Claims

1. A method for obtaining spectrum coefficients for a replacement frame of an audio signal, the method comprising:

detecting ~~(S206)~~ a tonal component of a spectrum of an audio signal based on a peak ~~(502)~~ that exists in the spectra of frames ~~(m-1, m-2)~~ preceding a replacement frame ~~(m)~~;

for the tonal component of the spectrum, predicting ~~(S210)~~ spectrum coefficients for the peak ~~(502)~~ and its surrounding in the spectrum of the replacement frame ~~(m)~~; and

for the non-tonal component of the spectrum, using ~~(S214)~~ a non-predicted spectrum coefficient for the replacement frame ~~(m)~~ or a corresponding spectrum coefficient of a frame preceding the replacement frame ~~(m)~~.

2. The method of claim 1, wherein

the spectrum coefficients for the peak ~~(502)~~ and its surrounding in the spectrum of the replacement frame ~~(m)~~ is predicted based on a magnitude of the complex spectrum of a frame ~~(m-2)~~ preceding the replacement frame ~~(m)~~ and a predicted phase of the complex spectrum of the replacement frame ~~(m)~~, and

the phase of the complex spectrum of the replacement frame ~~(m)~~ is predicted based on the phase of the complex spectrum of a frame ~~(m-2)~~ preceding the replacement frame ~~(m)~~ and a phase shift between the frames ~~(m-1, m-2)~~ preceding the replacement frame ~~(m)~~.

3. The method of claim 2, wherein

the spectrum coefficients for the peak ~~(502)~~ and its surrounding in the spectrum of the replacement frame ~~(m)~~ is predicted based on the magnitude of the complex spectrum of the second last frame ~~(m-2)~~ preceding the replacement frame ~~(m)~~ and the predicted phase of the complex spectrum of the replacement frame ~~(m)~~, and

the phase of the complex spectrum of the replacement frame ~~(m)~~ is predicted based on the complex spectrum of the second last frame ~~(m-2)~~ preceding the replacement frame ~~(m)~~.

4. The method of claim 2 or 3, wherein the phase of the complex spectrum of the replacement frame ~~(m)~~ is predicted based on a phase for each spectrum coefficient at the peak and its surrounding in the frame ~~(m-2)~~ preceding the replacement frame ~~(m)~~.

5. The method of one of claims 2 to 4, wherein the phase shift between the frames ~~(m-1, m-2)~~ preceding the replacement frame ~~(m)~~ is equal for each spectrum coefficient at the peak and its surrounding in the respective frames.

6. The method of one of claims 1 to 5, wherein the tonal component is defined by the peak and its surrounding.

7. The method of one of claims 1 to 6, wherein the surrounding of the peak is defined by a predefined number of coefficients around the peak ~~(502)~~.

8. The method of one of claims 1 to 7, wherein the surrounding of the peak comprises a first number of coefficients on the left from the peak ~~(502)~~ and a second number of coefficients on the right from the peak ~~(502)~~.

9. The method of claim 8, wherein the first number of coefficients comprises coefficients between a left foot ~~(508)~~ and the peak ~~(502)~~ plus the coefficient of the left foot ~~(508)~~, and wherein the second number of coefficients comprises coefficients between a right foot ~~(510)~~ and the peak ~~(502)~~ plus the coefficient of the right foot ~~(510)~~.

10. The method of claim 8 or 9, wherein the first number of coefficients on the left from the peak ~~(502)~~ and the second number of coefficients on the right from the peak ~~(502)~~ are equal or different.

11. The method of claim 10, wherein the first number of coefficients on the left from the peak ~~(502)~~ is three and the second number of coefficients on the right from the peak ~~(502)~~ is three.

12. The method of one of claims 6 to 11, wherein the predefined number of coefficients around the peak ~~(502)~~ is set prior to the step of detecting the tonal component.

13. The method of one of claims 1 to 12, wherein the size of the surrounding of the peak is adaptive.

14. The method of claim 13, wherein the surrounding of the peak is selected such that surroundings around two peaks do not overlap.

