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# Abstract

This report summarizes the activities of the JCT-VC ad hoc group on SCC extensions verification testing (AHG6) between the 26thJCT-VC meeting in Geneva, Switzerland, and the 27th JCT-VC meeting in Hobart, Australia.

# Mandates

* Study test conditions and coding performance analysis methods for verification of SCC coding performance.
* Produce the preliminary verification test resort for SCC JCTVC-Z1006
* Complete the remaining tests and prepare a proposed draft for the final SCC verification test report

# Activities

## Main activities

### Selection of the QPs

This verification testing effort was one of the more challenging ever done in MPEG so far, and not only for the amount of test points but also for the particular application that required a special care in the selection of the compression bit rates ranges.

Due to the very low time available to prepare the encoded video material, it was decided to make available to the Test group a decoded bit-stream for each test point, to make more quick and simple the file transfer from the encoding sites to the GBTech lab. Simple batch files were used to decode the bit-stream at the test site and this process worked rather easily.

What instead was not possible to be done in advance (as usually done for other verification test) was a careful selection of the bit rates (i.e. the QPs) that could allow the execution of a good subjective test experiment.

Due to the huge amount of video material to be evaluated (more than 600 test points), the whole test effort performed by the Test Group to Verify the features of the Screen Content Coding extension, was done through a two phases activity: the first formal testing activity was done in the period between the 116th (Chengdu) and 177th (Geneva) MPEG meetings; the second formal testing activity was done in the period between the 117th and the 118th (Hobart) MPEG meetings.

The QP values used for the first testing phase were originally selected by the SCC group of experts during the 116th (Chengdu) MPEG meeting, and then partially modified (mainly for the sequence BigBuck) by the Test Chair in agreement with the other SCC experts (by correspondence).

The QP values used for the second testing phase were selected by the Test Chair on the basis of the results of the test made during the first phase.

This two phases selection reflects also in some of the results presented in this report that, for some cases, do not show a use of the MOS scales grades along all its extent.

It has to be noted that the selection of the QPs during both test phases (but mainly during the second one) required a production of a many more encoded bit-streams (thanks for this to the active collaboration of MediaTek, Interdigital, Microsoft and Qualcomm) than those originally foreseen, and a very long process of decoding and visual inspection of the decoded video clips by GBTech.

A total of more than 1500 bit-streams were decoded and the resulting video clips were inspected to select video contents as much as possible suitable to perform a good formal subjective assessment.

### Preparation of report documents

Both documents below have been uploaded.

* Preliminary verification test report for HEVC screen content coding extensions (JCTVC-Z1006) : this report presents the subjective test results that compare the coding performance of 3 codecs (SCM, SCM without SCC tools (SCM-w/o-SCC), JM) for 4 sequences tested in both RGB and YUV 4:4:4 color space, with 3 coding structures (AI, LB, RA), at 4 quality levels. The total test points evaluated are 288.
* Draft of final report on SCC verification test (JCTVC-AA0040): this document presents the complete test results for both lossy and lossless compression modes. For the lossless mode, the coding performance of JM, SCM, and SCM without SCC coding tools (SCM-w/o-SCC) is evaluated in relative bit-rate savings. For the lossy mode, the coding performance of these three codecs is compared by using 6 test sequences coded in RGB, YUV 4:4:4, and YUV 4:2:0 color sampling formats with 3 coding structures (AI, LB, RA), at 4 quality levels. The total test points evaluated are 648. The test results are presented through MOS curves and BD-rate savings tables.

### Conclusion

Significant coding efficiency gain from the new coding tools specified in HEVC screen content coding. extensions has been verified. For TGM content, the compression efficiency gain achieved by SCM is 90% over JM and 80% over SCM without screen content tools, respectively, measured in BD rate savings for all lossy coding modes and bit rate savings for all lossless coding modes.

