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| *Title:* | **An Update of the Tone Mapping Information SEI Message** | | |
| *Status:* | Input Document | | |
| *Purpose:* | Proposal | | |
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# Abstract

This document proposes a slight modification of the existing Tone Mapping Information (TMI) Signal Enhancement Information (SEI) Message from the AVC and HEVC specification. The modification is to add a single one-bit flag, which indicates whether the tone mapping results in linear light or not. This clarifies the existing TMI SEI and expands the scope of its application, while using a slight modification that remains consistent with existing usage. This update of the TMI SEI is also proposed in JVET in document JVET-F0068.

# Introduction

An important objective of modern video coding standards is the efficient representation of high dynamic range video (HDR) with wide colour gamut [1, 2]. Within the AVC [3] and HEVC [4] codecs, popular tone mappings such as the Perceptual Quantizer (PQ, SMPTE ST-2084) or HLG [1, 6, 7] are signaled using a video usability information (VUI) signal. These are well known examples of static tone mappings, and require signalling only once in a stream. In the encoder, both typically apply in linear light RGB 4:4:4 signal components; at the decoder, a VUI signal for one of these tone mappings indicates that the signal should not be further nonlinearly mapped or color converted prior to display.

Two relatively recent developments now suggest the need for a more flexible signalling mechanism for tone mappings. First, while PQ and HLG are but two popular tone mappings, one can envision any number of additional mappings that may be useful in applications. At the encoder side, both of these tone mappings typically apply on linear light RGB 4:4:4 components. However, the syntax and semantics of the existing TMI SEI is somewhat at odds with this, in as much as it appears to apply in nonlinear light at the encoder; and at the decoder, the output of applying the signalled tone mapping would thus be nonlinear light. Since a variety of tone mappings can be envisioned, some in linear light and some in nonlinear light, the added flexibility of working in either space seems beneficial. Secondly, the recent appearance of “dynamic” tone mappings which are signal-dependent requires a more flexible signalling mechanism that can adapt during a stream, for which a flexible SEI is more appropriate than a VUI. Since effective dynamic tone mappings can be developed in either linear or nonlinear light (see [5,8-10]), we propose a modest change to the TMI SEI that enables this flexibility, by use of a one-bit flag, which we call “**tone\_map\_to\_linear\_light\_flag**”. When this flag is set to “0” (default), the tone mapping is applied in nonlinear light at the encoder; when set to “1”, it is applied in linear light. In either case, it may be applied on RGB components, or on a luma (or luminance) signal Y, as may be the case.

# Proposed syntax and semantics

The syntax and semantics of the Tone Mapping Information SEI message are described in the AVC and HEVC standards. Below we provide just the additional one bit flag that is to be added to the SEI.

## Syntax

**tone\_map\_to\_linear\_light\_flag u(1)**

## Semantics

**tone\_map\_to\_linear\_light\_flag**  equal to 0 indicates that the remapping results in nonlinear light components (either R’, G’, B’, or luma Y’), consistent with the prior TMI SEI signalling; when equal to 1, it indicates that the remapping results in linear light components (R, G, B, or luminance Y).

# Discussion

## Existing TMI SEI

The current TMI SEI message [3, 4] can, for example, be used to signal a tone mapping operation as in figure 1, acting on nonlinear light RGB components, where the blocks DRA/Inverse DRA are configured; it can also switch places with the next block, and on the luma signal just before the 4:4:4 to 4:2:0 / just after the 4:2:0 to 4:4:4 conversion. Note that nonlinearity in question, here pictured as the PQ EOTF, can be replaced by another transfer function or could be the gamma mapping. Furthermore, the color transformation need not be to Y’CbCr, but another luminance-chrominance decomposition.



Figure 1. Application of the existing TMI SEI message, pictured as the blocks called Inv. TM / TM, and acting on nonlinear light RGB components. That tone mapping can instead be applied to the **luma** signal Y’: in the encoder, just after the colour space Conv to Y’CbCr; in the decoder, just before the Conv to R’G’B’. In these cases, the default value of **tone\_map\_to\_linear\_light\_flag** of 0 would be used.

## New Functionality of TMI SEI

The additional functionality enabled by setting **tone\_map\_to\_linear\_light\_flag = 1** is that the tone mapping can now be applied directly to linear light RGB components (or to the **luminance** signal Y’).



Figure 2. Application of the new functionality TMI SEI message, pictured as the blocks called Inv. TM/TM, and acting on linear light RGB components in the encoder (and resulting in linear light RGB components in the decoder). That tone mapping can also instead be applied to the **luminance** signal Y’: in the encoder, just after the Conv to Y’CbCr; in the decoder, just before the Conv to R’G’B’. In these cases, the new value of **tone\_map\_to\_linear\_light\_flag** of 1 would be used.

# Experiments

Experimental results with using the HEVC codec are reported in [9, 10]. Results for JEM below are in comparison to HEVC, for RA configuration. (There was an error in the run for Cosmo1, which will be reported when rerun.)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Y psnr | U psnr | V psnr | tPSNRY | DE0100 | L100 |
| Market3Clip4000r2 | 27.41% | 0.00% | 0.00% | -0.74% | -10.26% | -33.50% |
| ShowGirl2TeaserClip4000 | -2.44% | 0.00% | 0.00% | -9.62% | -10.55% | -15.06% |
| EBU\_04\_Hurdles | 454.53% | 0.00% | 0.00% | 14.33% | -20.16% | -13.86% |
| EBU\_06\_Starting | 91.65% | 0.00% | 0.00% | 31.90% | -16.40% | -13.17% |
| Cosmos1 | #REF! | #REF! | #REF! | #REF! | #REF! | #REF! |
| **Overall** | #REF! | #REF! | #REF! | #REF! | #REF! | #REF! |

# References

[1] Recommendation ITU-R BT.2100-0 (2016), *Image parameter values for high dynamic range television for use in production and international programme exchange*.

[1] Recommendation ITU-R BT.2020-2 (2015), *Parameter values for ultra-high definition television systems for production and international programme exchange*.

[3] Recommendation ITU-T H.264 (in force), *Advanced video coding for generic audiovisual services*. | ISO/IEC 14496-10 (in force), *Information technology – Coding of audio-visual objects – Part 10: Advanced Video Coding*.

[4] Recommendation ITU-T H.265 (in force), *High Efficiency Video Coding*. |ISO/IEC 23008-2 (in force), *Information technology – High efficiency coding and media delivery in heterogeneous environments – Part 2: High efficiency video coding.*

[5] ETSI TS 103 433 (in force), *High-Performance Single Layer Directly Standard Dynamic Range (SDR) Compatible High Dynamic Range (HDR) System for use in Consumer Electronics devices (SL-HDR1)*.

[6] SMPTE ST 2084 (2014), *High Dynamic Range Electro-Optical Transfer Function for Mastering Reference Display*.

[7] SMPTE ST 2086 (2014), *Mastering Display Color Volume Metadata for High Luminance and Wide Color Gamut Images*.

[8] SMPTE ST 2094 (2016), *Dynamic Metadata for Color Transforms of HDR and WCG Images*.

[9] P. Topiwala, W. Dai, M. Krishnan, “AHG14: Tone Mapping and Related SEIs for HDR Coding”, JCTVC-Y0042, 25th JCT-VC Meeting, Chengdu, CN, Oct. 2016.

[10] P. Topiwala, W. Dai, M. Krishnan, “User Data Unregistered SEI for Backward Compatible HDR Coding”, JCTVC-AA0037, 27th JCT-VC Meeting, Hobart, AU, March, 2017.

# Patent rights declaration(s)

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