15. The method of claim 2, wherein

the spectrum coefficient for the peak ~~(502)~~ and its surrounding in the spectrum of the replacement frame ~~(m)~~ is predicted based on the magnitude of the complex spectrum of the second last frame ~~(m-2)~~ preceding the replacement frame ~~(m)~~ and the predicted phase of the complex spectrum of the replacement frame ~~(m)~~,

the phase of the complex spectrum of the replacement frame ~~(m)~~ is predicted based on the phase of the complex spectrum of the last frame ~~(m-1)~~ preceding the replacement frame ~~(m)~~ and a refined phase shift between the last frame ~~(m-1)~~ and the second last frame ~~(m-2)~~ preceding the replacement frame ~~(m)~~,

the phase of the complex spectrum of the last frame ~~(m-1)~~ preceding the replacement frame ~~(m)~~ is determined based on the magnitude of the complex spectrum of the second last frame ~~(m-2)~~ preceding the replacement frame ~~(m)~~, the phase of the complex spectrum of the second last frame ~~(m-2)~~ preceding the replacement frame ~~(m)~~, the phase shift between the last frame ~~(m-1)~~ and the second last frame ~~(m-2)~~ preceding the replacement frame ~~(m)~~ and the real spectrum of the last frame ~~(m-1)~~, and

the refined phase shift is determined based on the phase of the complex spectrum of the last frame ~~(m-1)~~ preceding the replacement frame ~~(m)~~ and the phase of the complex spectrum of the second last frame ~~(m-2)~~ preceding the replacement frame ~~(m)~~.

16. The method of claim 15, wherein the refinement of the phase shift is adaptive based on the number of consecutively lost frames.

17. The method of claim 16, wherein starting from a third lost frame, a phase shift determined for a peak is used for predicting the spectral coefficients surrounding the peak ~~(502)~~.

18. The method of claim 17, wherein for predicting the spectral coefficients in a second lost frame, a phase shift determined for the peak ~~(502)~~ is used for predicting the spectral coefficients for the surrounding spectral coefficients when the phase shift in the last frame ~~(m-1)~~ preceding the replacement frame ~~(m)~~ is equal or below a predefined threshold, and a phase shift determined for the respective surrounding spectral coefficients is used for predicting the spectral coefficients of the surrounding spectral coefficients when the phase shift in the last frame ~~(m-1)~~ preceding the replacement frame ~~(m)~~ is above the predefined threshold.

19. The method of claim 2, wherein

the spectrum coefficient for the peak ~~(502)~~ and its surrounding in the spectrum of the replacement frame ~~(m)~~ is predicted based on a refined magnitude of the complex spectrum of the last frame ~~(m-1)~~ preceding the replacement frame ~~(m)~~ and the predicted phase of the complex spectrum of the replacement frame ~~(m)~~, and

the phase of the complex spectrum of the replacement frame ~~(m)~~ is predicted based on the phase of the complex spectrum of the second last frame ~~(m-2)~~ preceding the replacement frame ~~(m)~~ and twice the phase shift between the last frame ~~(m-1)~~ and the second last frame ~~(m-2)~~ preceding the replacement frame ~~(m)~~.

20. The method of claim 19, wherein the refined magnitude of the complex spectrum of the last frame ~~(m-1)~~ preceding the replacement frame ~~(m)~~ is determined based on a real spectrum coefficient of the real spectrum of the last frame ~~(m-1)~~ preceding the replacement frame ~~(m)~~, the phase of the complex spectrum of the second last frame ~~(m-2)~~ preceding the replacement frame ~~(m)~~ and the phase shift between the last frame ~~(m-1)~~ and the second last frame ~~(m-2)~~ preceding the replacement frame ~~(m)~~.

21. The method of claim 19 or 20, wherein the refined magnitude of the complex spectrum of the last frame ~~(m-1)~~ preceding the replacement frame ~~(m)~~ is limited by the magnitude of the complex spectrum of the second last frame ~~(m-2)~~ preceding the replacement frame ~~(m)~~.

22. The method of claim 2, wherein

the spectrum coefficient for the peak (502) and its surrounding in the spectrum of the replacement frame (m) is predicted based on the magnitude of the complex spectrum of an intermediate frame between the last frame (m-1) and the second last frame (m-2) preceding the replacement frame (m) and the predicted phase of the complex spectrum of the replacement frame (m).

23. The method of claim 22, wherein

the phase of the complex spectrum of the replacement frame (m) is predicted based on the phase of the complex spectrum of the intermediate frame preceding the replacement frame (m) and a phase shift between intermediate frames preceding the replacement frame (m), or

the phase of the complex spectrum of the replacement frame (m) is predicted based on the phase of the complex spectrum of the last frame (m-1) preceding the replacement frame (m) and a refined phase shift between intermediate frames preceding the replacement frame (m), the refined phase shift being determined based on the phase of the complex spectrum of the last frame (m-1) preceding the replacement frame (m) and the phase of the complex spectrum of the intermediate frame preceding the replacement frame (m).

