

CLAIMS

1. A method for audio decoding, where an encoded primary signal is decoded to form a decoded primary signal, followed by a post-filtering of the decoded primary signal to form a post-filtered signal, where an output signal of the decoder is one of the decoded primary signal and the post-filtered signal, the method comprising:
 5 obtaining (1101, 800) an energy estimation of at least a part of a frequency spectrum of the primary signal being reconstructed by the decoder;
 obtaining (1103, 820) an analysis of discontinuities in time domain that is caused by the post-filtering of the decoded primary signal;
 10 generating (1105, 830) a decision variable based on the energy estimation obtained and the analysis of discontinuities obtained;
 comparing (1107, 850) the decision variable to a threshold; and
 setting (1109) the output signal to be the decoded primary signal or the post-filtered signal based on the comparing of the decision variable to the threshold.
 15
2. The method of Claim 1, wherein the primary signal reconstruction is done in frequency domain.
- 20 3. The method of Claim 2, wherein obtaining the energy estimation comprises summing energy coefficients of the at least a part of the frequency spectrum in the frequency domain.
- 25 4. The method of Claim 3, wherein obtaining the energy estimation comprises measuring an energy of a critical band of a reconstructed signal in accordance with

$$E_{\hat{s}_{cb}}(m) = \frac{1}{k_{end} - k_{start} + 1} \sum_{k=k_{start}}^{k_{end}} \left(\hat{S}(m, k) \right)^2$$

wherein m is a frame number, $E_{\hat{s}_{cb}}(m)$ is an energy of a critical band of a reconstructed signal, $\hat{S}(m, k)$ is a reconstructed signal, and frequency bin limits k_{start} and k_{end} are set to match a frequency range of a critical band.

5. The method of Claim 4, further comprising applying a low-pass filter to the energy $E_{\hat{s}_{cb}}(m)$ of the critical band of the reconstructed signal in accordance with

$$\tilde{E}_{\hat{s}_{cb}}(m) = \gamma E_{\hat{s}_{cb}}(m) + (1 - \gamma) E_{\hat{s}_{cb}}(m - 1)$$

5 wherein $\gamma \in (0, 1]$ and is a low-pass filtering coefficient which depends on a shape of modified discrete cosine transform, MDCT, synthesis windows and a length of an overlap.

6. The method of any of Claims 1-5, wherein obtaining the analysis of the discontinuities in time domain comprises measuring an average energy of a size of the discontinuities.

10

7. The method of Claim 6, wherein measuring the average energy of the size of the discontinuities comprises averaging a step at subframe boundaries of a filter difference signal $s_{diff}(m, n)$ in accordance with

$$\tilde{E}_{step}(m) = \frac{1}{N_{sf}} \sum_{i=1}^{N_{sf}} \left(s_{diff}(m, n_i) - s_{diff}(m, n_i - 1) \right)^2$$

15

wherein m is a frame number, i is a subframe number, $\tilde{E}_{step}(m)$ is an average energy of the step at the subframe boundaries, N_{sf} is a number of subframes and $n_1, n_2, \dots, n_{N_{sf}}$ are sample indices of the subframe boundaries marking the start of each subframe.

8. The method of any of Claims 1-7, wherein generating the decision variable comprises limiting (1201, 840) the decision variable to a maximum value.

20

9. The method of any of Claims 1-8 further comprising low-pass filtering (1203, 840) the decision variable.

25

10. The method of Claim 9, wherein generating the decision variable comprises generating the decision variable $\tilde{E}_{ratio,LP}(m)$ in accordance with

$$\tilde{E}_{ratio}(m) = \frac{\tilde{E}_{step}(m)}{\tilde{E}_{\hat{s}_{cb}}(m)}$$

$$\tilde{E}_{ratio,LP}(m) = \beta \tilde{E}_{ratio,1}(m) + (1 - \beta) \tilde{E}_{ratio,LP}(m - 1)$$

$$\tilde{E}_{ratio,1}(m) = \begin{cases} \tilde{E}_{ratio}(m), & \tilde{E}_{ratio}(m) \leq E_{ratio,lim} \\ E_{ratio,lim}, & \tilde{E}_{ratio}(m) > E_{ratio,lim} \end{cases}$$

wherein m is a frame number, $\tilde{E}_{ratio}(m)$ is an energy ratio between $\tilde{E}_{step}(m)$ and $\tilde{E}_{\hat{s}_{cb}}(m)$, $\tilde{E}_{step}(m)$ is an average energy of a step at subframe boundaries, $\tilde{E}_{\hat{s}_{cb}}(m)$ is a
 5 low-pass filtered energy $E_{\hat{s}_{cb}}(m)$ of a critical band of a reconstructed signal, $\beta \in (0, 1]$ is a low-pass filtering coefficient, and $E_{ratio,lim}$ is an upper limit for the energy ratio.

