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# Abstract

This document presents a test report on verification of the coding performance of the HEVC screen content coding (SCC) extensions. The coding performance of HEVC screen content model (SCM) reference software with the SCC extensions enabled is compared with that of HEVC test model (HM) without the SCC extensions, as well as with the AVC joint model (JM) reference software in both lossy and mathematically lossless compression modes using All-Intra (AI), Random Access (RA), and Low-delay B (LB) encoding structures and using similar encoding rate-distortion optimization techniques. Six test sequences are used in the test, which have been classified into two categories, namely “text and graphics with motion” (TGM) and “mixed content” (M). The test bitstreams were generated in the RGB 4:4:4, YCbCr 4:4:4, and YCbCr 4:2:0 colour sampling formats with 8 bits per sample. For lossless coding, the performance of the JM, SCM, and HM are evaluated in terms of relative bit-rate savings. For lossy compression, subjective testing was conducted at 4 quality levels for each coding case, and the test results are presented through mean opinion score (MOS) curves. The relative coding performance has also been evaluated in terms of Bjøntegaard-delta (BD) bit-rate savings for equal PSNR objective quality using all 648 subjective test points. The perceptual tests as well as objective metric measurements showed very substantial benefit in coding efficiency for the screen content coding extensions, and provided consistent results with a high degree of confidence. For TGM video, the estimated bit-rate savings for lossy and lossless coding ranged from 60–90% relative to the JM and 40–80% relative to the HM, depending on the AI/RA/LB configuration category and colour sampling format.

# Test conditions description

## General description

The coding performance of HEVC with screen content coding extensions, HEVC without screen content coding extensions, and AVC was compared by encoding selected video test sequences that contained rendered text and graphics content (instead of, or in addition to, camera-captured video content) at selected bit rates using reference software representing well-understood and similarly configured encoding methods for these video coding standards. Since the relevant video coding standards specify only bitstream syntax and decoding process, without prescribing how to perform encoding, it is not possible in general to directly compare the capabilities of such standards. Instead, some particular encoding method must be selected as a proxy to represent the coding capabilities of a standard, as encoding techniques and encoded video quality may vary widely from implementation to implementation. For purposes of this test, reference software codebases developed during the standardization process were used to represent each standard – i.e., the HEVC SCC Model (SCM) in the case of HEVC with and without SCC extensions and the Joint Model (JM) in the case of AVC. These two software codebases were developed for similar purposes, use similar encoding techniques such as rate-distortion optimization decision-making processing, and were configured in a very similar way for these tests, i.e., in terms of hierarchical picture referencing structures, random-access refresh periods, quantization control settings, etc.

## Test material

Table 1 below lists the video test sequences used in the verification testing. These test sequences are classified into two categories, namely “text and graphics with motion” (TGM) and “mixed content” (M). Both 4:4:4 and 4:2:0 sampling formats were tested. For the 4:4:4 colour sampling format, the tests were conducted in both RGB and YCbCr colour formats.

These test sequences have been available to members (at <ftp://hevc@ftp.tnt.uni-hannover.de/testsequences/FrExt-candidate-sequences/upload/screen_content/ScExt-TestSequences>, accessible using a password available to accredited members). Their md5 checksums are given in Annex A of this report.

**Table 1 – Test sequences**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Sequence number** | **Resolution** | **Sequence name** | **Category** | **fps** | **Frames encoded** |
| 01 | 1920×1080 | BigBuckBunnyStudio | M | 50\* | 0–399 |
| 02 | CircuitLayoutPresentation | TGM | 30 | 0–239 |
| 03 | ClearTypeSpreadsheet | TGM | 30 | 0–239 |
| 04 | EnglishDocumentEditing | TGM | 30 | 0–239 |
| 05 | ChineseDocumentEditing | TGM | 30 | 0–239 |
| 06 | KristenAndSaraScreen | M | 60 | 0–479 |
| \* Note that this sequence was captured at 60 fps, but it is tested at 50 fps to provide adequate visual duration.  TGM: Text and graphics with motion; M: mixed content. | | | | | |

## Encoder software

The bitstreams were generated by using the following reference software:

* SCM-8.1: available at <https://hevc.hhi.fraunhofer.de/svn/svn_HEVCSoftware/tags/HM-16.10+SCM-8.1>). This software was used to generate both the HEVC and HEVC-SCC bitstreams. When generating HEVC non-SCC bitstreams, all the new coding tools adopted in the specifications of HEVC SCC extensions were disabled.
* JM-19.0: available at <http://iphome.hhi.de/suehring/tml/download/>

## Coding configurations and bit rates

Both lossy and mathematically lossless encodings are tested using three commonly used encoding configurations, which are All-Intra (AI), Random Access (RA), and Low-delay B (LB).

