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| Question: | 6/16 (VCEG) | | |
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| Title: | **Report on compression performance of the H.BWC reference encoder version 2.1 over a state-of-the-art Extended HE-AAC audio encoder** | | |
| Purpose: | Report | | |

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**Abstract**

This document reports coding results for the H.BWC reference software version 2.1 (BWC-2.1) over a state-of-the-art Extended HE-AAC audio encoder configured for lossy compression of biomedical waveforms. BWC-2.1 achieves 46.55% (BD-PSNR1) and 45.50% (BD-PSNR2) BD rate gain on average in the joint channel coding (JCC) setting and 38.03% (BD-PSNR1) and 37.11% (BD-PSNR2) BD rate gain on average in the independent channel coding (ICC) setting, respectively.

1. **Introduction**

Between the 76th and 77th VCEG meetings the second version of the H.BWC reference software (BWC-2.1) has been issued [1], which implements the current specification [2] of the emerging standard on biomedical waveform coding H.BWC. For the success of the standard, it is inevitable that it offers clear advantages compared to available solutions on the market, especially in terms of compression performance. To accommodate for this, the compression performance of BWC-2.1 is evaluated with respect to an MSE-optimized Extended HE-AAC audio encoder (*exhale*) [3] configured for lossy compression of biomedical waveforms.

1. **Corrections to Extended HE-AAC Encoder (*exhale*)**

Documents VCEG-BT05 [4] and VCEG-BU01 [5]outline modifications to an open-source audio encoder (*exhale*) for the MPEG-D Unified Speech and Audio Coding (USAC) standard, also known as Extended HE-AAC, to make it applicable to lossy coding of biomedical waveforms. These modifications result in all controllable psychoacoustic optimizations typically utilized in perceptual audio codecs being disabled in favor of MSE optimized encoder operation, thereby allowing direct (objective) performance comparisons with, e.g., the H.BWC test model. However, in the course of this year, the following issues regarding this objective were identifed and corrected:

* Perceptual optimizations in the spectral quantization were still enabled in the results reported in [1] and [2]; this was addressed by introducing more flexibility in the source and by setting #define SFB\_QUANT\_PERCEPT\_OPT to 0 (instead of 1 or 2) in source file *lib/quantization.h*.
* The maximum allowed magnitude of quantized spectral coefficients was unnecessarily low; this was addressed by respective changes to the encoder-side quantization and by a necessary bugfix to the USAC decoder in FFmpeg [6], which would otherwise lead to faulty decodings.
* The maximum allowed frame size (byte-size of encoded access unit) was unnecessarily low; this was addressed by better data rate estimations and relaxation of obsolete size limitations.

A fixed version of the MSE-optimized *exhale* audio encoder is publicly available at [3] since June 2025 (Git commit bffead0), by setting SFB\_QUANT\_PERCEPT\_OPT as above and setting #define EE\_MORE\_MSE to a value greater than 0 (5 or 6 is recommended) in source file *lib/exhaleEnc.h*. This version has been used to generate the lossy audio anchor results reported in this document.

# Compression Results

Results for BWC-2.1 have been generated according to the common test conditions (CTC) described in [7]. 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. The audio anchor is generated according to VCEG-BT05 [4] with the corrections to *exhale* as described in section 2.

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.

Table 1 - Lossy compression results for joint channel coding

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| --- | --- | --- | --- | --- |
|  | **Lossy Compression** | | | |
|  | **Over Audio** | | | |
|  | BD-PSNR1 | BD-PSNR2 | EncT | DecT |
| MIT (ECG) | -43,08% | -42,89% | N/A | N/A |
| INCART (ECG) | -68,01% | -67,56% | N/A | N/A |
| CHBMIT (EEG) | -30,42% | -30,06% | N/A | N/A |
| NMR55 (EEG) | -47,34% | -44,74% | N/A | N/A |
| NMR57 (EEG) | -49,12% | -45,16% | N/A | N/A |
| Ozdemir (EMG) | -41,35% | -39,60% | N/A | N/A |
| **Overall** | -46,55% | -45,00% | N/A | N/A |

Table 2 - Lossy compression results for independent channel coding

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **Lossy Compression** | | | |
|  | **Over Audio** | | | |
|  | BD-PSNR1 | BD-PSNR2 | EncT | DecT |
| MIT (ECG) | -43,16% | -42,96% | N/A | N/A |
| INCART (ECG) | -62,13% | -61,73% | N/A | N/A |
| CHBMIT (EEG) | -15,51% | -15,12% | N/A | N/A |
| NMR55 (EEG) | -41,54% | -39,61% | N/A | N/A |
| NMR57 (EEG) | -27,42% | -23,80% | N/A | N/A |
| Ozdemir (EMG) | -38,44% | -39,43% | N/A | N/A |
| **Overall** | -38,03% | -37,11% | N/A | N/A |

1. **Conclusion**

This informational document presents results for BWC-2.1 with respect to a state-of-the-art audio encoder configured such that it is applicable for lossy coding of biomedical waveforms. The current version of the H.BWC reference software provides significant BD rate savings over this available audio encoder of up to 46.6% on average in a lossy coding scenario.

# References

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