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| *Title:* | **New HDR video coding results** | | |
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| *Source:* | Technicolor | | |

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# Abstract

This contribution presents results from the HDR video coding scheme already described in m32076/JCTVC-P0159. At the previous meeting, results using a configuration guaranteeing a backward compatibility with LDR devices (HEVC Main10 decoding and LDR displays) have been presented. In this new contribution, results from the coding scheme configured without LDR backward compatibility constraint are presented. In particular, the used HEVC codec is HM\_RExt 4:4:4 10bits. An accompanying demonstration is also proposed.

# Introduction

At the previous meeting, a generic dual-layer based HDR video coding scheme has been presented in m32076/JCTVC-P0159. In the proposed codec the HDR content is decomposed into one LDR signal and one side illumination signal. The LDR layer is then encoded using an AVC or HEVC encoder, while the side illumination signal, of very low entropy compared to the LDR signal, can be encoded with a simple entropy codec.

In m32076/JCTVC-P0159, we have shown results based on the following configuration of the proposed generic codec:

* The LDR signal is 4:2:0 10bits
* It is encoded/decoded using the HM conform to Main10 profile (HM-12.0)
* The reconstructed LDR can be displayed on a standard LDR display

To complement these first results, this contribution proposes results based on the following configuration:

* The LDR signal is 4:4:4 10bits
* It is encoded/decoded using the HM\_RExt (HM-13.0\_RExt-6.0)
* The reconstructed LDR is not viewable on an LDR display

The document first reminds the global architecture of the generic codec. Compression results with the configuration described above are then presented on a set of HDR test sequences. Comparisons with a PQ EOTF-based coding chain based on the 4:4:4 12bit HM\_RExt encoding/decoding are included.

# Overview of the coding scheme

The Figure 1 and Figure 2 provide a simplified synoptic of the proposed HDR encoder and decoder schemes. Both the encoder and decoder are made of two main parts:

* the HDR signal decomposition/recomposing, which decomposes at the encoder side the input HDR signal into two signals of low dynamic range and recomposes at the decoder side the HDR signal from two decoded signals of low dynamic range;
* the encoding/decoding, which aims at re-using limited bit-depth schemes such as AVC 8-bit, HEVC 8- or 10bit to encode/decode the LDR signals.

The proposed solution exploits the locally low dynamic range property of the HDR signal (LDR localization). Based on this property, the approach consists in splitting the input HDR signal into two integer signals of low dynamic range and limited bit-depth (e.g. 8 or 10 bits), a low frequency signal which corresponds to the local luminance signal mean, and a residual signal which corresponds to the locally LDR signal made of the remaining high frequency signal. The signal decomposition enables keeping a very high signal precision and finely adapting the quantization to the local signal characteristics.

At the encoder side (cf Figure 1), the HDR signal decomposition works as follows.

* The luminance component of the input HDR signal is first extracted.
* The luminance component is then processed to generate a low dynamic range low frequency signal. Thanks to its low frequency property, the spatial resolution of the low frequency signal can be significantly lower than the input signal resolution.
* The residual signal is then generated as the remaining high frequency component of the HDR signal once the low frequency signal has been extracted. This extraction is based on a demodulation of the HDR signal by the low frequency signal.
* A step of perceptual color transform is then applied in order to quantize the signal while perceptually preserving the signal characteristics and variations. In particular, low values are more finely quantized than high values; in addition high values are quantized in order to control luminance and color saturations. The process can also take into account local signal properties.
* Metadata are also associated to the HDR signal decomposition process.

The resulting signals are then encoded.

* The residual signal, of same resolution as the native HDR signal, can be encoded using an existing limited bit-depth encoder, such as AVC 8-bit, HEVC 8- or 10-bit.
* The low frequency signal can also be encoded using an existing limited bit-depth encoder. This signal is by nature of very low entropy. Its resolution can be reduced and its coding cost is small compared to the residual signal.



