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| *Title:* | **AHG7: indication of shutter angle for variable frame rate application** | | |
| *Status:* | Input document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

This contribution proposes an SEI message for HEVC and AVC to provide useful information about shutter angle, which is a term of art that indicates the effective exposure duration relative to frame duration and is thus also an indicator of motion blur. Shutter angle information can be particularly useful when different temporal sub-layers have different effective shutter angles and thus motion blur. In such cases, shutter angle information can be used to adjust the look of video on a display.

To enable shutter angle information to be signaled, we propose new syntax and semantics to:

1. indicate that shutter angle values are the same or different for different temporal sub-layers; and
2. signal one shutter angle value if all sub-layers have the same shutter angle, or signal one shutter angle value for each temporal sub-layer.

# Introduction

## Shutter angle

Shutter angle is a term of art that indicates shutter speed relative to frame rate, which is equivalent to indicating exposure duration relative to frame duration [1].

Shutter angle is expressed in degrees from 0 to 360 degrees. A shutter angle of 180 degrees, for example, indicates that the exposure duration is ½ the frame duration. (The use of degrees to measure relative exposure time is a hold over from the days when movie cameras used rotating disk shutters.) Shutter angle may be expressed as:

shutter\_angle = frame\_rate \* 360/shutter\_speed

where shutter\_speed is the inverse of exposure duration and frame\_rate is the inverse of frame duration.

Shutter angle affects the look of displayed video. A smaller value of shutter angle corresponds to a shorter effective exposure duration, and thus less motion blur, than a larger shutter angle value at the same frame rate. Similarly, a higher frame rate at a particular shutter angle would result in less motion blur than a lower frame rate at the same shutter angle.

Shutter angle also affects the perception of smooth and non-smooth motion. Small shutter angle leads to more motion judder and strobing, which is the perception of non-smooth motion as a result of temporal undersampling.

The effective shutter angle may be artificially modified by a display or other post-decode process to affect the look of displayed video. For example, synthetic motion blur may be increased or decreased to achieve a desired look. Providing shutter angle information would facilitate such processing.

Neither HEVC nor AVC currently provide a means of signalling shutter angle information to displays or other post-decode processes designed to achieve a desired look of displayed video.

## Temporal sub-layers

HEVC and AVC support temporal sub-layers that enable bitstreams to be extracted at multiple frame rates. For example, a 60 fps bit stream can be derived from a 120 fps video by dropping every other frame. Similarly, a 30 fps bitstream can be derived by dropping 3 out of every 4 frames, and a 24 fps bit stream can be derived by dropping 4 out of every 5 frames.

However, each of the resulting videos (24, 30, 60, and 120 fps) would have a different effective shutter angle and thus different look. For example, motion in the 24 fps video would be more juddery and non-smooth than the 120 fps video, and the shutter angle of the 24 fps video would be ⅕ of the shutter angle of the 120 fps video because only every 5th frame is retained. Likewise, the 30 fps video would have a shutter angle ¼ of the 120 fps video, and the 60 fps vide would have a shutter angle ½ of the 120 fps video. Motion in the 30 fps and 60 fps videos would appear less smooth than in the 120 fps video.

As noted in JVET-M0578 [3], the fidelity of extracted temporal sub-layers to the visual look of the original video sequence, including the smoothness of motion and amount of motion blur, is an important component of meeting quality expectations in broadcast use cases, including those that use temporal sub-layering as specified in ATSC 3.0 [4].

Neither HEVC nor AVC provide shutter angle information to displays or other post-decode processes to facilitate achieving a consistent or other desired look for different extracted temporal sub-layers.

# Proposal

In this contribution, we propose a shutter angle information SEI message for HEVC and AVC. The proposed SEI syntax elements provide support for both fixed shutter angle for all temporal sub-layers and variable shutter angles for different temporal sub-layers.

## HEVC

D**.2.1 General SEI message syntax**

|  |  |
| --- | --- |
| sei\_payload( payloadType, payloadSize ) { | **Descriptor** |
| if( nal\_unit\_type = = PREFIX\_SEI\_NUT ) |  |
| if( payloadType = = 0 ) |  |
| buffering\_period( payloadSize ) |  |
| […] |  |
| else if( payloadType  = =  153 ) |  |
| shutter\_angle\_info( payloadSize ) |  |
| […] |  |
| } |  |
| } |  |

D**.2.41.3 Shutter angle information SEI message syntax**

|  |  |
| --- | --- |
| shutter\_angle\_info ( payloadSize ) { ( ) { | **Descriptor** |
| **fixed\_****shutter\_angle\_within\_cvs\_flag** | u(1) |
| if (fixed\_shutter\_angle\_within\_cvs\_flag) |  |
| **fixed\_shutter\_angle** | u(9) |
| else { |  |
| for( i = 0; i <= sps\_max\_sub\_layers\_minus1; i++ ) { |  |
| **sub\_layer\_shutter\_angle**[ i ] | u(9) |
| **}** |  |
| } |  |

**D.3.41.3 Shutter angle information SEI message semantics**

This SEI message indicates the shutter angle value associated with each temporal sub-layer for a progressive scanned CVS (field\_seq\_flag equal to 0). Shutter angle is a term of art that indicates shutter speed relative to frame rate, which is equivalent to indicating exposure duration relative to frame duration, used while authoring the video content.

This SEI message does not specify the measurement methodologies and procedures used for determining shutter angle values nor any description of the authoring conditions.

