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| **ITU – Telecommunications Standardization Sector**  STUDY GROUP 21 Question 6  **Video Coding Experts Group (VCEG)**  77th Meeting: 26 June – 4 July 2025, Daejeon, KR | Document VCEG-BY06-v1 |

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| Question: | 6/21 (VCEG) | | |
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| Title: | **Report on reference software development and anchor results for H.BWC** | | |
| Purpose: | Report | | |

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**Abstract**

This document summarizes reference software development for biomedical waveform coding (H.BWC) between the 76th and 77th VCEG meetings and presents anchor results for version 2.1 of the reference software.

1. **Introduction**

The reference software is a common framework which enables testing of new coding technologies in a unified environment and provides an exemplary implementation conforming to the draft specification of biomedical waveform coding (H.BWC).

This document reports on the progress of reference software development and provides anchor results for BWC-2.1.

1. **Software Development**

Development of the reference software was continued on the GitLab server located at:  
<https://vcgit.hhi.fraunhofer.de/vceg-sw/bwc>

The registration and development workflow are documented at:  
<https://vcgit.hhi.fraunhofer.de/vceg-sw/bwc/-/wikis/BWC-Software-Development-Workflow>

The latest software model version before the start of the meeting was BWC-2.1:

<https://vcgit.hhi.fraunhofer.de/vceg-sw/bwc/-/tree/BWC-2.1?ref_type=tags>

The repositories for the core experiments can be found at:  
<https://vcgit.hhi.fraunhofer.de/vceg-bwc-ce/2503_tel-ce1/bwc>

<https://vcgit.hhi.fraunhofer.de/vceg-bwc-ce/2503_tel-ce2/bwc>

<https://vcgit.hhi.fraunhofer.de/vceg-bwc-ce/2503_tel-ce-3/bwc>

<https://vcgit.hhi.fraunhofer.de/vceg-bwc-ce/2503_tel-ce-4/bwc>

<https://vcgit.hhi.fraunhofer.de/vceg-bwc-ce/2503_tel-ce-5/bwc>

The CE repositories are only accessible by the CE participants and the CE coordinators. Access can be granted by the CE coordinators.

# Software Development Progress

The progress in software development before the start of this meeting can be summarized as follows:

* Aligned the software with the draft specification [1]
* Bugfixes
* Integrated VCEG-BX07 [2], VCEG-BX11 [3], VCEG-BX12 [4]
* Integrated BDF reading support
* Provided excel reporting templated and a python script for BD-rate calculation
* Modified combinedPresetECG.cfg configuration to achieve comparable coding performance (with faster encoding) for ECG data with respect to BWC-1.0
* Issued the first version 2.1 of the BWC reference software (BWC-2.1)
* Created software repositories for the core experiments defined in [5] based on BWC-2.1
* Generated anchor coding results for further testing

# Anchor Results

Anchor results have been generated according to the common test conditions (CTC) described in [6] based on BWC-2.1. For each test set, there are two configurations. The first configuration realizes a joint coding of the channels while the second configuration realizes an independent coding of the channels.

Summaries of the results are shown in Table 1 and Table 2, detailed results are attached to this document as (Excel) xlsm and pdf (plots) files.

There are two xlsm files reporting results for the joint channel coding configuration and the independent channel coding configuration, respectively. The xlsm files are based on the excel reporting template, which can be found in the software repository (see sec. 2).

Each xlsm file reports the number of bits per samples (BPS), PSNR1,PSNR2 and Bjøntegaard Delta (BD) rates based on PSNR1 and PSNR2 for each test sequence and dataset as defined in the CTC document [6]. Furthermore, there are plot pdf-files per configuration, input sequence and PSNR measure (PSNR1 and PSNR2) showing coding results with respect to BWC-1.0.

Table 1 - Lossy compression results for joint channel coding

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| --- | --- | --- | --- | --- |
|  | **Lossy Compression** | | | |
|  | **Over BWC-1.0** | | | |
|  | BD-PSNR1 | BD-PSNR2 | EncT | DecT |
| MIT (ECG) | -0,45% | -0,47% | 82% | 42% |
| INCART (ECG) | 2,01% | 1,97% | 78% | 97% |
| CHBMIT (EEG) | 0,38% | 0,38% | 53% | 97% |
| NMR55 (EEG) | 0,80% | 1,32% | 77% | 70% |
| NMR57 (EEG) | 0,07% | 0,07% | 83% | 96% |
| Ozdemir (EMG) | 0,03% | 0,01% | 77% | 89% |
| **Overall** | 0,47% | 0,55% | 75% | 82% |

Table 2 - Lossy compression results for independent channel coding

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| --- | --- | --- | --- | --- |
|  | **Lossy Compression** | | | |
|  | **Over BWC-1.0-ICC** | | | |
|  | BD-PSNR1 | BD-PSNR2 | EncT | DecT |
| MIT (ECG) | -1,14% | -1,14% | 92% | 43% |
| INCART (ECG) | -0,49% | -0,48% | 85% | 93% |
| CHBMIT (EEG) | 0,06% | 0,08% | 91% | 93% |
| NMR55 (EEG) | 0,00% | 0,02% | 88% | 48% |
| NMR57 (EEG) | -0,08% | -0,07% | 90% | 79% |
| Ozdemir (EMG) | 0,00% | -0,01% | 91% | 86% |
| **Overall** | -0,28% | -0,27% | 90% | 74% |

# References

1. J. Pfaff, C.Fersch ,“H.BWC Draft 2 Specification Text,” VCEG-BX21, May 2025.  
   <https://www.itu.int/wftp3/av-arch/video-site/2503_Tel/>
2. C. Fersch, P. Setiawan, “Updates and Corrections to H.BWC High Level Syntax,“ VCEG-BX07, Mar. 2025.  
   <https://www.itu.int/wftp3/av-arch/video-site/2503_Tel/>
3. C. Helmrich, S. Pientka, H. Schwarz, J. Pfaff, “Description and correction of errors in H.BWC test model since January meeting,“ VCEG-BX11, Mar. 2025.  
   <https://www.itu.int/wftp3/av-arch/video-site/2503_Tel/>
4. C. Helmrich, S. Pientka, G. Hege, H. Kirchhoffer, P. Haase H. Schwarz, J. Pfaff, “Speedup of H.BWC reference software via pre-search and predictor optimizaiton,“ VCEG-BX12, Mar. 2025.  
   <https://www.itu.int/wftp3/av-arch/video-site/2503_Tel/>
5. J. Pfaff, C.Fersch ,“CE description for H.BWC,” VCEG-BX24, May 2025.  
   <https://www.itu.int/wftp3/av-arch/video-site/2503_Tel/>
6. J. Pfaff, C.Fersch, S. Jelfs, P. Haase ,“Common test conditions and evaluation procedures for H.BWC technical experiments,” VCEG-BX23, May 2025.  
   <https://www.itu.int/wftp3/av-arch/video-site/2503_Tel/>