# Preliminary verification test report for HEVC screen content coding extensions (JCTVC-Z1006)-----uploaded [1]

## Summary

This document presents a preliminary test report on verification of the coding performance of the HEVC screen content coding (SCC) extensions. The coding performance of HEVC with screen content coding extensions was compared with that of HEVC without screen content coding extensions as well as AVC, using two reference software codecs with similar encoding structures and rate-distortion optimization techniques. Both lossy and mathematical lossless compression modes were tested using All-Intra (AI), Random Access (RA), and Low-delay B (LB) encoding structures. A total of six test sequences were used in the test, which had been classified into two categories, namely “text and graphics with motion” (TGM)’ and “mixed content” (M)”. The test bitstreams were generated in RGB, YUV 4:4:4, and YUV 4:2:0 color sampling formats with bit-depth equal to 8 for each color component. More details of the test condition are given [2].

The subjective testing was organized in two steps, as shown below. This document discusses the test results in Step 1.

* Step 1: a reduced set of test cases were evaluated according to Table 1; the subjective evaluation of these test cases were executed in the period between the Cheng-Du and the Geneva Meetings;
* Step 2: all the remaining test cases are to be evaluated in the period between the Geneva and the Hobart Meetings

Table List of test cases in Step 1

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

Table List of test cases in Step 2

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Sequence**  **code** | **Sequence name** | **Test** | | |
| **RGB** | **YUV 4:2:0** | **YUV 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** |

## Test results (see details in [1])

### Bistreams

For the lossy coding conditions described above, bitstreams have been generated by using all integer QP values between 10 and 47. Additional bitstreams have also been generated by using QP values between 1 and 10 for AVC and HEVC and QP values between 47 and 51 for HEVC-SCC. Superior coding efficiency of HEVC-SCC over HEVC and AVC has been exhibited for every test point in PSNR objective terms. Figure 1 and Figure 2 below present two R/D comparison examples.

Figure EnglishDocumentEditing RGB sequence coded in AI configuration

Figure EnglishDocumentEditing RGB sequence coded in RA configuration

### Test plan for subjective testing

The subjective testing was done in Rome at the GBTech laboratory, during the week before the Geneva 2017 JCT-VC meeting. Originally it was intended to complete the test by 5 January 2017, but an additional up-load of bitstreams was required to try to optimize the visual assessment. This led also to a very long analysis of many additional decoded bitstreams that required much more time than what originally estimated. Due to the above situation, the Test Chair (in agreement with the members of the AHG) planned to modify the general schedule of the verification test in two steps as described in.3.1.

### Selection of test points

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 bitstreams at the test site. Tens of newly decoded bitstreams were preliminary assessed by the GBTech experts to select QP values more appropriate to perform a valid formal subjective assessment.

### Method for subjective testing

The test method is derived from the DCR (Degradation Category Rating) as specified in Recommendation ITU-T P.910 [3] with some variation in the timing of the Basic Test Cell (see Figure 3) and in the adoption of an 11 grades impairment scale, as defined in Recommendation ITU-R BT.2095 [4], ranging from "0" (lowest quality) to "10" (highest quality).



Figure DCR\_BCT

Eighteen young university students all aging below 30 years were selected as the test subjects after being carefully screened for visual acuity and colour blindness. They have been carefully trained on both the test protocol and the kind of impairments they have to detect.

The Test Sessions were preceded by a training activity during which a detailed explanation of the test scope, of the test method and of the vote procedure was provided.

### Step 1 Results for RGB color space

Table 3 below shows the test sequences used in this part of the test.

Table List of the sequences tested in Step 1 for teh RGB color space

|  |  |  |
| --- | --- | --- |
| **Sequence code** | **Test sequence name** | **RGB** |
| S01 | BigBuckBunnyStudio | **X** |
| S04 | ClearTypeSpreadsheet | **** |
| S05 | EnglishDocumentEditing | **** |
| S06 | KristenAndSaraScreen | **** |

The test results for the 12 combinations of test sequences and coding configurations are presented through MOS curves along with the test data tables. Figure 4 below shows an example for sequence S01 coded with AI coding configuration. See the rest of test results in [1].