For the RA configuration, the period for intra random access frames for each test sequence is configured in the SCM by the following parameter:

* IntraPeriod: Specifies the intra refresh period in the RA configuration. The intra refresh period is dependent on the frame rate of the test sequence. A value 32 is used for test sequences at 30 fps, 48 for those at 50 fps, and 64 for those at 60 fps.

The same intra refresh structure is also used in JM-19.0.

A list of the encoder configuration files used in the tests is shown in Table 2 and attached to this report.

**Table 2 – Configuration files for JM and SCM**

|  |  |  |
| --- | --- | --- |
| Coding configuration | JM configuration file | SCM configuration file |
| AI | encoder\_JM\_Intra\_RExt.cfg | encoder\_intra\_main\_scc.cfg |
| RA | encoder\_JM\_RA\_B\_RExt.cfg | encoder\_randomaccess\_main\_scc.cfg |
| LB | encoder\_JM\_LB\_RExt.cfg | encoder\_lowdelay\_main\_scc.cfg |

Beside these general encoder configuration files, a set of sequence-specific configuration files have also been generated for JM to specify the width, height, frame rate, colour format, etc. These configuration files are also attached with this report document.

For lossless compression, the following encoder settings have been applied to the encoders:

* JM: No additional configuration settings noted.
* SCM: TransquantBypassEnableFlag = 1, CUTransquantBypassFlagForce = 1, CostMode = lossless, IntraReferenceSmoothing = 0.

When using SCM to generate HEVC non-SCC (a.k.a. HM) bitstreams, the following encoder settings were applied to disable the SCC specific tools:

* HM: IntraBlockCopyEnabled = 0, ColourTransform = 0, PaletteMode = 0, IntraBoundaryFilterDisabled = 0, TransquantBypassInferTUSplit = 0

For each test case, a formal subjective evaluation was conducted by comparing bitstreams from the three encoders at 4 different quantization parameter (QP) values on all lossy coding conditions. The final QP values have been selected based on the actual encoding results.

# Working effort and financial support to the evaluation process

Huawei, InterDigital, MediaTek, Microsoft, Qualcomm and GBTech provided logistic and work support for the success of this effort.

Huawei contributed in the overall effort coordination and objective evaluation of lossless test conditions. InterDigital, MediaTek, Microsoft and Qualcomm provided financial support and a huge work in encoding thousands of files, making them available for the decoding and evaluation process that was performed by GBTech.

Table 3 lists the encodings provided by the InterDigital, MediaTek, Microsoft and Qualcomm in producing the encoded bitstream.

**Table 3 – Companies encoding bitstream**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Companies | Encoder | Sequences | | | | | |
| BigBuck | ChineseDE | CircuitLP | ClearTypeSS | EnglishDE | Kristen&Sara |
| InterDigital | SCM | x | x | x |  |  |  |
| MediaTek | SCM |  |  |  | x | x | x |
| Microsoft | JM | x | x | x | x | x | x |
| Qualcomm | HM | x | x | x | x | x | x |

Microsoft provided all the JM encoding, Qualcomm provided the HM encoding (i.e., the SCM with SCC features disabled), MediaTek and InterDigital provided the SCM encoding. The same companies produced also many other bitstream files (around 5000) that were used to perform the lossless evaluation process.

The encoded bitstream were put in an FTP site and made available to the Test Chair that downloaded and decoded a selected set of the encoded files, to produce the 648 video files used in the subjective assessment. The correctness of the download process was verified by means of MD5 files.

The wide number of encoded bitstream files made available in the FTP site, allowed to the Test Chair a careful selection of the more appropriate QPs; this selection was necessary to design a subjective assessment test providing meaningful MOS results, i.e. as much as possible well distributed over the entire quality scale. This process was long and went through the decoding and careful check of more than 3500 video clips.

