|  |
| --- |
| **INTERNATIONAL ORGANIZATION FOR STANDARDIZATION ORGANISATION INTERNATIONALE DE NORMALISATION ISO/IEC JTC 1/SC 29/WG 5 MPEG JOINT VIDEO CODING TEAM(S) WITH ITU-T SG 16** |
| **ISO/IEC JTC 1 / SC 29 / WG 5 N 74** |
| **Online, 7–16 July 2021** |
| |  |  | | --- | --- | | **Title:** | **Core experiment on film grain synthesis** | | **Source:** | **Convenor (Jens-Rainer Ohm)** | | **Type:** | **General** | | **Subtype:** | **N/A** | | **Status:** | **Approved** | | **Date:** | **2021-07-30** | | **Expected Action:** | **Info** | | **Action due date:** | **N/A** | | **No. of pages** | **5** (without this cover page) | | **Email of convenor:** | **ohm @ ient . rwth-aachen . de** | | **Committee URL:** | **https://sd.iso.org/documents/ui/#!/browse/iso/iso-iec-jtc-1/iso-iec-jtc-1-sc-29/iso-iec-jtc-1-sc-29-wg-5** | |

|  |  |
| --- | --- |
| **Joint Video Experts Team (JVET)**  **of ITU-T SG 16 WP 3 and ISO/IEC JTC 1/SC 29**  23rd Meeting, by teleconference, 7–16 July 2021 | Document: JVET-W2022-v2 |

|  |  |  |  |
| --- | --- | --- | --- |
| *Title:* | **Core Experiment on Film Grain Synthesis** | | |
| *Status:* | Output document approved by JVET | | |
| *Purpose:* | Core Experiment description | | |
| *Author(s) or Contact(s):* | Sean McCarthy Miloš Radosavljević Jay Shingala | Email: | [sean.mccarthy@dolby.com](file:///C:\Users\smcca\Downloads\sean.mccarthy@dolby.com) [milos.radosavljevic@interdigital.com](mailto:milos.radosavljevic@interdigital.com) [jay.shingala@ittiam.com](file:///C:\Users\smcca\Box\Sean%20McCarthy\MPEG\MPEG%20135\FGC%20SEI%20modification\CE\jay.shingala@ittiam.com) |
| *Source:* | CE | | |

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

# Abstract

The goal of this Core Experiment (CE) is to conduct a study of the grain blending processes for the film grain characteristics SEI message proposed at the V and W meetings of JVET. The purpose of the CE is to show that the proposed technologies have comparable performance compared to SMPTE RDD 5, but with lower complexity in implementation.

The software basis for this CE is VTM-13.0. The test sequences, configurations and test conditions are specified in the CE descriptions.

# Participants

|  |  |  |  |
| --- | --- | --- | --- |
| Nr. | Name | Company | Email |
| 1 | S. McCarthy | Dolby | [sean.mccarthy@dolby.com](file:///C:\Users\smcca\Downloads\sean.mccarthy@dolby.com) |
| 2 | M. Radosavljević | InterDigital | [milos.radosavljevic@interdigital.com](file:///C:\Users\smcca\Box\Sean%20McCarthy\MPEG\MPEG%20135\FGC%20SEI%20modification\CE\milos.radosavljevic@interdigital.com) |
| 3 | J. Shingala | Ittiam | [jay.shingala@ittiam.com](file:///C:\Users\smcca\Box\Sean%20McCarthy\MPEG\MPEG%20135\FGC%20SEI%20modification\CE\jay.shingala@ittiam.com) |
| 4 | R.-L. Liao | Alibaba | [ruling.lrl@alibaba-inc.com](file:///C:\Users\smcca\Box\Sean%20McCarthy\MPEG\MPEG%20135\FGC%20SEI%20modification\CE\ruling.lrl@alibaba-inc.com) |
| 5 | D. Grois | Comcast | [dan\_grois@comcast.com](file:///C:\Users\smcca\Box\Sean%20McCarthy\MPEG\MPEG%20135\FGC%20SEI%20modification\CE\dan_grois@comcast.com) |
| 6 | F. Pu | Dolby | [Fangjun.pu@dolby.com](file:///C:\Users\smcca\Box\Sean%20McCarthy\MPEG\MPEG%20135\FGC%20SEI%20modification\CE\Fangjun.pu@dolby.com) |
| 7 | P. Yin | Dolby | [pyin@dolby.com](mailto:pyin@dolby.com) |
| 8 | W. Husak | Dolby | [wjh@dolby.com](file:///C:\Users\smcca\Box\Sean%20McCarthy\MPEG\MPEG%20135\FGC%20SEI%20modification\CE\wjh@dolby.com) |
| 9 | W. Hamidouche | INSA Rennes | [Wassim.Hamidouche@insa-rennes.fr](mailto:Wassim.Hamidouche@insa-rennes.fr) |
| 10 | E. Francois | InterDigital | [Edouard.Francois@InterDigital.com](file:///C:\Users\smcca\Box\Sean%20McCarthy\MPEG\MPEG%20135\FGC%20SEI%20modification\CE\Edouard.Francois@InterDigital.com) |
| 11 | A. Luthra | Picsel Labs | [ajay@picsellabs.com](file:///C:\Users\smcca\Box\Sean%20McCarthy\MPEG\MPEG%20135\FGC%20SEI%20modification\CE\ajay@picsellabs.com) |

