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| *Title:* | **Request for a New Profile: HEVC Monochrome 10** | | |
| *Status:* | Input Document to JCT-VC | | |
| *Purpose:* | Proposal | | |
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# Abstract

This contribution proposes the creation of a new Monochrome HEVC profile that will be restricted to a maximum of 10 bits. This profile will complement other 10 bit profiles, such as the Main 10, Main 10 Still Picture, and Main 4:4:4 10 profiles and is expected to be used in a variety of applications that may require signalling of 10 bit monochrome auxiliary information, such as depth information, infrared, and alpha planes.

# Introduction

Recently, the HEVC video coding standard [1][3] has started seeing a a considerable uptake in terms of deployment [4], especially for consumer video and still image applications. This includes broadcast applications, over the top delivery, HD Blu-ray, and Still and Video camera applications among others. Its adoption, especially for the later, is augmented by the creation and use of the HEIF (High Efficiency Image Format), that was relatively recently finalized by MPEG [2]. Unlike in the past, however, where interest was predominantly on 8 bit applications, HEVC has also enabled several 10 bit applications, such as High Dynamic Range (HDR) and Wide Colour Gamut (WCG) content distribution. Support for 10 bits is also very important for still photography, whereas it can improve the overall quality of SDR material since, not only because 10 bits can provide improved gradation in the decoded material but since it can provide for improved accuracy during the prediction and coding process.

Unfortunately, even though HEVC specifies a variety of profiles for 8 and 10 bit applications, as well as profiles with higher capabilities, it currently does not specify a 10 bit monochrome only profile. 10 bit applications that may desire to use auxiliary monochrome information such as depth (e.g. for augmented reality applications), infrared/thermal, and alpha planes (e.g. for video editing among other applications), are restricted in using either 8 bit monochrome data or would need to consider higher capability monochrome decoders such as decoders complying to the Monochrome 12 profile for signaling monochrome data with bitdepths higher than 8. An alternative method would be to use the neutral chroma indication flag in the VUI, which informs the decoder that a non 4:0:0 signal should be considered as monochrome for processing or display purposes, and that the decoded chroma values should essentially be ignored. Even though this is a perfectly valid solution, it does have the drawback that it can increase the complexity of an encoder and decoder unnecessarily. In particular, such systems, and especially mobile devices, would still be required to store and manage the chroma information, which may result in non-insignificant power consumption due to the increased requirements in memory bandwidth (50% higher for the 4:2:0 format). Essentially, any of these solutions would potentially add increased and unnecessary burden on applications that may require support for 10 bit monochrome information. It should also be noted that currently there seems to be a logical gap in the definitions of the Monochrome profiles, since HEVC currently specifies an 8 bit, a 12 bit, and a 16 bit profile. However, a 10 bit monochrome profile, which seems to be the current sweet spot for implementers for all other types of content, seems to be strangely missing from the specification. We therefore believe that the creation of a Monochrome 10 profile is needed.

# Proposal

Very similar to what was done previously for the Main 10 and Main 10 Still Picture profiles, the proposed Monochrome 10 profile is based on the Monochrome profile, and only the bit depth is extended to up to 10 bits. That is, the main difference of this profile vs the Monochrome profile is that in the SPS, the bit\_depth\_luma\_minus8 parameter can now take values in the range of 0 to 2, inclusive. The required changes for this profile are presented in the next section.

# Proposed Text Changes

A.3.5 Format range extensions profiles

The following profiles, collectively referred to as the format range extensions profiles, are specified in this clause:

* The Monochrome, Monochrome 10, Monochrome 12, and Monochrome 16 profiles
* The Main 12 profile
* The Main 4:2:2 10 and Main 4:2:2 12 profiles
* The Main 4:4:4, Main 4:4:4 10, and Main 4:4:4 12 profiles
* The Main Intra, Main 10 Intra, Main 12 Intra, Main 4:2:2 10 Intra, Main 4:2:2 12 Intra, Main 4:4:4 Intra, Main 4:4:4 10 Intra, Main 4:4:4 12 Intra, and Main 4:4:4 16 Intra profiles
* The Main 4:4:4 Still Picture and Main 4:4:4 16 Still Picture profiles