Financial support to the evaluation process was limited to funding the fees used to hire the 102 test subjects necessary to complete the test experiment across eighteen full testing days. The financial support was provided by **InterDigital** (2000 €), **MediaTek** (2000 €), **Microsoft** (4000 €) and **Qualcomm** (2000 USD).

Lossy coding conditions were evaluated executing a formal subjective assessment test covering a total of 648 test points. The test points considered were selected choosing 6 test sequences, 4 compression bit rates (QPs), three encoders (JM, HM and SCM), three colour subsampling methods (RGB 4:4:4, YCrCb 4:2:0 and YCrCb 4:4:4) and four coding conditions (AI, LB, RA).

For objective performance comparison purposes, the lossy coding conditions were evaluated computing PSNR values for each test point listed in section 1. The lossy coding configuration test results are collected into an Excel file similar to the result-reporting templates in JCTVC-X1015 [1]. The relative coding performance in the Excel files is reported in terms of Bjøntegaard-delta (BD) bit rates for equal PSNR-measured quality.

The formal subjective testing was designed, coordinated and supervised by the Test Chair (V. Baroncini) and conducted in Rome, Italy, at the GBTech Laboratories.

# Verification of superiority of HEVC-SCC vs. HEVC and AVC

The verification of the coding efficiency of HEVC-SCC over HEVC and AVC was done for both lossless and lossy coding conditions. The lossless coding conditions were verified by comparing the coding gain. The lossy coding condition benefits were verified by executing formal subjective assessment tests.

# Lossless coding test results

The verification of the efficiency for the lossless coding conditions was done comparing the savings obtained in bit rate. Tables 4 to 6 show the improvements measured for the three coding conditions considered, i.e. all Intra (AI), Random Access (RA) and Low-delay B (LB).

Tables 4 to 6 show details for the two kinds of test material, i.e. TGM (text and graphics with motion) and mixed (video and graphs mixed), and for the three colour subsampling methods considered (RGB 4:4:4, YCrCb 4:2:0 and YCrCb 4:4:4).

The details of compression ratio for each test sequence from each encoding are given in the Excel file attached to this report. In Tables 4 to 6, for the bit rate saving columns, negative numbers indicate percentage bit rate *reductions* relative to the reference (i.e., negative values indicate improved compression efficiency).

Table 4 – Lossless coding efficiency comparisons for AI

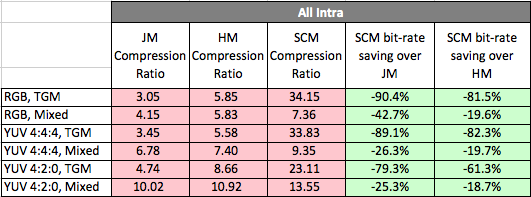


Table 5 – Lossless coding efficiency comparisons for RA

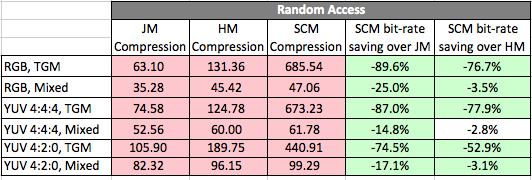
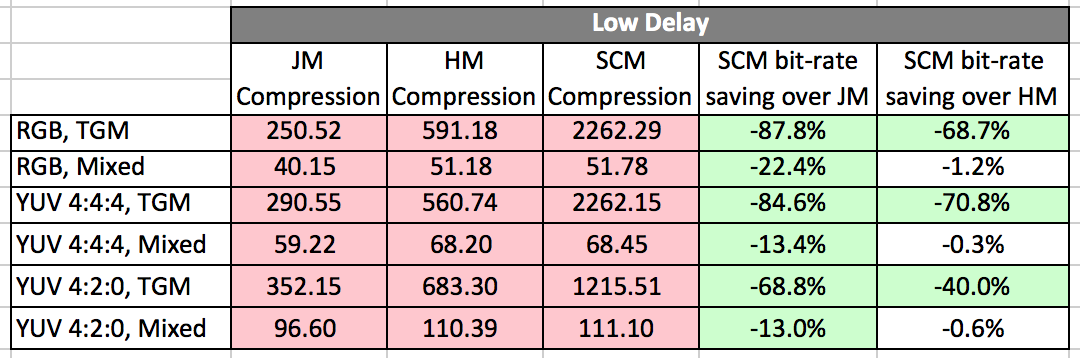


