

Advanced Micro Devices

# Advanced Media Framework – HEVC Video Encoder

Programming Guide



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## Contents

|   |          |
|---|----------|
| <b>1.....INTRODUCTION</b>                                   | <b>4</b> |
| 1.1    SCOPE.....   | 4        |
| 1.2    PRE-DEFINED ENCODER USAGES .....                     | 5        |
| <b>2.....AMF VIDEO ENCODER UVD/VCN-HEVC COMPONENT</b>       | <b>6</b> |
| 2.1    INPUT SUBMISSION AND OUTPUT RETRIEVAL.....           | 6        |
| 2.2    ENCODE PARAMETERS .....                              | 6        |
| 2.2.1    Static Properties.....                             | 6        |
| 2.2.2    Dynamic Properties.....                            | 6        |
| 2.2.3    Frame Per-Submission Properties .....              | 6        |
| 2.2.4    ROI feature.....                                   | 6        |
| <b>3.....SAMPLE APPLICATIONS</b>                            | <b>7</b> |
| 3.1    LIST OF PARAMETERS .....                             | 7        |
| 3.2    COMMAND LINE EXAMPLE.....                            | 8        |
| 3.2.1    Transcoding application (TranscodeHW.exe) .....    | 8        |
| 3.2.2    D3D application (VCEEncoderD3D.exe) .....          | 8        |
| <b>ANNEX A: ENCODING &amp; FRAME PARAMETERS DESCRIPTION</b> | <b>9</b> |
| TABLE A-1. ENCODER PARAMETERS .....                         | 9        |
| TABLE A-2. INPUT FRAME AND ENCODED DATA PARAMETERS .....    | 12       |
| TABLE A-3. DEFAULT VALUE OF PARAMETERS.....                 | 14       |

# 1 Introduction

## 1.1 Scope

This document provides a complete description of the AMD Advanced Media Framework (AMF) Video Encoder Component. This component exposes the AMD Video Compression Engine, which provides hardware accelerated HEVC video encoding functionality.

Figure 1 provides a system overview of the AMF Video Encoder Component.

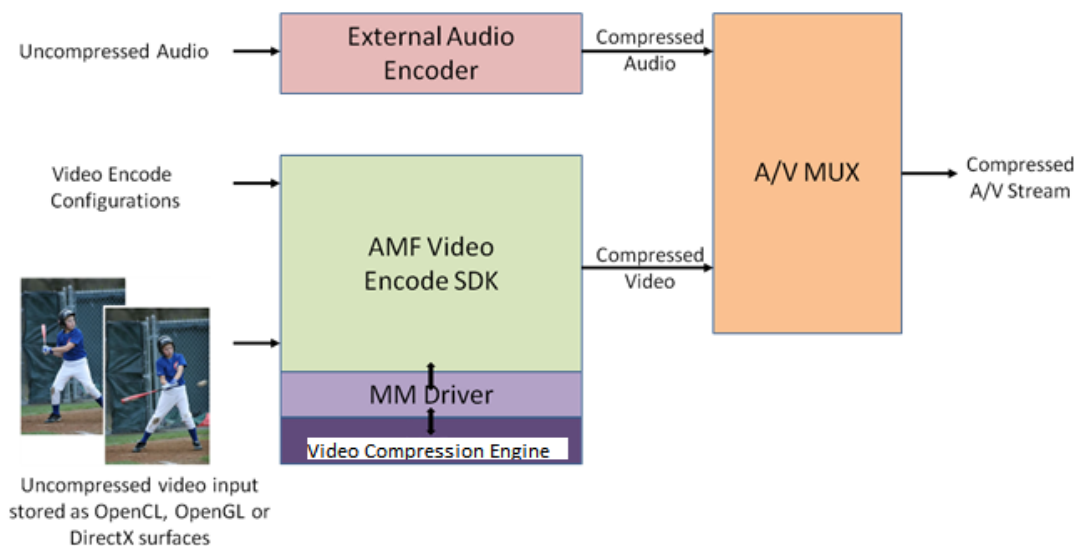


Figure 1 — System overview of the AMF Video Encode SDK

The AMF Video Encoder Component compresses RAW uncompressed video to an HEVC elementary bitstream.