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | |  |  |  |  | | --- | --- | --- | --- | | Codec | QP | MOS | Bitstreams (MB) | | JM | R26 | 5.38 | 113.683 | | JM | R30 | 2.88 | 85.815 | | JM | R34 | 1.50 | 60.381 | | JM | R36 | 1.06 | 49.110 | | HM | R26 | 5.44 | 59.351 | | HM | R30 | 3.13 | 44.028 | | HM | R34 | 2.06 | 31.257 | | HM | R36 | 1.13 | 26.193 | | SCM | R26 | 8.38 | 49.371 | | SCM | R30 | 6.63 | 36.328 | | SCM | R34 | 3.88 | 26.340 | | SCM | R36 | 2.88 | 22.177 | |

Figure MOS curves and table for test sequence S01 coded with AI coding configuration

### Step 1 Results for YUV color space in 4:4:4 sampling format

Table 4 below shows the test sequences used in this part of the test.

Table List of the sequences tested in Step 1 for YUV Color space in 4:4:4 sampling format

|  |  |  |
| --- | --- | --- |
| **Sequence code** | **Sequence name** | **YUV 4:4:4** |
| S02 | ChineseDocumentEditing | **X** |
| S03 | CircuitLayoutPresentation | **X** |
| S04 | ClearTypeSpreadsheet | **X** |
| S05 | EnglishDocumentEditing | **X** |

The test results for the 12 combinations of test sequences and coding configurations are presented through MOS curves along with the test data tables. Figure 5 below shows an example for sequence S02 coded with AI coding configuration. See the rest of test results in [1].

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | |  |  |  |  | | --- | --- | --- | --- | | Codec | QP | MOS | Bit-streams | | JM | QP30 | 8,44 | 7559 | | JM | QP34 | 6,69 | 4990 | | JM | QP36 | 5,25 | 4048 | | JM | QP38 | 4,69 | 3253 | | HM | QP30 | 8,06 | 5427 | | HM | QP34 | 7,13 | 3824 | | HM | QP36 | 6,00 | 3169 | | HM | QP38 | 4,56 | 2593 | | SCM | QP30 | 8,63 | 2495 | | SCM | QP34 | 8,06 | 1685 | | SCM | QP36 | 7,00 | 1408 | | SCM | QP38 | 5,25 | 1161 | |

Figure MOS curves for test sequence S02 coded with AI coding configuration

# Draft of final report on SCC verification test (JCTVC-AA0040)-----uploaded [3]

## Summary

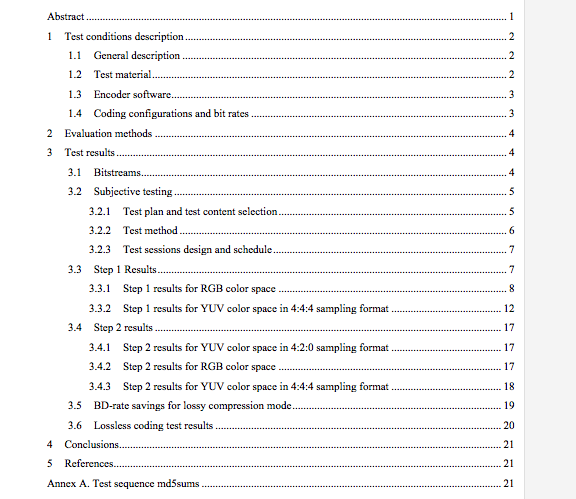
This document presents the complete test results for both lossy and lossless compression modes. The coding performance of JM, SCM, and SCM without SCC coding tools is evaluated and compared for both lossless and lossy coding modes. A total of 6 test sequences were encoded in RGB, YUV 4:4:4 and YUV 4:2:0 color sampling formats with the AI, LB, and RA coding structures.

For the lossless coding mode, the test results are presented through relative bit-rate savings tables.