Table 6 – Lossless coding efficiency comparisons for LB



# Lossy coding conditions – PSNR evaluation

To produce the coded video clips necessary to perform a suitable formal subjective evaluation of the lossy coding conditions, bitstreams were generated by using all integer QP values between 10 and 47 (which required a very large number of encodings). Additional bitstreams were also generated by using QP values between 1 and 10 for the AVC JM and HEVC HM and QP values between 47 and 51 for the HEVC-SCC SCM. Superior coding efficiency of HEVC-SCC over HEVC and AVC has been exhibited for every test case in PSNR objective terms. Figure 1 and Figure 2 below present two R/D comparison examples. Complete details of the PSNR objective results are available in the attached Excel spreadsheets.

Figure 1 – EnglishDocumentEditing RGB 4:4:4 sequence coded in AI configuration

Figure 2 – EnglishDocumentEditing RGB 4:4:4 sequence coded in RA configuration

The test data were collected into an Excel file similar to the result-reporting templates in JCTVC-X1015 [1]. Tables 7 to 9 below show the summary results. Further details of BD-rate savings data are given in the attached Excel file.

Table 7 – BD-rate savings of SCM over JM and HM for AI coding configuration

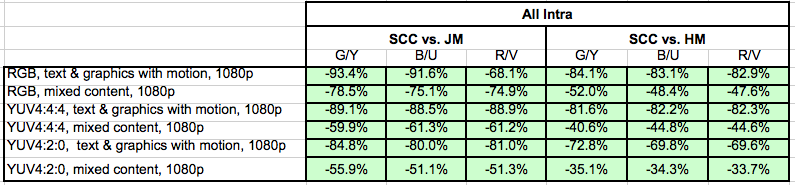


Table 8 – BD-rate savings of SCM over JM and HM for RA coding configuration

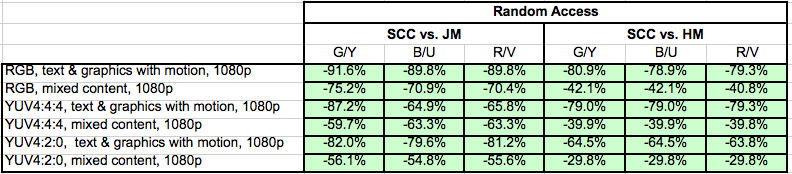
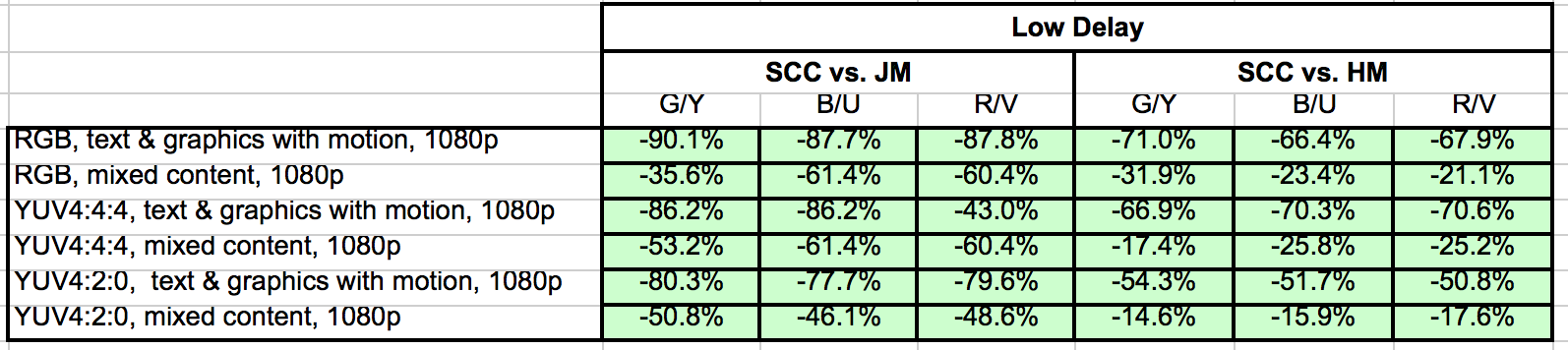


Table 9 – BD-rate savings of SCM over JM and HM for LB coding configuration



# Lossy coding conditions – formal subjective evaluation

The evaluation of the lossy coding conditions was done designing a formal subjective assessment test that included a total of 648 test points, that led to the design of a total of 18 test sessions, that were assessed hiring a total of 102 human viewing subjects.