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* In bitstreams conforming to the Monochrome, Monochrome 10, Monochrome 12, Monochrome 16, Main 12, Main 4:2:2 10, Main 4:2:2 12, Main 4:4:4, Main 4:4:4 10, Main 4:4:4 12, Main Intra, Main 10 Intra, Main 12 Intra, Main 4:2:2 10 Intra, Main 4:2:2 12 Intra, Main 4:4:4 Intra, Main 4:4:4 10 Intra, Main 4:4:4 12 Intra, or Main 4:4:4 16 Intra profiles, general\_level\_idc and sub\_layer\_level\_idc[ i ] for all values of i in active SPSs for the base layer shall not be equal to 255 (which indicates level 8.5).
* The level constraints specified for the Monochrome, Monochrome 10, Monochrome 12, Monochrome 16, Main 12, Main 4:2:2 10, Main 4:2:2 12, Main 4:4:4 10, Main 4:4:4 12, Main Intra, Main 10 Intra, Main 12 Intra, Main 4:2:2 10 Intra, Main 4:2:2 12 Intra, Main 4:4:4 10 Intra, Main 4:4:4 12 Intra, or Main 4:4:4 16 Intra profiles in clause A.4, as applicable, shall be fulfilled.
* Table A.1 – Allowed values for syntax elements in the format range extensions profiles

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Profile for which constraint is specified** | **chroma\_format\_idc** | **bit\_depth\_luma\_minus8** and **bit\_depth\_chroma\_minus8** | **transform\_skip\_rotation\_enabled\_flag, transform\_skip\_context\_enabled\_flag, implicit\_rdpcm\_enabled\_flag, explicit\_rdpcm\_enabled\_flag, intra\_smoothing\_disabled\_flag, persistent\_rice\_adaptation\_enabled\_flag**, and **log2\_max\_transform\_skip\_block\_size\_minus2** | **extended\_precision\_processing\_flag** | **chroma\_qp\_offset\_list\_enabled\_flag** |
| Monochrome | 0 | 0 | 0 | 0 | 0 |
| Monochrome 10 | 0 | 0..2 | 0 | 0 | 0 |
| Monochrome 12 | 0 | 0..4 | 0 | 0 | 0 |
| Monochrome 16 | 0 | – | – | – | 0 |
| Main 12 | 0 or 1 | 0..4 | 0 | 0 | 0 |
| Main 4:2:2 10 | 0..2 | 0..2 | 0 | 0 | – |
| Main 4:2:2 12 | 0..2 | 0..4 | 0 | 0 | – |
| Main 4:4:4 | – | 0 | – | 0 | – |
| Main 4:4:4 10 | – | 0..2 | – | 0 | – |
| Main 4:4:4 12 | – | 0..4 | – | 0 | – |
| Main Intra | 0 or 1 | 0 | 0 | 0 | 0 |
| Main 10 Intra | 0 or 1 | 0..2 | 0 | 0 | 0 |
| Main 12 Intra | 0 or 1 | 0..4 | 0 | 0 | 0 |
| Main 4:2:2 10 Intra | 0..2 | 0..2 | 0 | 0 | – |
| Main 4:2:2 12 Intra | 0..2 | 0..4 | 0 | 0 | – |
| Main 4:4:4 Intra | – | 0 | – | 0 | – |
| Main 4:4:4 10 Intra | – | 0..2 | – | 0 | – |
| Main 4:4:4 12 Intra | – | 0..4 | – | 0 | – |
| Main 4:4:4 16 Intra | – | – | – | – | – |
| Main 4:4:4 Still Picture | – | 0 | – | 0 | – |
| Main 4:4:4 16 Still Picture | – | – | – | – | – |

Table A.2 – Bitstream indications for conformance to format range extensions profiles