# Test conditions and evaluation criteria

The proposals will be tested under the Random Access settings specified in [1]. The QPs and test clips will be specified in each CE description. The anchor is using SMPTE RDD 5 [2] grain blending technology. The test is using specified technology in the CE descriptions.

Planned tests in the CE shall be implemented on VTM-13.0 with the modifications described in references [3], [4] and [5].

Proposals will be evaluated based on subjective and complexity comparison.

1. **Proposal descriptions**

The following contributions have been selected for CE study.

1. [JVET-V0093](https://jvet-experts.org/doc_end_user/current_document.php?id=10741) AHG9: Film grain estimation and film grain synthesis for VVC – SEI message characteristics, film grain estimation and film grain synthesis modules [M. Radosavljević, E. François (InterDigital)]
2. [JVET-W0095](https://jvet-experts.org/doc_end_user/current_document.php?id=10911) AHG9: Fixed-point grain blending process for film grain characteristics SEI message [S. McCarthy, P. Yin, W. Husak, F. Pu, T. Lu, T. Chen (Dolby), E. François, M. Radosavljević (InterDigital), V. G R, K. Patankar, S. Kadaramandalgi, Ajayshyam (Ittiam)]

JVET-V0093 proposed a software implementation to illustrate the use of the film grain for VVC. Specifically, the software illustrates:

1. Film grain characteristics SEI message for VVC specified in ITU-T H.274 | ISO/IEC 23002-7;
2. Film grain synthesis module based on frequency filtering model specified in SMPTE RDD 5;
3. Film grain analysis (parameter estimation) module used to estimate film grain parameters according to SMPTE RDD 5 model.

JVET-V0093 proposed to use the VVC core 64x64 DCT-2 transform instead of the 64x64 transform specified in SMPTE RDD 5.

JVET-W0095 proposed an example of SMPTE RDD 5, Film Grain Technology, as a fixed-point process with support for 4K and 8K, and VVC DCT2. The process is identical to the SMPTE RDD 5 process already referenced in the FGC SEI message, except for two modifications:

1. The transformation process as specified in VVC (Rec. ITU-T H.266 | ISO/IEC 23090-3, clause 8.7.4.4, with trType inferred to equal 0) is used instead of the transform specified in SMPTE RDD 5. The VVC transform is more mature than the SMPTE RDD 5 transform. The VVC transform may also be already available on decoders and may thus be considered implementation friendly.
2. For picture resolutions greater than 1920x1080, the grain block size is increased proportionally from the fixed 8x8-size in SMPTE RDD 5 to 16x16 for resolutions up to 3840x2160 (4K) and 32x32 for resolutions greater than 4K including 8K. Use of larger block sizes for larger resolutions reduces implementation complexity and makes the grain pattern block size proportionally consistent across 2k, 4k, and 8k resolutions.
3. **Description of SMPTE RDD 5 and proposed extensions**

The anchor of the CE is obtained using the grain blending technology specified in SMPTE RDD 5. The proposed extensions studied in this CE are also based on SMPTE RDD 5 but provide additional support for resolutions greater than 1920x1080 and support for use of the VVC core 64x64 DCT2. This section summarizes both SMPTE RDD 5 and the proposed extensions.