The test was designed by the Chair of Test and was performed by GBTech (Italy) in its Rome Laboratory.

## Test method

The test method used for the HEVC-SCC Formal Subjective Assessment test is the DCR (Degradation Category Rating) as specified in Recommendation ITU-T P.910 [2]. The scoring of the test points was done using an 11 grade impairment scale, ranging from "0" (lowest quality) to "10" (highest quality), as specified in the Recommendation ITU-R BT.2095 [3].

The structure of the Basic Test Cell (BTC) of the DCR method is made of the five steps (see Figure 3):

* a mid grey screen showing the letter “A” in the middle (1 second);
* the uncompressed source video clip (original not coded);
* a mid grey screen showing the letter “B” in the middle (1 second);
* the coded video clip to evaluate;
* a mid grey screen showing the message “Vote N”, where N is a progressive number indicating the BTC to vote.



B

A

Figure 3 – DCR Basic Test Cell (BTC)

The scores were collected on paper scoring sheets. Figure 4 provides an example of scoring sheet for 39 test points. The test subjects express their impairment opinion writing a number (from 0 to 10) in the box numbered with the same number just shown on the screen with the message “Vote”. The scoring sheets include a section that allows identifying the viewers by means of a code; another section of the scoring sheet allows identifying the seat where each test subject was placed during that test session. The viewers were instructed to write the scores only when the message “Vote N” was present on the screen.