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Profile for which the bitstream indicates conformance** | **general\_max\_12bit\_constraint\_flag** | **general\_max\_10bit\_constraint\_flag** | **general\_max\_8bit\_constraint\_flag** | **general\_max\_422chroma\_constraint\_flag** | **general\_max\_420chroma\_constraint\_flag** | **general\_max\_monochrome\_constraint\_flag** | **general\_intra\_constraint\_flag** | **general\_one\_picture\_only\_constraint\_flag** | **general\_lower\_bit\_rate\_constraint\_flag** |
| Monochrome | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 |
| Monochrome 10 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 |
| Monochrome 12 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 |
| Monochrome 16 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 |
| Main 12 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| Main 4:2:2 10 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| Main 4:2:2 12 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| Main 4:4:4 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| Main 4:4:4 10 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Main 4:4:4 12 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Main Intra | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 or 1 |
| Main 10 Intra | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 or 1 |
| Main 12 Intra | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 or 1 |
| Main 4:2:2 10 Intra | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 or 1 |
| Main 4:2:2 12 Intra | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 or 1 |
| Main 4:4:4 Intra | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 or 1 |
| Main 4:4:4 10 Intra | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 or 1 |
| Main 4:4:4 12 Intra | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 or 1 |
| Main 4:4:4 16 Intra | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 or 1 |
| Main 4:4:4 Still Picture | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 or 1 |
| Main 4:4:4 16 Still Picture | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 or 1 |

A.4.2 Profile-specific level limits for the video profiles

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Bitstreams and sub-layer representations conforming to the Monochrome, Monochrome 10, Monochrome 12, Monochrome 16, Main, Main 10, Main 12, Main 4:2:2 10, Main 4:2:2 12, Main 4:4:4 10, Main 4:4:4 12, Main Intra, Main 10 Intra, Main 12 Intra, Main 4:2:2 10 Intra, Main 4:2:2 12 Intra, Main 4:4:4 10 Intra, Main 4:4:4 12 Intra, Main 4:4:4 16 Intra, High Throughput 4:4:4, High Throughput 4:4:4 10, High Throughput 4:4:4 14, High Throughput 4:4:4 16 Intra, Screen-Extended Main, Screen-Extended Main 10, Screen-Extended Main 4:4:4, Screen-Extended Main 4:4:4 10, Screen-Extended High Throughput 4:4:4, Screen-Extended High Throughput 4:4:4 10, or Screen-Extended High Throughput 4:4:4 14 profile at a specified tier and level shall obey the following constraints for each bitstream conformance test as specified in Annex C

Table A.3 – Specification of CpbVclFactor, CpbNalFactor, FormatCapabilityFactor, and MinCrScaleFactor