The SMPTE RDD 5 process generates grain using the frequency-filtering method (fg\_model\_id is equal to 0) and blends grain with the decoded picture using the additive method (fg\_blending\_mode is equal to 0). In addition, the grain and the decoded picture have the same bit depth, color primaries, transfer characteristics, and matrix coefficients (fg\_separate\_colour\_description\_present\_flag is equal to 0). In SMPTE RDD 5, grain is blended with the decoded picture in 8x8 blocks. Each 8x8 block in the decoded picture is assigned an intensity interval index based on the average luma value of the block. Each 8x8 block may be assigned at most one intensity interval index. The strength of the blended grain is determined using the values of syntax elements fg\_comp\_model\_value[ c ][ i ][ 0 ] and fg\_log2\_scale\_factor, where the variable c indicates the luma or chroma component and the variable i indicates the intensity interval. The horizontal and vertical lowpass cut-off frequencies of the grain pattern for each 8x8 are determined from the values of the syntax elements fg\_comp\_model\_value[ c ][ i ][ 1 ] and fg\_comp\_model\_value[ c ][ i ][ 2 ], respectively

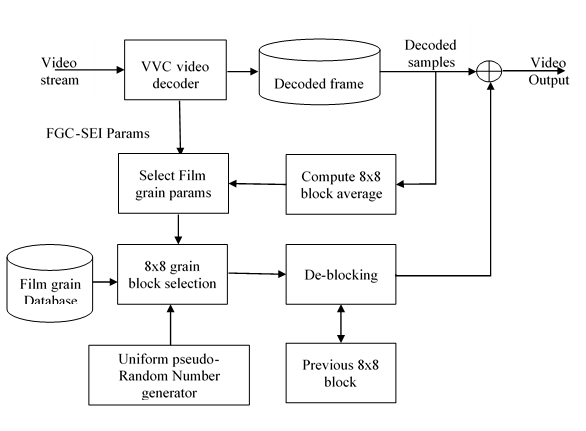


Figure 1 Film grain simulation and blending workflow for SMPTE RDD 5

The film grain simulation and blending workflow for SMPTE RDD 5 is illustrated in Figure 1. SMPTE RDD 5 film grain simulation is accomplished by the following steps:

1. Generate a database of grain patterns. The database can be generated once per sequence or can be pre-generated and stored. The database is a collection of up to 169 64x64 grain patterns each having a different combination of horizontal and vertical cut-off frequencies. Generation of the database at the beginning of the grain generation and blending process avoids any need to perform block-based transforms during the grain generation and blending process.
2. Determine the intensity interval to which each 8x8 block in the decoded picture belongs by comparing the average luma value of the block to the upper and lower intensity interval bounds signalled by the syntax elements fg\_intensity\_interval\_upper\_bound[ c ][ i ] and fg\_intensity\_interval\_lower\_bound[ c ][ i ], respectively.
3. Select grain blocks from the database. First, for each 8x8 block in the decoded picture, select a particular 64x64 grain pattern from the database based on the cut-off frequencies indicated for the corresponding intensity interval. Second, generate horizontal and vertical offests within the selected 64x64 grain pattern using a pseudo-random process. (Offsets are updated in raster scan order every 16 columns (horizontally) and every 16 lines (vertically) of the decoded picture starting at the upper left corner). Finally, select an 8x8 grain block specified by the offsets from the 64x64 grain pattern.
4. Scale the sample values of each 8x8 grain block based on the grain strength indicated for the corresponding intensity interval.
5. Deblock horizontal 8x8 grain block edges.
6. Add the sample values of the grain blocks and the sample values of the corresponding decoded picture block to produce the grain-blended output picture.

CE1 replaces SMPTE RDD 5 inverse DCT2 (64x64) transform with VVC inverse DCT2 (64x64) transform for database generation. CE2 enables grain block sizes greater than 8x8 for picture resolutions greater than 1920x1080, i.e., 4K and 8K.