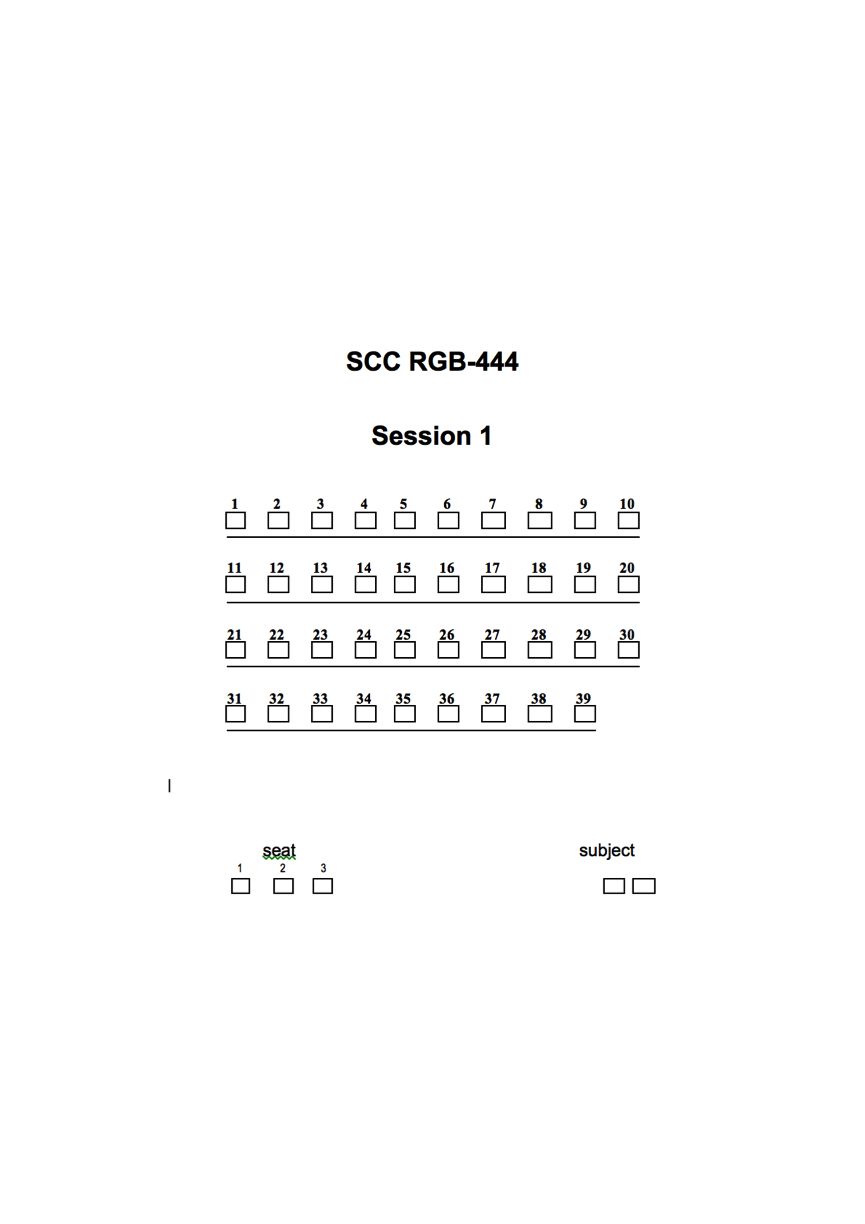


Figure 4 – Illustration of test scoring sheet

Eighteen university students all below 30 years of age were selected as the test subjects for each experiment after being carefully screened for visual acuity and colour blindness. They were carefully trained on both the test protocol and the kind of impairments they would need to detect.

Before participating in a test experiment, the viewers participated in a training activity during which a detailed explanation of the test scope, of the test protocol and of the vote procedure are provided.

The training activity included a short (10 BTCs) training session conducted after the training explanation, to let the viewers practice with the scoring procedure and to allow them to familiarize with the video content; some explanations are provided about the kind of impairments to look for in the coded video.

The video clips included in the training session try to cover, as much as possible, the whole range of quality of the test experiment.

### Test plan and test content selection

The subjective testing was done in Rome at the GBTech laboratory, during the week before the Geneva 2017 JCT-VC meeting and in the period between the Geneva and the Hobart JCT-VC meetings. Originally it was intended to complete the whole test experiment by 5 January 2017, but the short available time, the concurrent holidays (new year) and an additional up-load and evaluation of bitstream (required to try to optimize the visual assessment) suggested to modify the schedule.

The selection of the compression rates led to a very long analysis of many additional decoded bitstream. This process required much more time than what had been originally estimated and a large amount of work to the companies volunteering to provide the bitstreams and to the Test Group.

Each additional bitstream had to be decoded and visually inspected to select the desired level of visual quality. This process led to generate more than several hundreds extra bitstream and decoded video clips.

Due to the above situation, the AhG chairs and experts planned to modify the general schedule of the verification test in two stages:

* Stage 1: included 288 test points (see Table 10), among the total of 648 test points of the whole verification experiment; the step 1 test points were evaluated in the period between the Chengdu and the Geneva JCT-VC meetings
* Stage 2: included the remaining 360 test points (see Table 11); Stage 2 test points were evaluated in the period between the Geneva and the Hobart JCT-VC meetings

Table 10 – List of test points considered in Stage 1

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sequence**  **code** | **Sequence name** | **Test** | | |
| **RGB 4:4:4** | **YCbCr 4:2:0** | **YCbCr 4:4:4** |
| S01 | BigBuckBunnyStudio | **x** |  |  |
| S02 | ChineseDocumentEditing |  |  | **x** |
| S03 | CircuitLayoutPresentation |  |  | **x** |
| S04 | ClearTypeSpreadsheet | **x** |  | **x** |
| S05 | EnglishDocumentEditing | **x** |  | **x** |
| S06 | KristenAndSaraScreen | **x** |  |  |

During the execution of the test of Stage 1, two test sequences (ClearTypeSpreadsheet and EnglishDocumentEditing) were used for both colour representations, allowing a sort of crosschecking of the results.

Table 11 – List of test points considered in Stage 2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sequence**  **code** | **Sequence name** | **Test** | | |
| **RGB 4:4:4** | **YCbCr 4:2:0** | **YCbCr 4:4:4** |
| S01 | BigBuckBunnyStudio |  | **x** | **x** |
| S02 | ChineseDocumentEditing | **x** | **x** |  |
| S03 | CircuitLayoutPresentation | **x** | **x** |  |
| S04 | ClearTypeSpreadsheet |  | **x** |  |
| S05 | EnglishDocumentEditing |  | **x** |  |
| S06 | KristenAndSaraScreen |  | **x** | **x** |

The initial selection of the bit rates (generated by selected QP values) for the three encoders had to be reconsidered to allow a valid visual assessment of the decoded video clips. This new selection of the bit rates required a time-consuming effort dedicated to additional decoding of bitstream at the test site. Hundreds of newly decoded bitstreams were preliminary assessed by the GBTech experts to select QP values more appropriate to perform a valid formal subjective assessment.

