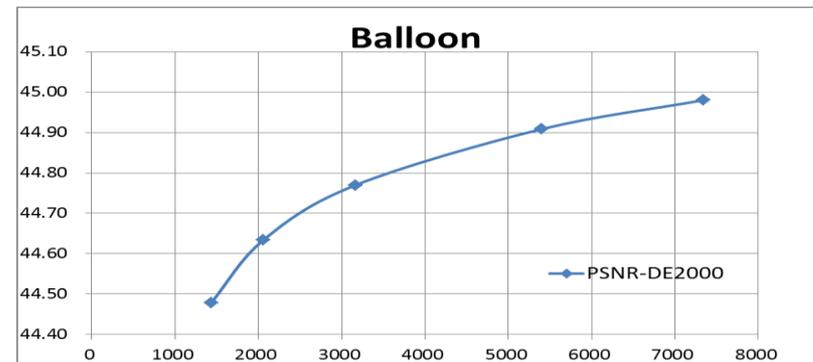
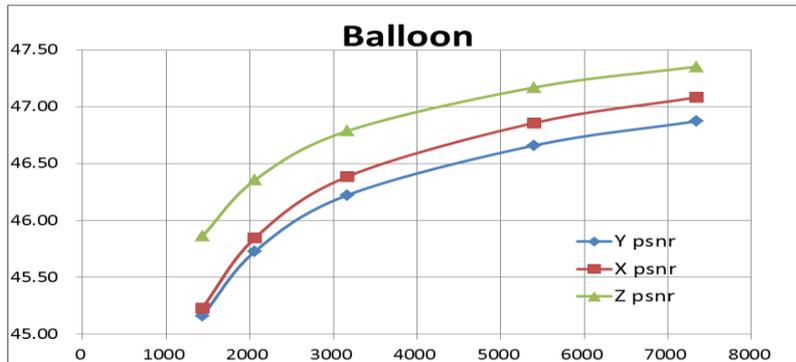
- embedding the modulation picture into an SEI message (one per picture)
- only valuable if the size of the modulation channel is small, that is, resulting from a significant downsampling of the modulation signal



Experiments

2 implementations:

- Auxiliary picture (SHM7.0) / Frame Packing (HM13.0_RExt6.0rc1)
- Test using EXR 1080p sequences converted to XYZ 16b gamma2.4
- Modulation channel of very low cost
 - Very smooth signal that can be significantly downsampled



Conclusions

- A new SEI message proposed to support modulation video channel
- 2 functional modulation modes proposed
 - YCbCr mode: LBD channel is compatible with Rec.709 or Rec.2020
 - Lab mode: perceptual color space (from CIE Lab), no viewability, for improved coding efficiency
- Enables high bit-depth / floating-point video coding using low bit-depth encoding/decoding devices

Thanks to Arris, Orange Labs, Sony for cross-checking