NOTE 1 – Shutter angle is expressed in degrees from 0 to 360 degrees. A shutter angle of 180 degrees, for example, indicates that the exposure duration is ½ the frame duration. The use of degrees to measure relative exposure time began when movie cameras used mechanical rotating disk shutters.

NOTE 2 – Shutter angle may be expressed as: shutter\_angle = frame\_rate \* 360/shutter\_speed, where shutter\_speed is the inverse of exposure duration and frame\_rate is the inverse of frame duration. frame\_rate for the given temporal sub-layer Tid may be indicated by the **vui\_num\_units\_in\_tick**, **vui\_time\_scale** , **elemental\_duration\_in\_tc\_minus1**[Tid]. For example, when fixed\_pic\_rate\_within\_cvs\_flag[ Tid ] is equal to 1, the frame rate for temporal sub-layer Tid may be indicated by frame\_rate = vui\_time\_scale /( vui\_num\_units\_in\_tick \* (elemental\_duration\_in\_tc\_minus1[Tid] + 1 ) ) .

**fixed\_shutter\_angle\_within\_cvs\_flag** equal to 1 specifies that shutter angle value is the same for all temporal sub-layers in the CVS. fixed\_shutter\_angle\_within\_cvs\_flagequal to 0 specifies that shutter angle value may not be the same for all temporal sub-layers in the CVS.

**fixed\_shutter\_angle** specifies the shutter angle value in degrees. The value of fixed\_shutter\_angle shall be in the range of 0 to 360.

**sub\_layer\_shutter\_angle**[ i ]specifies the shutter angle value in degrees when HighestTid is equal to i. The value of sub\_layer\_shutter\_angle[ i ] shall be in the range of 0 to 360.

## AVC

**D.1.1 General SEI message syntax**

|  |  |  |
| --- | --- | --- |
| sei\_payload( payloadType, payloadSize ) { | **C** | **Descriptor** |
| […] |  |  |
| else if( payloadType = = 153) |  |  |
| Shutter\_angle\_info( payloadSize ) | 5 |  |
| […] |  |  |
| } |  |  |

D**.1.35.3 Shutter angle information SEI message syntax**

|  |  |
| --- | --- |
| shutter\_angle\_info ( payloadSize ) { ( ) { | **Descriptor** |
| **fixed\_shutter\_angle\_within\_cvs\_flag** | u(1) |
| if (fixed\_shutter\_angle\_within\_cvs\_flag) |  |
| **fixed\_shutter\_angle** | u(9) |
| else { |  |
| for( i = 0; i <= num\_layers\_minus1; i++ ) { |  |
| **sub\_layer\_shutter\_angle**[ i ] | u(9) |
| **}** |  |
| } |  |

**D.2.35.3 Shutter angle information SEI message semantics**

This SEI message indicates the shutter angle value associated with each temporal sub-layer for a progressive scanned coded video sequence (field\_pic\_flag equal to 0). Shutter angle is a term of art that indicates shutter speed relative to frame rate, which is equivalent to indicating exposure duration relative to frame duration, used while authoring the video content.

This SEI message does not specify the measurement methodologies and procedures used for determining shutter angle values nor any description of the authoring conditions.

NOTE 1 – Shutter angle is expressed in degrees from 0 to 360 degrees. A shutter angle of 180 degrees, for example, indicates that the exposure duration is ½ the frame duration. The use of degrees to measure relative exposure time began when movie cameras used mechanical rotating disk shutters.

NOTE 2 – Shutter angle may be expressed as: shutter\_angle = frame\_rate \* 360/shutter\_speed, where shutter\_speed is the inverse of exposure duration and frame\_rate is the inverse of frame duration. frame\_rate for the given temporal sub-layer Tid may be indicated by the **vui\_ext\_num\_units\_in\_tick**[Tid] and **vui\_ext\_time\_scale**[Tid]. For example, when vui\_ext\_fixed\_frame\_rate\_flag[Tid] is equal to 1, the frame rate for temporal sub-layer Tid may be indicated by frame\_rate = vui\_ext\_time\_scale[Tid] /vui\_ext\_num\_units\_in\_tick[Tid] .

**fixed\_shutter\_angle\_within\_cvs\_flag** equal to 1 specifies that shutter angle value is the same for all temporal sub-layers in the coded video sequence. fixed\_shutter\_angle\_within\_cvs\_flag equal to 0 specifies that shutter angle value may not be the same for all temporal sub-layers in the coded video sequence.

**fixed\_shutter\_angle** specifies the shutter angle value in degrees. The value of fixed\_shutter\_angle shall be in the range of 0 to 360.

**sub\_layer\_shutter\_angle**[ i ]specifies the shutter angle value in degrees when HighestTid is equal to i. The value of sub\_layer\_shutter\_angle[ i ] shall be in the range of 0 to 360.

# Conclusion

This contribution proposes a shutter angle information SEI message for HEVC and AVC. Shutter angle information can be particularly useful when different temporal sub-layers have different effective shutter angles. Shutter angle information may be used by display or other post-decode processes to achieve a consistent or other desired look for bitstreams extraced at different frame rates.

# References

1. C. Carbonara ; J. DeFilippis ; M. Korpi, “High Frame Rate Capture and Production”, SMPTE 2015 Annual Technical Conference and Exhibition, Oct. 2015
2. A. Segall, S. Deshpande, M. Hannuksela, “On Frame Rate Support and Extraction in VVC”, JVET-M0579, Marrakech, Morocco, Jan., 2019
3. “ATSC Standard: Video – HEVC”, Advanced Television Systems Committee, A/341:2019, 14 Feb. 2019

# Patent rights declaration(s)

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