The component does not provide a mechanism to handle audio compression, or stream multiplexing.

The component provides four different sets of pre-defined usages, which provide a convenient way for developers to configure the encoder to match the intended application use case. Advanced developers can also adjust encoding parameters to tailor the behavior to their specific application requirements.



## 1.2 *Pre-defined Encoder Usages*

The following table provides a brief overview of the encoding usage modes that have been defined:

| Usage Mode               | Intended use-cases                  | Comments   |
|--------------------------|-------------------------------------|--|
| <b>Transcoding</b>       | Transcoding, video editing          | Favor compression efficiency and throughput over latency.  |
| <b>Ultra-low latency</b> | Video game streaming                | Optimize for extremely low latency use cases (e.g. cap the number of bits per frame), to enable high-interactivity applications. |
| <b>Low Latency</b>       | Video collaboration, remote desktop | Optimize for low latency scenarios, but allow occasional bitrate overshoots to preserve quality.                                 |
| <b>Webcam</b>            | Video conferencing                  | Optimize for a low-latency video conferencing scenario.  |



## 2 AMF Video Encoder UVD/VCN-HEVC Component

The AMF Video Encoder HEVC component provides hardware accelerated HEVC encoding using AMD's IP.

To instantiate the AMF Video Encoder component, call the *AMFFactory::CreateComponent* method passing *AMFVideoEncoderHW\_HEVC* component IDs defined in the */include/components/VideoEncoderHEVC.h* header.

### 2.1 Input Submission and Output Retrieval

The AMF Video Encoder component accepts *AMFSurface* objects as input and produces *AMFBuffer* objects for output.

### 2.2 Encode Parameters

Annex A provides the detailed description of encoding parameters (i.e., encoder properties) exposed by the Video Encoder HEVC component for the following four usages:

- Transcoding mode,
- Ultra-low latency mode,
- Low Latency mode, and
- Webcam mode.

All properties are accessed using the *AMFPropertyStorage* interface of the Encoder object.

#### 2.2.1 Static Properties

Static properties (e.g., profile, tier, level, usage) must be defined before the *Init()* function is called, and will apply until the end of the encoding session.

#### 2.2.2 Dynamic Properties

All dynamic properties have default values. Several properties can be changed subsequently and these changes will be flushed to encoder only before the next *Submit()* call.

#### 2.2.3 Frame Per-Submission Properties

Per submission properties are applied on a per frame basis. They can be set optionally to force a certain behavior (e.g., force frame type to IDR) by updating the properties of the *AMFSurface* object that is passed through the *AMFComponent::Submit()* call.

#### 2.2.4 ROI feature

Region of importance (ROI) feature provides a way to specify the relative importance of the macroblocks in the video frame. Encoder will further adjust the bits allocation among code blocks based on the importance, on top of the base rate control decisions. More important blocks will be encoded with relatively better quality.

The ROI map can be attached to the input frame on a per frame basis. Currently, the ROI map can only use system memory. The ROI map includes the importance values of each 64x64 CTB, ranging from 0 to 10, stored in 32bit unsigned format. Refer to SimpleROI sample application for further implementation details.



### 3 Sample Applications

The AMF Encoder Sample application show how to setup and use the AMF Video Encoder HEVC Component to encode video frames that are loaded from disk or rendered by the DirectX 3D engine.

#### 3.1 List of Parameters

Sample applications support almost all visible encoder parameters (except PictureStructure, EndOfSequence, EndOfStream) and few additional parameters.