Figure 1: simplified encoding scheme

The decoder operates as follows (cf Figure 2).

First the LDR low frequency and residual signals are decoded. A legacy decoder (AVC 8-bit, HEVC 8- or 10-bit) can be used.

The decoded signals are then post-processed to generate the decoded HDR signal.

* An inverse color transform is applied to the decoded residual signal. This step possibly uses the low frequency signal as input, in order to locally adapt the transform process to the local low frequency luminance.
* Then both signals are combined to generate the reconstructed HDR signal. The combination is similar to a modulation process of the residual signal by the low frequency signal.



Figure 2: simplified decoding scheme

As mentioned above, the residual signal can be encoded using an existing limited bit-depth encoder, such as AVC 8-bit, HEVC 8- or 10-bit.

The low frequency signal is of lower resolution than the native HDR pictures. It can be encoded as a side information embedded in an SEI message. Another solution consists in embedding this side information as an auxiliary picture. Referring to HEVC, an additional auxiliary picture type, “Illumination plane”, is added to the existing types of auxiliary picture. In addition a new SEI message “auxiliary\_hdr\_channel\_info” is specified related to the usage of the auxiliary pictures of type “Illumination plane”.

# Experiments

This section reports results using the proposed coding scheme. A comparison with an implementation of the PQ-EOTF/Ydzdx approach is also made.

## Test conditions

Five HDR test sequences are used: Balloon, Market3, Fire-Eater2, Seine, Tibul2 (more details can be found in m32306/JCTVC-P0228). The quantization steps are adaptively chosen to reach bitrates ranges typically used in consumer oriented video distribution applications such as broadcast.

The objective performance is measured using the *E2000* PSNR. *E2000* has been specified by the CIE to measure the perceptual distance or difference between two colors. Additional explanations about *E2000* can be found in m32307/JCTVC-P0229. The PSNR*E* is computed for each picture as follows:

with *Emean* being the average *E2000* over the picture. 65504 is the peak value of the half-float representation of the HDR sequences. The PSNR is averaged over the entire sequence.

## PQ EOTF/ Ydzdx chain implementation

An implementation of the PQ-EOTF/Ydzdx approach has been made for comparisons. The coding chain has been implemented according to the SMPTE draft recommendations WD ST 2084 EOTF and SMPTE 2085 ‘YDzDx Color-Difference Encoding for XYZ Signals’, as illustrated in Figure 3.





Figure 3: implementation of the PQ EOTF / Ydzdx coding chain.

The Ydzdx transform generates some issues regarding luma/chroma balance. The chroma signal has generally a range which is significantly lower than the luma signal. To compensate this issue and to have a better luma/chroma balance, we have used a Chroma QP offset of -9.