For the lossy coding mode, the tests were conducted at 4 different quality levels and there are a total of 648 test points. The test results are presented through MOS curves and BD-rate savings tables.

For TGM content, the compression efficiency gain achieved by SCM is 90% over JM and 80% over SCM without screen content tools, respectively, measured in BD rate savings for all lossy coding modes and bit rate savings for all lossless coding modes.

## Table of contents



## Lossless coding test results (see details in [3])

The lossless coding efficiency of the three codecs is compared in Table 5, Table 6, and Table 7 below for AI, RA, and LB respectively. The details of compression ratio for each sequence from each codec are given in the Excel file attached to [3].

Table Lossless coding efficiency comparisons for AI

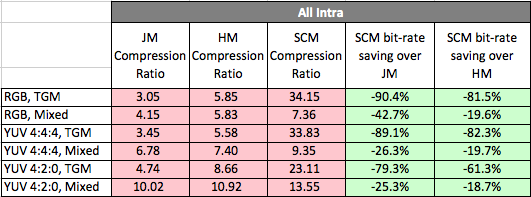


Table Lossless coding efficiency comparisons for RA

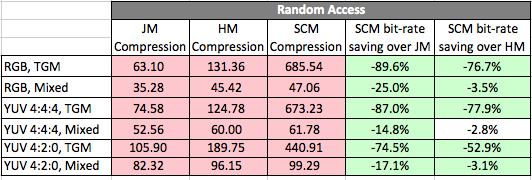
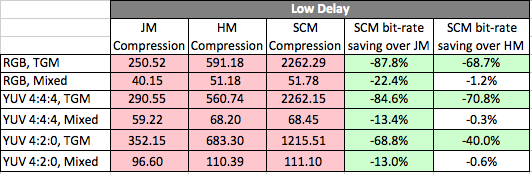


Table Lossless coding efficiency comparisons for LB



## Step 2 Subjective test results for lossy coding (see details in [3])

### Results for YUV color space in 4:2:0 sampling format

Table 8 below shows the test sequences used in this part of the test.

Table List of the sequences tested in Step 2 for YUV color space in 4:2:0 sampling format

|  |  |  |
| --- | --- | --- |
| **Sequence code** | **Sequence name** | **YUV 4:2:0** |
| S01 | BigBuckBunnyStudio | **X** |
| S02 | ChineseDocumentEditing | **X** |
| S03 | CircuitLayoutPresentation | **X** |
| S04 | ClearTypeSpreadsheet | **X** |
| S05 | EnglishDocumentEditing | **X** |
| S06 | KristenAndSaraScreen | **X** |

The test results for the 18 combinations of test sequences and coding configurations are presented through MOS curves along with the test data tables. Figure 6 below shows an example for sequence S05 with RA coding configuration. See the rest of test results in [3].



Figure MOS curves for test sequence S05 with RA coding configuration

### Results for RGB color space

Table 9 below shows the test sequences used in this part of the test.

The test results for the 6 combinations of test sequences and coding configurations are presented through MOS curves along with the test data tables. Figure 7 below shows an example for sequence S03 with AI coding configuration. See the rest of test results in [3].

Table List of the sequences tested in Step 2 for RGB color space

|  |  |  |
| --- | --- | --- |
| **Sequence code** | **Sequence name** | **RGB** |
| S02 | ChineseDocumentEditing | **X** |
| S03 | CircuitLayoutPresentation | **X** |



Figure MOS curves for test sequence S03 with RA coding configuration

### Results for YUV color space in 4:4:4 sampling format

Table 10 List of the sequences tested in Step 2 for YUV Color space in 4:4:4 sampling format below shows the test sequences used in this part of the test.

The test results for the 6 combinations of test sequences and coding configurations are presented through MOS curves along with the test data tables. Figure 8 below shows an example for sequence S01 with LB coding configuration. See the rest of test results in [3].