Additional parameters of TranscodeHW application:

| Category                 | Name      | Values                               | Description                          |
|--------------------------|-----------|--------------------------------------|--------------------------------------|
| Miscellaneous parameters | Frames    | Number of frames to be encoded       | Number of frames to render           |
|                          | Codec     | HEVC or H265                         | Specify codec type                   |
|                          | Input     | File name, relative or absolute path | Input file with frames (AVC or HEVC) |
|                          | Output    | File name, relative or absolute path | Output HEVC file for encoded data    |
|                          | Engine    | DX9, DX11                            | Specify Engine type                  |
|                          | AdapterID | Number                               | Index of GPU adapter                 |

Additional parameters of VCEEncoderD3D application:

| Category                 | Name               | Values                                 | Description   |
|--------------------------|--------------------|--|---|
| Miscellaneous parameters | Frames             | Number of frames to be encoded         | Number of frames to be encoded  |
|                          | Codec              | HEVC or H265                           | Specify codec type  |
|                          | Output             | File name, relative or absolute path   | Output HEVC file for encoded data   |
|                          | Render             | DX9, DX9EX, DX11, OpenGL, OpenCL, etc. | Specify render type   |
|                          | AdapterID          | Number                                 | Index of GPU adapter  |
|                          | Windowmode         | Flag ( without any values )            | Shows rendering window for D3D sample application                                       |
|                          | FullScreen         | Flag ( without any values )            | Enables full screen   |
|                          | QueryInstanceCount | Flag ( without any values )            | If the flag is set, the number of independent VCE instances will be queried and printed |
|                          | UseInstance        | 0 to (number of instances -1)          | If there are more than one VCE instances, allow to force which instance to use.         |





## 3.2 *Command line example*

### 3.2.1 Transcoding application (TranscodeHW.exe)

```
TranscodeHW.exe -input input.h264 -output out.h265 -codec HEVC -width 1280 -height 720 -Usage transcoding -RateControlMethod cbr -TargetBitrate 100000
```

This command transcodes H264 elementary stream to H.265 video. Encoder is created with “Transcoding” usage.

### 3.2.2 D3D application (VCEEncoderD3D.exe)

```
VCEEncoderD3D.exe -output VideoSample_1024x768.h265 -codec HEVC -width 1024 -height 768 -Usage transcoding -RateControlMethod cbr -TargetBitrate 500000 -frames 400
```

This command encodes 400 frames through D3D renderer and creates an output file with the encoded data. Encoder is created with “Transcoding” usage. Initial configuration sets bitrate to a value of 500kbts/sec.



## Annex A: Encoding & frame parameters description

**Table A-1. Encoder parameters**

| Category                        | Name                                    | Values  | Description  |
|---------------------------------|---|---|--|
| Encoder static parameters       | AMF_VIDEO_ENCODER_HEVC_USAGE            | Transcoding, UltraLowLatency, LowLatency, Webcam    | Selects the AMF usage (see Section 1.2)  |
|                                 | AMF_VIDEO_ENCODER_HEVC_PROFILE          | Main  | Selects the HEVC profile   |
|                                 | AMF_VIDEO_ENCODER_HEVC_TIER             | Main, High  | Selects the HEVC tier  |
|                                 | AMF_VIDEO_ENCODER_HEVC_PROFILE_LEVEL    | 1, 2, 2.1, 3, 3.1, 4, 4.1, 5, 5.1, 5.2, 6, 6.1, 6.2 | Selects the HEVC ProfileLevel  |
|                                 | AMF_VIDEO_ENCODER_HEVC_MAX_LTR_FRAMES   | 0 ... 16  | <p>The number of long-term references controlled by the user.</p> <p>Remarks:</p> <ul style="list-style-type: none"> <li>When == 0, the encoder may or may not use LTRs during encoding.</li> <li>When &gt; 0, the user has control over all LTR.</li> <li>With user control of LTR, Intra-refresh features are not supported.</li> <li>The actual maximum number of LTRs allowed depends on H.265 (HEVC) Annex A Table A-4 Level limits, which defines dependencies between the H.265 Level number, encoding resolution, and DPB size. The DPB size limit impacts the maximum number of LTR allowed.</li> </ul> |
|                                 | AMF_VIDEO_ENCODER_HEVC_MAX_NUM_REFRAMES | 0 ... 16  | Maximum number of reference frames   |
|                                 | AMF_VIDEO_ENCODER_HEVC_LOWLATENCY_MODE  | True/False (On/Off); default is false               | Enables low latency mode in the encoder  |
| Encoder resolution parameters   | AMF_VIDEO_ENCODER_HEVC_FRAME_SIZE       | Width: 192 – 4096<br>Height: 128 – 2176             | Frame width/Height in pixels, maximum value is hardware-specific, should be queried through <i>AMFCaps</i>   |
|                                 | AMF_VIDEO_ENCODER_HEVC_ASPECT_RATIO     | Default 1:1   | Pixel aspect ratio   |
| Encoder rate-control parameters | AMF_VIDEO_ENCODER_HEVC_TARGET_BITRATE   | >0  | Sets the target bitrate, bit/s based on use case   |
|                                 | AMF_VIDEO_ENCODER_HEVC_PEAK_BITRATE     | >= TargetBitrate                                    | Sets the peak bitrate  |