### Test sessions design and test schedule

To complete the test activities in Stage 1, eight test sessions were conducted: four YCbCr 4:4:4 and four RGB 4:4:4. During Stage 2 ten test sessions were conducted: six YCbCr 4:2:0 test sessions and four test sessions including both RGB 4:4:4 and YCbCr 4:4:4 video content.

All the test sessions were done of 39 test points, including a stabilization phase made of three dummy test points inserted at the beginning of each session, to allow a smooth creation of the quality scale to the viewers. All the test sessions did not exceed 20 minutes in overall length.

The eighteen test subjects for each experiment were grouped in six groups of three people each. Each group participated to a maximum of four test sessions during the same day. Subjects could work again the day after. The execution of the test activities in Stage 1 required 6 testing days; the execution of the test activities in Stage 2 required 8 testing days.

### Laboratory set up

The GBTech Laboratory allowed the use in parallel of two viewing areas where two commercial top level TV sets were used as monitors[[1]](#footnote-1); all TV sets internal features were disabled to avoid non-faithful presentation of the images. Three test subjects were seated in front of a monitor at a viewing distance of 2.5H. The ambient light was below 20 cd/m2 and a light source set to 30 cd/m2 was illuminating the wall behind the monitors. The viewing area was completely isolated from any external light or audio noise source. The ceiling, floor and walls were made of non-reflecting dark grey material.

The monitors were driven for the play-out of the video clips using two identical PC equipped with high speed M2 SSD drives (in Raid 0 configuration), last generation motherboards based on Z270 chip-set, i7-7700 4.50 GHz Intel CPUs and 64G of DDR-4 RAM. The play out of video was done using the new version of the MUP[[2]](#footnote-2) video player improved to display planar RGB 4:4:4 video clips and to play in a synchronized way on two different PCs.

To void any influence of the display technology, the groups of three viewers were seated changing the display at any test sessions; in other words, each group of three subjects watched four test sessions on the OLED and the other four test sessions on the Samsung. No statistical evidence of difference in evaluation scores among data coming was noted from observations made on different displays.

# Results

In this section, the results of the formal subjective assessment of the lossy coding conditions are reported in form of graphs.

In the graphs, the results are depicted for the three encoders, i.e. a red line for JM, blue for HM (referring to SCM-w/o-SCC) and green for SCM.

There is a graph for each combination of test sequence, coding configuration (AI, LB and RA) and colour subsampling (RGB 4:4:4, YCrCb 4:4:4 and YCrCb 4:2:0).

All the graphs have on the Y axis the mean opinion score (MOS) values and on the X axis the bitstream lengths (in Kbytes). Since each video sequence had an 8-second display duration, the file size in Kbytes also corresponds to the bit rate in Kbits per second of display duration. Please note that in some figure legends, a dot is used as a thousands separator rather than a decimal place marker.

## Results for RGB 4:4:4

### All Intra coding configuration

Below are the graphs for the RGB 4:4:4 colour sampling and the AI (All Intra) coding configuration.













### Low-delay B coding configuration

Below are the graphs for the RGB 4:4:4 colour sampling and the LB (Low-delay B) coding configuration.













### Random Access coding configuration

Below are the graphs for the RGB 4:4:4 colour sampling and the RA (Random Access) coding configuration.













## Results for YCbCr 4:4:4

### All Intra coding configuration

Below are the graphs for the YCrCb 4:4:4 colour sampling and the AI (All Intra) coding configuration.













### Low-delay B coding configuration

Below are the graphs for the YCrCb 4:4:4 colour sampling and the LB (Low-delay B) coding configuration.













### Random Access coding configuration

Below are the graphs for the YCrCb 4:4:4 colour sampling and the RA (Random Access) coding configuration.













## Results for YCbCr 4:2:0

### All Intra coding configuration

Below are the graphs for the YCrCb 4:2:0 colour sampling and the AI (All Intra) coding configuration.