11. The method of any of Claims 1-10, wherein setting the output signal to be the decoded primary signal or the post-filtered signal based on the comparing of the decision variable to the threshold comprises: responsive to an energy ratio between an average energy of a
 10 step at subframe boundaries and an energy estimation of the at least a part of the frequency spectrum of the primary signal being less than a threshold (1301), setting (1303) the output signal to the post-filtered signal; and responsive to the energy ratio between the average energy of the step at subframe boundaries and the energy of the at
 15 least a part of the frequency spectrum of the primary signal being equal to the threshold or higher than the threshold (1301), setting (1305) the output signal to the decoded primary signal.

12. The method of Claim 11, further comprising: providing hysteresis for the comparing of
 20 the decision variable to the threshold to prevent the output signal from being set back and forth between the primary signal and the post-filtered signal when the energy ratio goes above and below the threshold level in a specified period of time.

13. A decoder (100) for audio decoding, where an encoded primary signal is decoded to form
 25 a decoded primary signal, followed by a post-filtering of the decoded primary signal to form a post-filtered signal, where an output signal of the decoder is one of the decoded primary signal and the post-filtered signal, the decoder comprising: processing circuitry (1001); and memory (1003) coupled with the processing circuitry, wherein the memory

includes instructions that when executed by the processing circuitry causes the decoder to perform operations comprising:

obtaining (1101, 800) an energy estimation of at least a part of a frequency spectrum of the primary signal being reconstructed by the decoder;

5 obtaining (1103, 820) an analysis of discontinuities in time domain that is caused by the post-filtering of the decoded primary signal;

generating (1105, 830) a decision variable based on the energy estimation obtained and the analysis of discontinuities obtained;

comparing (1107, 850) the decision variable to a threshold; and

10 setting (1109) the output signal to be the decoded primary signal or the post-filtered signal based on the comparing of the decision variable to the threshold.

14. The decoder of Claim 13, wherein a primary signal reconstruction is done in frequency domain.

15

15. The decoder of Claim 14, wherein in obtaining the energy estimation, the memory includes further instructions that when executed by the processing circuitry causes the decoder to perform operations comprising summing energy coefficients of the at least a part of the frequency spectrum in the frequency domain.

20

16. The decoder of Claim 15, wherein in obtaining the energy estimation, the memory includes further instructions that when executed by the processing circuitry causes the decoder to perform operations comprising measuring an energy of a critical band of a reconstructed signal in accordance with

25
$$E_{\hat{s}_{cb}}(m) = \frac{1}{k_{end} - k_{start} + 1} \sum_{k=k_{start}}^{k_{end}} \left(\hat{S}(m, k) \right)^2$$

wherein m is a frame number, $E_{\hat{s}_{cb}}(m)$ is the energy of the critical band of the reconstructed signal, $\hat{S}(m, k)$ is a reconstructed signal, and frequency bin limits k_{start} and k_{end} are set to match a frequency range of the critical band.

17. The decoder of Claim 16, wherein the memory includes further instructions that when executed by the processing circuitry causes the decoder to perform further operations comprising applying a low-pass filter to the energy $E_{\hat{s}_{cb}}(m)$ of the critical band of the reconstructed signal in accordance with

$$\tilde{E}_{\hat{s}_{cb}}(m) = \gamma E_{\hat{s}_{cb}}(m) + (1 - \gamma) E_{\hat{s}_{cb}}(m - 1)$$

wherein $\gamma \in (0, 1]$ and is a low-pass filtering coefficient which depends on a shape of modified discrete cosine transform, MDCT, synthesis windows and a length of an overlap.

18. The decoder of any of Claims 13-17, wherein in obtaining the analysis of the discontinuities in time domain, the memory includes further instructions that when executed by the processing circuitry causes the decoder to perform operations comprising measuring an average energy of a size of the discontinuities.

19. The decoder of any of Claims 13-18, wherein in measuring the average energy of the size of the discontinuities, the memory includes further instructions that when executed by the processing circuitry causes the decoder to perform operations comprising averaging a step at subframe boundaries of a filter difference signal $s_{diff}(m, n)$ in accordance with

$$\tilde{E}_{step}(m) = \frac{1}{N_{sf}} \sum_{i=1}^{N_{sf}} \left(s_{diff}(m, n_i) - s_{diff}(m, n_i - 1) \right)^2$$

wherein m is a frame number, i is a subframe number, $\tilde{E}_{step}(m)$ is an average energy of the step at the subframe boundaries, N_{sf} is a number of subframes and $n_1, n_2, \dots, n_{N_{sf}}$ are sample indices of the subframe boundaries marking the start of each subframe.

20. The decoder of any of Claims 13-19, wherein in generating the decision variable, the memory includes further instructions that when executed by the processing circuitry causes the decoder to perform operations comprising limiting (1201, 840) the decision variable to a maximum value.

21. The decoder of any of Claims 13-20, wherein the memory includes further instructions that when executed by the processing circuitry causes the decoder to perform operations comprising low-pass filtering (1203, 840) the decision variable.