| Category                           | Name   | Values                                 | Description   |
|------------------------------------|--|--|---|
|                                    | AMF_VIDEO_ENCODER_HEVC_RATE_CONTROL_METHOD             | CQP, CBR, VBR, VBR_LAT                 | Selects the rate control method: <ul style="list-style-type: none"> <li>• CQP – Constrained QP,</li> <li>• CBR - Constant Bitrate,</li> <li>• VBR - Peak Constrained VBR,</li> <li>• VBR_LAT - Latency Constrained VBR</li> </ul> |
|                                    | AMF_VIDEO_ENCODER_HEVC_RATE_CONTROL_SKIP_FRAME_ENABLE  | True/False                             | Enables skip frame for rate control   |
|                                    | AMF_VIDEO_ENCODER_HEVC_MIN_QP_I                        | 0 – 51                                 | Sets the minimum QP for I frame   |
|                                    | AMF_VIDEO_ENCODER_HEVC_MAX_QP_I                        | 0 – 51                                 | Sets the maximum QP for I frame   |
|                                    | AMF_VIDEO_ENCODER_HEVC_MIN_QP_P                        | 0 – 51                                 | Sets the minimum QP for P frame   |
|                                    | AMF_VIDEO_ENCODER_HEVC_MAX_QP_P                        | 0 – 51                                 | Sets the maximum QP for P frame   |
|                                    | AMF_VIDEO_ENCODER_HEVC_QP_I                            | 0 – 51                                 | Sets the constant QP for I-pictures.<br><br>Remarks:<br>Only available for CQP rate control method.   |
|                                    | AMF_VIDEO_ENCODER_HEVC_QP_P                            | 0 – 51                                 | Sets the constant QP for P-pictures.<br><br>Remarks:<br>Only available for CQP rate control method.   |
|                                    | AMF_VIDEO_ENCODER_HEVC_FRAMERATE                       | 1*FrameRateDen ...<br>60* FrameRateDen | Frame rate numerator/denominator  |
|                                    | AMF_VIDEO_ENCODER_HEVC_VBV_BUFFER_SIZE                 | >0                                     | Sets the VBV buffer size in bits based on use case  |
|                                    | AMF_VIDEO_ENCODER_HEVC_INITIAL_VBV_BUFFER_FULLNESS     | 0 - 64                                 | Sets the initial VBV buffer fullness  |
|                                    | AMF_VIDEO_ENCODER_HEVC_ENFORCE_HRD                     | True/False                             | Disables/enables constraints on QP variation within a picture to meet HRD requirement(s)  |
|                                    | AMF_VIDEO_ENCODER_HEVC_RATE_CONTROL_PREANALYSIS_ENABLE | True/False                             | Pre-analysis assisted rate control  |
|                                    | AMF_VIDEO_ENCODER_HEVC_ENABLE_VBAQ                     | True/False                             | By default, disable VBAQ  |
|                                    | AMF_VIDEO_ENCODER_HEVC_FILLER_DATA_ENABLE              | True/False                             | Enable filler data for CBR usage  |
| Encoder picture-control parameters | AMF_VIDEO_ENCODER_HEVC_MAX_AU_SIZE                     | 0 – 100 000 000 bits                   | Maximum AU size in bits   |
|                                    | AMF_VIDEO_ENCODER_HEVC_HEADER_INSERTION_MODE           | NONE, GOP aligned, IDR aligned         | Sets the headers insertion mode   |
|                                    | AMF_VIDEO_ENCODER_HEVC_GOP_SIZE                        | 0 ... 1000                             | The period to insert IDR/CRA in fixed size mode. 0 means only insert the first IDR/CRA (infinite GOP size)  |