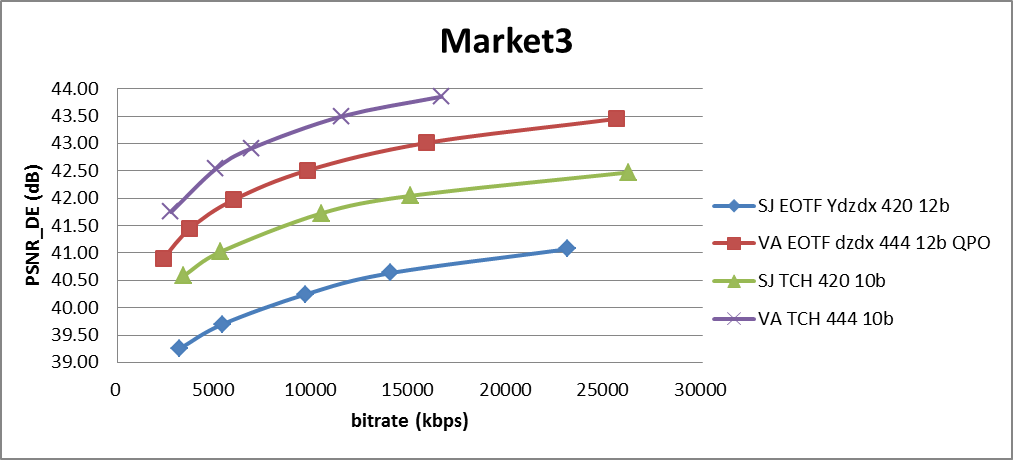
**Encoder settings**

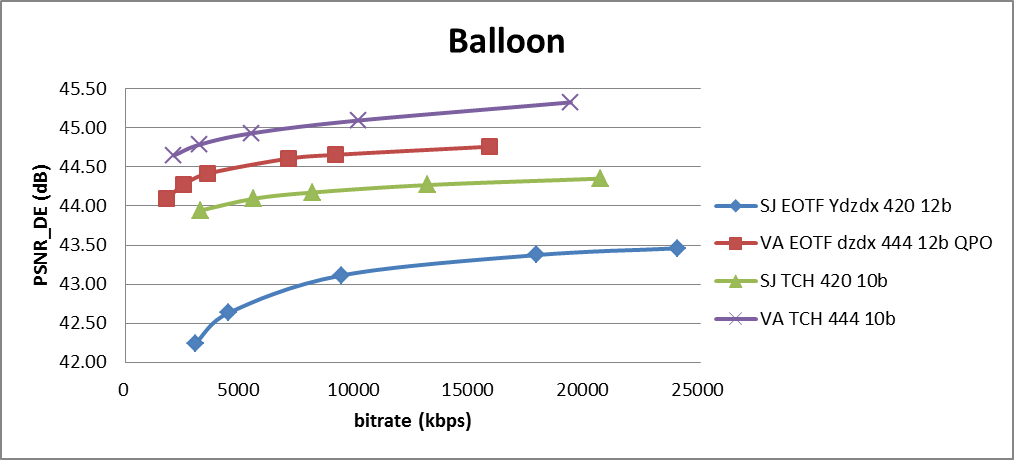
* HM-13.0\_RExt-6.0
* 4:4:4
* 12bits
* Chroma QP offset set to -9