1. **Planned tests**
   1. ***Comparison of SMPTE RDD 5 transform and VVC DCT2 (JVET-W0095)***

|  |  |  |
| --- | --- | --- |
| **Test** | **Proponent(s)** | **Cross-checker(s)** |
| *CE1.1* | InterDigital | Dolby |

This test compares the complexity and quality of using the VVC 64x64 DCT2 to the complexity and quality of using the 64x64 transform specified in SMPTE RDD 5.

The anchor of the CE uses SMPTE RDD 5 64x64 transform. The test in CE1.1 uses VVC 64x64 DCT2.

* 1. ***Comparison of grain block size (JVET-W0095)***

|  |  |  |
| --- | --- | --- |
| **Test** | **Proponent(s)** | **Cross-checker(s)** |
| *CE2.1* | Dolby | Alibaba |
| *CE2.2* | Dolby | InterDigital |

In JVET-W0095, instead of using fixed 8x8 block size for grain block generation and blending, the following changes are proposed.

PicSizeinLumaSamples = PicHeightInLumaSamples \* PicWidthInLumaSamples

if PicSizeinLumaSamples <= (1920 \* 1080)  
 BlockSize = 8  
else if PicSizeinLumaSamples <= (3840 \* 2160)  
 BlockSize = 16  
else  
 BlockSize = 32

The anchor of the CE is SMPTE RDD 5 with fixed 8x8 grain block size for all resolutions (HD, 4K and 8K). If appropriate 8K content is not available, 4K content will be upsampled to 8K using HDRTools before applying grain. The test of the CE is adaptive grain block size based on picture resolution as described in JVET-W0095. Two sub-CEs are proposed. CE2.1 is to test adaptive block size with SMPTE RDD 5 DCT2 inverse transform for the grain database generation. CE2.2 is to test adaptive block size with VVC DCT2 inverse transform in CE1 for the grain database generation. The same film grain parameters are applied for both the anchor and the test candidates.

Subjective evaluation will be performed by comparing anchor and test videos to determine visual differences, if any. Complexity comparison will be done using worst case multiplications, additions and memory access for different block sizes. Indicative software complexity is also compared by measuring the absolute runtime of the tested grain blending process and the relative runtime of the tested grain blending process compared to the runtime of SMTE RDD 5.

1. **Timeline and Responsibilities**

T1: 2021-July-30: Version of CE description with final descriptions of tests is uploaded. Any changes of planned tests after this time need to be announced and discussed on the JVET reflector. Initially assigned description numbers shall not be changed later. If a test is skipped, it is to marked as "withdrawn".

T2: T1 + 2 weeks Initial CE test SW

T3: JVET meeting start – 4 weeks : Final version of CE tests software and full results are provided, final cross-check begins.

T4: 2021-Sep-30: CE contribution documents including specification text and complete test results are uploaded to the JVET document repository. Work on CE report is starting.

1. **References**
2. Frank Bossen, Jill Boyce, Karsten Suehring, Xiang Li, Vadim Seregin, “VTM common test conditions and software reference configurations for SDR video”, JVET-T2010, Teleconference, 7-16 Oct. 2020.
3. RDD 5:2006 - SMPTE Registered Disclosure Doc - Film Grain Technology — Specifications for H.264 | MPEG-4 AVC Bitstreams,” RDD 5:2006, pp. 1–18, Mar. 2006, doi: 10.5594/SMPTE.RDD5.2006
4. Miloš Radosavljević, Edouard François, Wassim Hamidouche, Thomas Amestoy, Guillaume Gautier, “AHG9: Film grain estimation and film grain synthesis for VVC – Film grain characteristics SEI message characteristics, film grain estimation and film grain synthesis modules”, JVET-V0093, Teleconference, 20-28 April, 2021.
5. Miloš Radosavljević, Edouard François, Wassim Hamidouche, Thomas Amestoy and Guillaume Gautier, “AHG9: Enhancement of film grain parameter estimation for different intensity intervals”, JVET-W0072, Teleconference, 7-16 July, 2021.
6. Sean McCarthy, Peng Yin, Walt Husak, Fangjun Pu, Taoran Lu, Tao Chen, Edouard François, Miloš Radosavljević, Vijayakumar G R, Kaustubh Patankar, Shireesh Kadaramandalgi, Ajayshyam, “AHG9: Fixed-point grain blending process for film grain characteristics SEI message”, JVET-W0095, Teleconference, 7-16 July, 2021.