| Category                             | Name  | Values                   | Description   |
|--------------------------------------|---|--------------------------|---|
|                                      | AMF_VIDEO_ENCODER_HEVC_NUM_GOPS_PER_IDR           | 1 – 65535                | Determines the frequency to insert IDR as start of a GOP. 0 means no IDR will be inserted except for the first picture in the sequence. |
|                                      | AMF_VIDEO_ENCODER_HEVC_DE_BLOCKING_FILTER_DISABLE | True/False               | Disable/enable the de-blocking filter   |
|                                      | AMF_VIDEO_ENCODER_HEVC_SLICES_PER_FRAME           | 1 - #CTBs per frame      | Sets the number of slices per frame   |
| Encoder miscellaneous parameters     | AMF_VIDEO_ENCODER_HEVC_QUALITY_PRESET             | Balanced, Quality, Speed | Selects the quality preset  |
| Encoder motion estimation parameters | AMF_VIDEO_ENCODER_HEVC_MOTION_HALF_PIXEL          | True/False               | Turns on/off half-pixel motion estimation   |
|                                      | AMF_VIDEO_ENCODER_HEVC_MOTION_QUARTERPIXEL        | True/False               | Turns on/off quarter-pixel motion estimation  |
| Encoder color conversion parameters  | AMF_VIDEO_ENCODER_HEVC_COLOR_BIT_DEPTH            | 8, 10, 16                | Sets the number of bits in each pixel's color component in the encoder's compressed output bitstream. Default is 8.                     |

**Table A-2. Input frame and encoded data parameters**

| Category                        | Name   | Values                     | Description   |
|---------------------------------|--|----------------------------|---|
| Frame per-submission parameters | AMF_VIDEO_ENCODER_HEVC_INSERT_HEADER               | True/False                 | Inserts SPS, PPS and VPS  |
|                                 | AMF_VIDEO_ENCODER_HEVC_INSERT_AUD                  | True/False                 | Inserts AUD   |
|                                 | AMF_VIDEO_ENCODER_HEVC_FORCE_PICTURE_TYPE          | NONE, IDR, I, P            | Forces the picture type   |
|                                 | AMF_VIDEO_ENCODER_HEVC_END_OF_SEQUENCE             | True/False                 | End of sequence   |
|                                 | AMF_VIDEO_ENCODER_HEVC_MARK_CURRENT_WITH_LTR_INDEX | -1 ... (MaxOfLTRFrames -1) | <p>If != -1, the current picture is coded as a long-term reference with the given index.</p> <p>Remarks:</p> <ul style="list-style-type: none"> <li>When the user controls N LTRs (using the corresponding Create parameter), then the LTR Index the user can assign to a reference picture varies from 0 to N-1. By default, the encoder will “use up” available LTR Indices (i.e. assign them to references) even if the user does not request them to be used.</li> <li>If the user submits multiple requests to mark current as LTR between base temporal layer pictures, then only the last request is applied.</li> </ul> |