Table List of the sequences tested in Step 2 for YUV color space in 4:4:4 sampling format

|  |  |  |
| --- | --- | --- |
| **Sequence code** | **Sequence name** | **YUV 4:4:4** |
| S01 | BigBuckBunnyStudio | **X** |
| S06 | KristenAndSaraScreen | **X** |



Figure MOS curves for test sequence S01 with LB coding configuration

## BD-rate savings for lossy compression mode

BD-rate savings of SCM over JM and SCM-w/o-SCC for RGB, YUV 4:4:4, and YUV 4:2:0 color sampling formats were calculated by using the actual 648 test points that were used in the subjective testing.

The test data were collected into an Excel file similar to the result-reporting templates in JCTVC-X1015 [4]. Table 11, Table 12, and Table 13 below show the summary results. The details of BD-rate savings data are given in the attached Excel file in [3].

Table BD-rate savings of SCM over JM and SCM-w/o-SCC for AI coding configuration

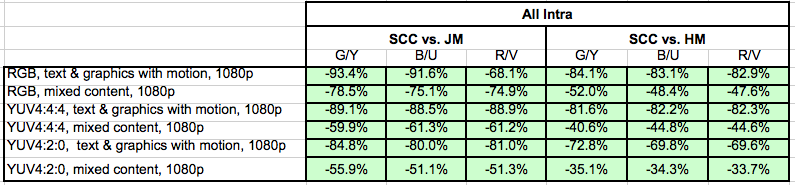


Table BD-rate savings of SCM over JM and SCM-w/o-SCC for RA coding configuration

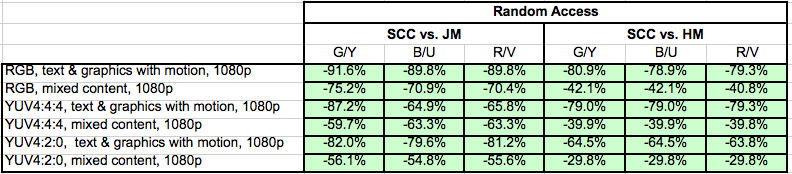
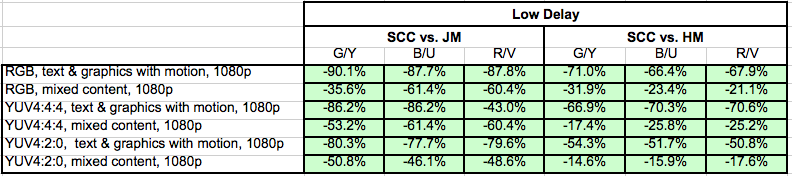


Table BD-rate savings of SCM over JM and SCM-w/o-SCC for LB coding configuration



# Related contributions

**JCTVC-AA0040:** Draft of final report on SCC verification test**, [V. Baroncini, H. Yu, R. Joshi, S. Liu, X. Xiu, J. Xu]**

This contribution proposes a draft of final verification test report for HEVC screen content coding extensions.

# Recommendations

It is recommended to accomplish the following tasks during the 27th JCTVC meeting:

* Review JCTVC-AA0040 Draft of final report on SCC verification test [3];
* Prepare the final SCC verification test report.

# References

1. JCTVC-Z1006, “Preliminary verification test report for HEVC screen content coding extensions,” Geneva, Switzerland, Jan. 12-20, 2017.
2. JCTVC-Y1006, “Verification test plan for HEVC screen content coding extensions,” Chengdu, China, Oct. 14-21, 2016.
3. JCTVC-AA0040, “Draft of final report on SCC verification test,” Hobart, Australia, Mar. 31 to April 7, 2017.
4. JCTVC-X1015, “Common test conditions for screen content coding,” Geneva, CH, May 26 to June 1, 2016.
5. Rec. ITU-T P.910, Subjective video quality assessment methods for multimedia applications, April 2008.
6. Rec. ITU-R BT.2095, Subjective assessment of video quality using Expert Viewing Protocol, April 2016.