24. The method of one of claims 1 to 23, wherein detecting a tonal component of the spectrum of the audio signal comprises:

searching (S400) peaks in the spectrum of the last frame (m-1) preceding the replacement frame (m) based on one or more predefined thresholds;

adapting (S402) the one or more thresholds; and

searching (S404) peaks in the spectrum of the second last frame (m-2) preceding the replacement frame (m) based on one or more adapted thresholds.

25. The method of claim 24, wherein adapting the one or more thresholds comprises setting the one or more thresholds for searching a peak in the second last frame (m-2) preceding the replacement frame (m) in a region around a peak found in the last frame (m-1) preceding the replacement frame (m) based on the spectrum and a spectrum

envelope of the last frame ~~(m-1)~~ preceding the replacement frame ~~(m)~~, or based on the fundamental frequency.

26. The method of claim 25, wherein the fundamental frequency is for the signal including the last frame ~~(m-1)~~ preceding the replacement frame ~~(m)~~ and the look-ahead of the last frame ~~(m-1)~~ preceding the replacement frame ~~(m)~~.

27. The method of claim 26, wherein the look-ahead of the last frame ~~(m-1)~~ preceding the replacement frame ~~(m)~~ is calculated on the encoder side using the look-ahead.

28. The method of one of claims 24 to 27, wherein adapting ~~(S402)~~ the one or more thresholds comprises setting the one or more thresholds for searching a peak in the second last frame ~~(m-2)~~ preceding the replacement frame ~~(m)~~ in a region not around a peak found in the last frame ~~(m-1)~~ preceding the replacement frame ~~(m)~~ to a predefined threshold value.

29. The method of one of claims 1 to 28, comprising:

determining ~~(S204)~~ for the replacement frame ~~(m)~~ whether to apply a time domain concealment or a frequency domain concealment using the prediction of spectrum coefficients for tonal components of the audio signal.

30. The method of claim 29, wherein the frequency domain concealment is applied in case the last frame ~~(m-1)~~ preceding the replacement frame ~~(m)~~ and the second last frame ~~(m-2)~~ preceding the replacement frame ~~(m)~~ have a constant pitch, or an analysis of one or more frames preceding the replacement frame ~~(m)~~ indicates that a number of tonal components in the signal exceeds a predefined threshold.

31. The method of one of claims 1 to 30, wherein the frames of the audio signal are coded using MDCT.

32. The method of one of claims 1 to 31, wherein a replacement frame ~~(m)~~ comprises a frame that cannot be processed at an audio signal receiver, e.g. due to an error in the received data, or a frame that was lost during transmission to the audio signal receiver, or a frame not received in time at the audio signal receiver.

33. The method of one of claims 1 to 32, wherein a non-predicted spectrum coefficient is generated using a noise generating method, e.g. sign scrambling, or using a predefined spectrum coefficient from a memory, e.g. a look-up table.

34. A non-transitory computer program product comprising a computer readable medium storing instructions which, when executed on a computer, carry out the method of one of claims 1 to 33.

35. An apparatus for obtaining spectrum coefficients for a replacement frame ~~(m)~~ of an audio signal, the apparatus comprising:

a detector ~~(134)~~ configured to detect a tonal component of a spectrum of an audio signal based on a peak that exists in the spectra of frames preceding a replacement frame ~~(m)~~; and

a predictor ~~(138)~~ configured to predict for the tonal component of the spectrum the spectrum coefficients for the peak ~~(502)~~ and its surrounding in the spectrum of the replacement frame ~~(m)~~;

wherein for the non-tonal component of the spectrum a non-predicted spectrum coefficient for the replacement frame ~~(m)~~ or a corresponding spectrum coefficient of a frame preceding the replacement frame ~~(m)~~ is used.

36. An apparatus for obtaining spectrum coefficients for a replacement frame ~~(m)~~ of an audio signal, the apparatus being configured to operate according to the method of one of claims 1 to 33.

37. An audio decoder, comprising an apparatus of claim 35 or 36.

38. An audio receiver, comprising an audio decoder of claim 37.

39. A system for transmitting audio signals, the system comprising:

an encoder ~~(100)~~ configured to generate coded audio signal; and

a decoder ~~(120)~~ according to claim 37 configured to receive the coded audio signal, and to decode the coded audio signal.