| Category     | Name  | Values  | Description  |
|--------------|---|---|--|
|              | AMF_VIDEO_ENCODER_HEVC_FORCE_LTR_REFERENCE_BITFIELD | Bitfield<br>(MaxOfLTRFrames (max possible 16 bits)) | <p>Force LTR Reference allowed bitfield. If == 0, the current picture should predict from the default reference. If != 0, the current picture should predict from one of the LTRs allowed by the bitfield (bit# = LTR Index#).</p> <p>Remarks:</p> <ul style="list-style-type: none"> <li>E.g. if Bit#0 = 1, then the existing LTR with LTR Index = 0 may be used for reference. The bitfield may allow more than one LTR for reference, in which case the encoder is free to choose which one to use. This bitfield also disallows existing LTRs not enabled by it from current/future reference.</li> <li>E.g. if Bit#1 = 0, and there is an existing reference with LTR Index = 1, then this LTR Index will not be used for reference until it is replaced with a newer reference with the same LTR Index.</li> </ul> |
|              | AMF_VIDEO_ENCODER_ROI_DATA                          | Video surface in AMF_SURFACE_GRAY32 format          | Important value for each 64x64 block ranges from 0 to 10, stored in 32bit unsigned format.   |
| Encoded data | AMF_VIDEO_ENCODER_HEVC_OUTPUT_DATA_TYPE             | I, P  | Type of encoded data   |



| Category   | Name  | Values   | Description   |
|------------|---|--|---|
| parameters | AMF_VIDEO_ENCODER_HEVC_OUTPUT_MARKED_LTR_INDEX              | -1 ... (MaxOfLTRFrames -1)                       | Marked as LTR Index. If != -1, then this picture was coded as a long-term reference with this LTR Index.  |
|            | AMF_VIDEO_ENCODER_HEVC_OUTPUT_REFERENCED_LTR_INDEX_BITFIELD | Bitfield (MaxOfLTRFrames (max possible 16 bits)) | Referenced LTR Index bitfield. If != 0, this picture was coded to reference long-term references. The enabled bits identify the LTR Indices of the referenced pictures (e.g. if Bit #0 = 1, then LTR Index 0 was used as a reference when coding this picture). |