5 22. The decoder of Claim 21, wherein in generating the decision variable, the memory includes further instructions that when executed by the processing circuitry causes the decoder to perform operations comprising generating the decision variable $\tilde{E}_{ratio,LP}(m)$ in accordance with

$$\tilde{E}_{ratio}(m) = \frac{\tilde{E}_{step}(m)}{\tilde{E}_{\hat{s}_{cb}}(m)}$$

$$10 \quad \tilde{E}_{ratio,LP}(m) = \beta \tilde{E}_{ratio,1}(m) + (1 - \beta) \tilde{E}_{ratio,LP}(m - 1)$$

$$\tilde{E}_{ratio,1}(m) = \begin{cases} \tilde{E}_{ratio}(m), & \tilde{E}_{ratio}(m) \leq E_{ratio,lim} \\ E_{ratio,lim}, & \tilde{E}_{ratio}(m) > E_{ratio,lim} \end{cases}$$

wherein m is a frame number, $\tilde{E}_{ratio}(m)$ is an energy ratio between $\tilde{E}_{step}(m)$ and $\tilde{E}_{\hat{s}_{cb}}(m)$, $\tilde{E}_{step}(m)$ is an average energy of a step at subframe boundaries, $\tilde{E}_{\hat{s}_{cb}}(m)$ is a low-pass filtered energy $E_{\hat{s}_{cb}}(m)$ of the critical band of the reconstructed signal, $\beta \in$
 15 $(0, 1]$ is a low-pass filtering coefficient, and $E_{ratio,lim}$ is an upper limit for the energy ratio.

23. The decoder of any of Claims 13-22, wherein in setting the output signal to be the primary signal or the post-filtered signal based on the comparing of the decision variable to the threshold, the memory includes further instructions that when executed by the
 20 processing circuitry causes the decoder to perform operations comprising: responsive to an energy ratio between an average energy of a step at subframe boundaries and an energy estimation of the at least a part of the frequency spectrum of the primary signal being less than a threshold (1301), setting (1303) the output signal to the post-filtered
 25 signal; and responsive to the energy ratio between the average energy of the step at subframe boundaries and the energy of the at least a part of the frequency spectrum of the

primary signal being equal to the threshold or higher than the threshold (1301), setting (1305) the output signal to the decoded primary signal.

- 5 24. The decoder of Claim 23, wherein the memory includes further instructions that when executed by the processing circuitry causes the decoder to perform further operations comprising: providing hysteresis for the comparing of the decision variable to the threshold to prevent the output signal from being set back and forth between the primary signal and the post-filtered signal when the energy ratio goes above and below the threshold level in a specified period of time.
- 10 25. A decoder (100) adapted to perform operations comprising: obtaining (1101, 800) an energy estimation of at least a part of a frequency spectrum of a primary signal being reconstructed by the decoder to form a decoded primary signal; obtaining (1103, 820) an analysis of discontinuities in time domain that is caused by post-filtering of the decoded primary signal; generating (1105, 830) a decision variable based on the energy estimation obtained and the analysis of discontinuities obtained; comparing (1107, 850) the decision variable to a threshold; and setting (1109) the output signal to be the decoded primary signal or a post-filtered signal based on the comparing of the decision variable to the threshold.
- 15 26. The decoder (100) of Claim 25, wherein the decoder (100) is adapted to perform operations according to any of Claims 2-12.
- 20 27. A computer program comprising program code to be executed by processing circuitry (1001) of a decoder (100), whereby execution of the program code causes the decoder (100) to perform operations comprising: obtaining (1101, 800) an energy estimation of at least a part of a frequency spectrum of a primary signal being reconstructed by the decoder to form a decoded primary signal; obtaining (1103, 820) an analysis of discontinuities in time domain that is caused by post-filtering of the decoded primary signal; generating (1105, 830) a decision variable based on the energy estimation obtained and the analysis of discontinuities obtained; comparing (1107, 850) the decision
- 25
- 30

variable to a threshold; and setting (1109) the output signal to be the primary signal decoded or a post-filtered signal based on the comparing of the decision variable to the threshold.

5 28. The computer program of Claim 27 comprising further program code, whereby execution of the program code causes the decoder (100) to perform operations according to any of Claims 2-12.

10 29. A computer program product comprising a non-transitory storage medium including program code to be executed by processing circuitry (1001) of a decoder (100), whereby execution of the program code causes the decoder (100) to perform operations comprising: obtaining (1101, 800) an energy estimation of at least a part of a frequency spectrum of a primary signal being reconstructed by the decoder; obtaining (1103, 820) an analysis of discontinuities in time domain that is caused by post-filtering of the
15 primary signal; generating (1105, 830) a decision variable based on the energy estimation obtained and the analysis of discontinuities obtained; comparing (1107, 850) the decision variable to a threshold; and setting (1109) the output signal to be the primary signal decoded or the post-filtered signal based on the comparing of the decision variable to the threshold.

20

30. The computer program product of Claim 29 wherein the non-transitory storage medium includes further program code, whereby execution of the further program code causes the decoder (100) to perform operations according to any of Claims 2-12.