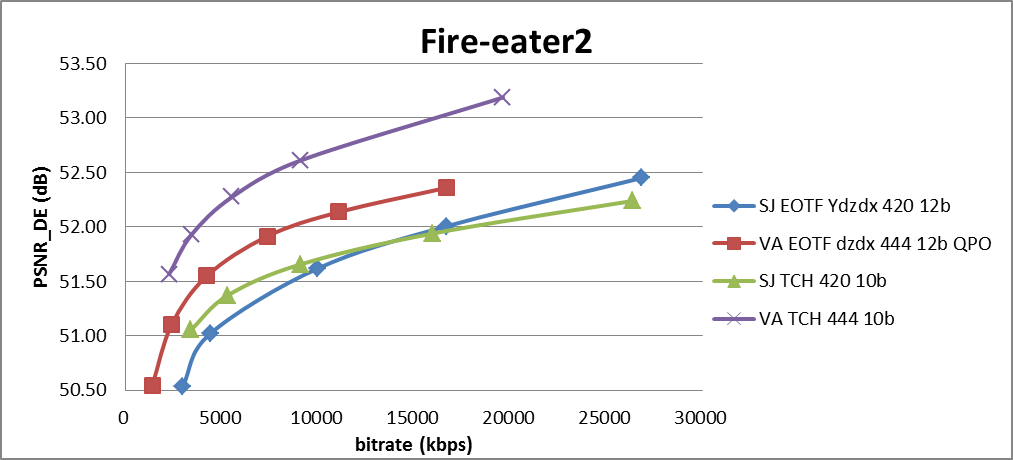
## Results

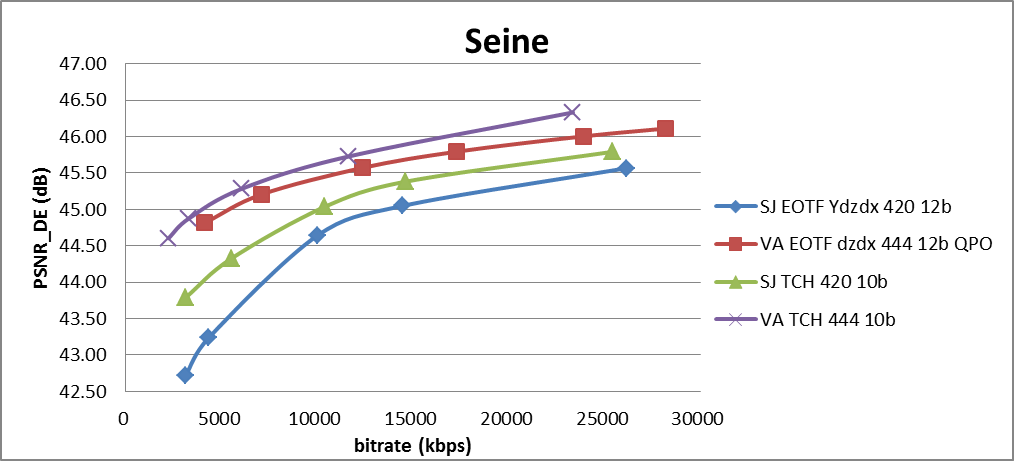
The results are reported in the following plots and can also be found in the attached xls file. The new results are indicated by ‘VA’ (Valencia) while the results previously reported in m32076/JCTVC-P0159 are indicated by ‘SJ’ (San Jose).

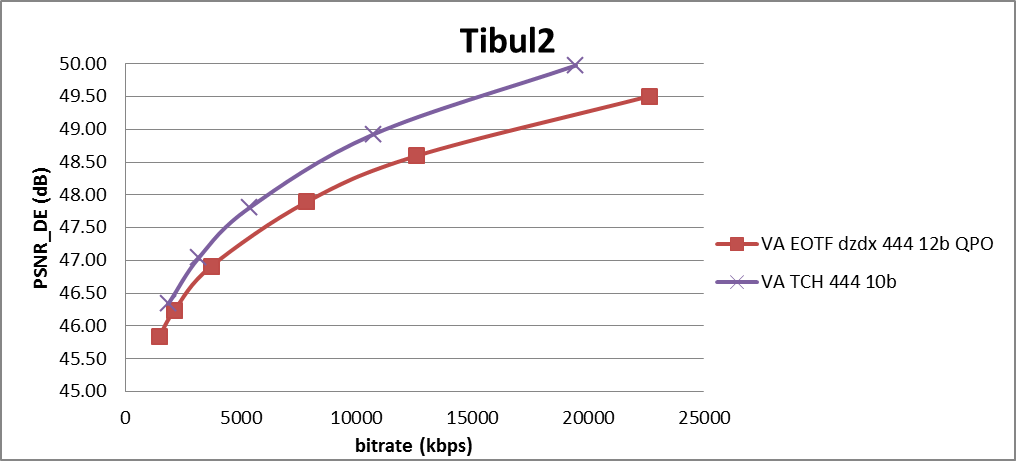
Viewing sessions are also proposed.











# References

[1] S. Lasserre, F. Le Léannec, E. François, Description of HDR sequences proposed by Technicolor, ISO/IEC JTC1/SC29/WG11 MPEG2014/ m31957, Oct. 2014, San Jose, USA

[2] S. Lasserre, F. Le Léannec, E. François, Quantitative quality evaluation of images for MPEG XYZ, ISO/IEC JTC1/SC29/WG11 MPEG2014/ m31959, Oct. 2014, San Jose, USA

# Patent rights declaration

**Technicolor 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).**