**Table A-3. Default value of parameters**

| Type  | Name   | Transcoding          | Ultra low latency       | Low latency          | Webcam               |
|---|--|----------------------|-------------------------|----------------------|----------------------|
| Static Parameters<br>(Set at creation time) | AMF_VIDEO_ENCODER_HEVC_PROFILE                         | Main                 | Main                    | Main                 | Main                 |
|   | AMF_VIDEO_ENCODER_HEVC_PROFILE_LEVEL                   | 6.2                  | 6.2                     | 6.2                  | 6.2                  |
|   | AMF_VIDEO_ENCODER_HEVC_TIER                            | Main                 | Main                    | Main                 | Main                 |
|   | AMF_VIDEO_ENCODER_HEVC_MAX_LTR_FRAMES                  | 0                    | 0                       | 0                    | 0                    |
| Rate control                                | AMF_VIDEO_ENCODER_HEVC_RATE_CONTROL_METHOD             | PEAK_CONstrained_VBR | LATENCY_Constrained_VBR | PEAK_Constrained_VBR | PEAK_Constrained_VBR |
|   | AMF_VIDEO_ENCODER_HEVC_FRAMERATE                       | 30 fps               | 30 fps                  | 30 fps               | 30 fps               |
|   | AMF_VIDEO_ENCODER_HEVC_VBV_BUFFER_SIZE                 | 20 mbits             | 735 kbits               | 4 mbits              | 2 mbits              |
|   | AMF_VIDEO_ENCODER_HEVC_INITIAL_VBV_BUFFER_FULLNESS     | 64                   | 64                      | 64                   | 64                   |
|   | AMF_VIDEO_ENCODER_HEVC_RATE_CONTROL_PREANALYSIS_ENABLE | false                | false                   | false                | false                |
|   | AMF_VIDEO_ENCODER_HEVC_ENABLE_VBAQ                     | false                | false                   | false                | false                |
| Picture Control                             | AMF_VIDEO_ENCODER_HEVC_TARGET_BITRATE                  | 20 mbps              | 20 mbps                 | 20 mbps              | 20 mbps              |
|   | AMF_VIDEO_ENCODER_HEVC_PEAK_BITRATE                    | 30 mbps              | 20 mbps                 | 20 mbps              | 20 mbps              |
|   | AMF_VIDEO_ENCODER_HEVC_MIN_QP_I                        | 18                   | 22                      | 22                   | 22                   |
|   | AMF_VIDEO_ENCODER_HEVC_MAX_QP_I                        | 46                   | 48                      | 48                   | 48                   |
|   | AMF_VIDEO_ENCODER_HEVC_MIN_QP_P                        | 18                   | 22                      | 22                   | 22                   |
|   | AMF_VIDEO_ENCODER_HEVC_MAX_QP_P                        | 46                   | 48                      | 48                   | 48                   |
|   | AMF_VIDEO_ENCODER_HEVC_QP_I                            | 26                   | 26                      | 26                   | 26                   |
|   | AMF_VIDEO_ENCODER_HEVC_QP_P                            | 26                   | 26                      | 26                   | 26                   |
|   | AMF_VIDEO_ENCODER_HEVC_ENFORCE_HRD                     | false                | true                    | false                | false                |
|   | AMF_VIDEO_ENCODER_HEVC_MAX_AU_SIZE                     | 0                    | 0                       | 0                    | 0                    |
|   | AMF_VIDEO_ENCODER_HEVC_FILLER_DATA_ENABLE              | false                | false                   | false                | false                |
|   | AMF_VIDEO_ENCODER_HEVC_RATE_CONTROL_SKIP_FRAME_ENABLE  | false                | true                    | true                 | true                 |
|   | AMF_VIDEO_ENCODER_HEVC_HEADER_INSERTION_MODE           | 0                    | 0                       | 0                    | 0                    |
| Motion                                      | AMF_VIDEO_ENCODER_HEVC_GOP_SIZE                        | 30                   | 300                     | 300                  | 30                   |
|   | AMF_VIDEO_ENCODER_HEVC_NUM_GOPS_PER_IDR                | 1                    | 1                       | 1                    | 1                    |
|   | AMF_VIDEO_ENCODER_HEVC_DE_BLOCKING_FILTER_DISABLE      | false                | false                   | false                | false                |
|   | AMF_VIDEO_ENCODER_HEVC_SLICES_PER_FRAME                | 1                    | 1                       | 1                    | 1                    |
|   | AMF_VIDEO_ENCODER_HEVC_QUALITY_PRESET                  | Balanced             | Speed                   | Speed                | Speed                |
| Motion                                      | AMF_VIDEO_ENCODER_HEVC_MOTION_HALF_PIXEL               | 1                    | 1                       | 1                    | 1                    |



| Type                      | Name  | Transcoding | Ultra low latency | Low latency | Webcam |
|---------------------------|---|-------------|-------------------|-------------|--------|
| estimation                | AMF_VIDEO_ENCODER_HEVC_MOTION_QUARTERPIXEL          | 1           | 1                 | 1           | 1      |
| Per-submission parameters | AMF_VIDEO_ENCODER_HEVC_INSERT_HEADER                | 0           | 0                 | 0           | 0      |
|                           | AMF_VIDEO_ENCODER_HEVC_FORCE_PICTURE_TYPE           | 0           | 0                 | 0           | 0      |
|                           | AMF_VIDEO_ENCODER_HEVC_INSERT_AUD                   | false       | false             | false       | false  |
|                           | AMF_VIDEO_ENCODER_HEVC_END_OF_SEQUENCE              | false       | false             | false       | false  |
|                           | AMF_VIDEO_ENCODER_HEVC_MARK_CURRENT_WITH_LTR_INDEX  | -1          | -1                | -1          | -1     |
|                           | AMF_VIDEO_ENCODER_HEVC_FORCE_LTR_REFERENCE_BITFIELD | 0x0         | 0x0               | 0x0         | 0x0    |
|                           | AMF_VIDEO_ENCODER_ROI_DATA                          | N/A         | N/A               | N/A         | N/A    |