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Profile** | **CpbVclFactor** | **CpbNalFactor** | **FormatCapabilityFactor** | **MinCrScaleFactor** |
| Monochrome | 667 | 733 | 1.000 | 1.0 |
| Monochrome 10 | 833 | 917 | 1.250 | 1.0 |
| Monochrome 12 | 1000 | 1100 | 1.500 | 1.0 |
| Monochrome 16 | 1333 | 1467 | 2.000 | 1.0 |
| Main | 1000 | 1100 | 1.500 | 1.0 |
| Screen-Extended Main | 1000 | 1100 | 1.500 | 1.0 |
| Main 10 | 1000 | 1100 | 1.875 | 1.0 |
| Screen-Extended Main 10 | 1000 | 1100 | 1.875 | 1.0 |
| Main 12 | 1500 | 1650 | 2.250 | 1.0 |
| Main Still Picture | 1000 | 1100 | 1.500 | 1.0 |
| Main 4:2:2 10 | 1667 | 1833 | 2.500 | 0.5 |
| Main 4:2:2 12 | 2000 | 2200 | 3.000 | 0.5 |
| Main 4:4:4 | 2000 | 2200 | 3.000 | 0.5 |
| High Throughput 4:4:4 | 2000 | 2200 | 3.000 | 0.5 |
| Screen-Extended Main 4:4:4 | 2000 | 2200 | 3.000 | 0.5 |
| Screen-Extended High Throughput 4:4:4 | 2000 | 2200 | 3.000 | 0.5 |
| Main 4:4:4 10 | 2500 | 2750 | 3.750 | 0.5 |
| High Throughput 4:4:4 10 | 2500 | 2750 | 3.750 | 0.5 |
| Screen-Extended Main 4:4:4 10 | 2500 | 2750 | 3.750 | 0.5 |
| Screen-Extended High Throughput 4:4:4 10 | 2500 | 2750 | 3.750 | 0.5 |
| Main 4:4:4 12 | 3000 | 3300 | 4.500 | 0.5 |
| High Throughput 4:4:4 14 | 3500 | 3850 | 5.250 | 0.5 |
| Screen-Extended High Throughput 4:4:4 14 | 3500 | 3850 | 5.250 | 0.5 |
| Main Intra | 1000 | 1100 | 1.500 | 1.0 |
| Main 10 Intra | 1000 | 1100 | 1.875 | 1.0 |
| Main 12 Intra | 1500 | 1650 | 2.250 | 1.0 |
| Main 4:2:2 10 Intra | 1667 | 1833 | 2.500 | 0.5 |
| Main 4:2:2 12 Intra | 2000 | 2200 | 3.000 | 0.5 |
| Main 4:4:4 Intra | 2000 | 2200 | 3.000 | 0.5 |
| Main 4:4:4 10 Intra | 2500 | 2750 | 3.750 | 0.5 |
| Main 4:4:4 12 Intra | 3000 | 3300 | 4.500 | 0.5 |
| Main 4:4:4 16 Intra | 4000 | 4400 | 6.000 | 0.5 |
| Main 4:4:4 Still Picture | 2000 | 2200 | 3.000 | 0.5 |
| Main 4:4:4 16 Still Picture | 4000 | 4400 | 6.000 | 0.5 |
| High Throughput 4:4:4 16 Intra | 4000 | 4400 | 6.000 | 0.5 |

A.4.3 Effect of level limits on picture rate for the video profiles (informative)

This clause does not form an integral part of this Specification.

Informative Tables A.9 and a.10 provide examples of maximum picture rates for the Monochrome, Monochrome 10, Monochrome 12, Monochrome 16, Main, Main 10, Main 12, Main 4:2:2 10, Main 4:2:2 12, Main 4:4:4, Main 4:4:4 10, Main 4:4:4 12, Main Intra, Main 10 Intra, Main 12 Intra, Main 4:2:2 10 Intra, Main 4:2:2 12 Intra, Main 4:4:4 Intra, Main 4:4:4 10 Intra, Main 4:4:4 12 Intra, Main 4:4:4 16 Intra and High Throughput 4:4:4 16 Intra profiles for various picture formats when MinCbSizeY is equal to 64.

# Referenced Publications

1. ITU-T and ISO/IEC, [*High Efficiency Video Coding*](https://www.itu.int/rec/T-REC-H.265), Rec. ITU-T H.265 and ISO/IEC 23008-2, ITU-T approval dates: Edition 1 – April 2013; Edition 2 – October 2014; Edition 3 – April 2015; Edition 4 – December 2016.
2. ISO/IEC, [ISO/IEC FDIS 23008-12.2 Information technology -- MPEG systems technologies -- Part 12: Image File Format](https://www.iso.org/standard/66067.html), June 2017.
3. G. J. Sullivan, J.-R. Ohm, W.-J. Han, and T. Wiegand, “[Overview of the High Efficiency Video Coding (HEVC) Standard](http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6316136)”, *IEEE Trans. Circuits and Systems for Video Technology*, Vol. 22, No. 12, pp. 1649‒1668, Dec. 2012.
4. G. J. Sullivan, “Deployment status of the HEVC standard”, JCTVC-AB0020, Torino, IT, July 2017.

# Patent rights declaration(s)

**Apple Inc., MovieLabs, ARM, Intel Inc., and Microsoft Inc. 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).**