### Low-delay B coding configuration

Below are the graphs for the YCrCb 4:2:0 colour sampling and the LB (Low-delay B) coding configuration.













### Random Access coding configuration

Below are the graphs for the YCrCb 4:2:0 colour sampling and the RA (Random Access) coding configuration.













# Conclusions

Significant coding efficiency gain from the new coding tools specified in HEVC screen content coding extensions has been verified. For test content in the “text and graphics with motion” (TGM) category, the compression efficiency gain (as measured in terms of percentage bit rate savings for equivalent video quality) from the tested SCM encoder that includes the SCC extensions is approximately in the range of 60–90% over the JM AVC encoder and 40–80% over the HM encoder (i.e., the SCM encoder without screen content tools enabled), respectively, as measured in perceptual-based bit rate savings for lossy coding modes. For test content in the TGM with lossless coding, the bit rate savings averaged 70–90% over the JM and 40–80% over the HM, depending on the configuration category and colour sampling format. The perceptual tests as well as objective metric measurements showed very substantial benefit in coding efficiency for the screen content coding extensions, and provided consistent results with a high degree of confidence.

# References

1. JCTVC-X1015, “Common test conditions for screen content coding,” Geneva, CH, May 26 to June 1, 2016.
2. Rec. ITU-T P.910, Subjective video quality assessment methods for multimedia applications, April 2008.
3. Rec. ITU-R BT.2095, Subjective assessment of video quality using Expert Viewing Protocol, April 2016.

# Annex A. Test sequence md5sums

For the test sequences used in this verification test, the ‘md5sum’ values are provided in Table 12 below.

Table 12 – md5sum values of the test sequences

|  |  |  |
| --- | --- | --- |
| Format | File name | MD5 |
| 4:4:4 RGB and 4:4:4 YCbCr\* | ChineseDocumentEditing\_1920x1080\_30\_8bit.zip | 5300fd95c19d179a6ddfa12288240d00 |
| CircuitLayoutPresentation\_1920x1080\_30\_8bit.zip | 186b11635d64b1c5e146750aa4b803b7 |
| ClearTypeSpreadsheet\_1920x1080\_30\_8bit.zip | 6499a6bb378a4ad5ec55c5bc29632f16 |
| EnglishDocumentEditing\_1920x1080\_30\_8bit.zip | 98f865d30a01460a10e2903ea44fec79 |
| 4:4:4 RGB | BigBuck\_1920x1080\_60p\_8b444.zip | 8b92be4db9461cf8ee05adb35ef9f5c1 |
| KristenAndSaraScreen\_1920x1080\_60p\_8b444.zip | a4d9217ba38a4b9a4a6818ae22b49a7e |
| 4:4:4 YCbCr | BigBuck\_1920x1080\_60p\_8b444YUV.zip | 6402bc8c267e5ebc7d6726793a801444 |
| KristenAndSaraScreen\_1920x1080\_60p\_8b444YUV.zip | b4bd1eb10b97df273860908498001306 |
| 4:2:0 YCbCr | ChineseDocumentEditing\_1920x1080\_30\_8bit\_420.zip | dbce1e459826c487e962f56b63f1b5ab |
| CircuitLayoutPresentation\_1920x1080\_30\_8bit\_420.zip | 3269bae52ed3054ca81b7d311921a10f |
| ClearTypeSpreadsheet\_1920x1080\_30\_8bit\_420.zip | 77ea70821ac9915778d3030548aceb2d |
| EnglishDocumentEditing\_1920x1080\_30\_8bit\_420.zip | 3fdb7e41963bd4d7ee3b26586b699d93 |
| BigBuck\_1920x1080\_60p\_8b420.zip | 79404d73847560f4e2c2a74475fbd7a1 |
| KristenAndSaraScreen\_1920x1080\_60p\_8b420.zip | 9d21a8054265e94e32c2bb8e2f49b984 |
| \*Note: each of these zip files consists of both 4:4:4 RGB and 4:4:4 YCbCr sequences. | | |

1. *LG OLED B6 (55″ flat screen); Samsung 55KS7500 (55″ curved screen);* [↑](#footnote-ref-1)
2. *MUP is a product of Tretag srl* [↑](#footnote-ref-2)