Claims

1. A decoder for decoding a current frame to reconstruct an audio signal, wherein the audio signal is encoded within the current frame, wherein the current frame comprises a current bitstream payload, wherein the current bitstream payload comprises a plurality of payload bits, wherein the plurality of payload bits encodes a plurality of spectral lines of a spectrum of the audio signal, wherein each of the payload bits exhibits a position within the current bitstream payload,

wherein the decoder comprises

a decoding module configured to reconstruct the audio signal, and

an output interface configured to output the audio signal,

wherein the decoding module comprises an error concealment mode, wherein, if the decoding module is in said error concealment mode, the decoding module is configured to reconstruct the audio signal by conducting error concealment for those spectral lines of the spectrum of the audio signal, which exhibit a frequency being greater than a threshold frequency; and/or

wherein, if error concealment is conducted by the decoding module, the decoding module is configured to conduct error concealment in a way that depends on whether or not a previous bitstream payload of a previous frame preceding the current frame encodes a signal component of the audio signal which is tonal or harmonic.

2. A decoder according to claim 1,

wherein said error concealment mode is a partial frame loss concealment mode, wherein, if the decoding module is in the partial frame loss concealment mode, the decoding module is configured

to reconstruct the audio signal without conducting error concealment for one or more first spectral lines of the plurality of spectral lines of the spectrum, which exhibit a frequency being smaller than or equal to the threshold frequency, wherein said one or more first spectral lines have been encoded by a first group of one or more of the plurality of payload bits, and

to reconstruct the audio signal by conducting error concealment for one or more second spectral lines of the plurality of spectral lines of the spectrum, which exhibit a frequency being greater than the threshold frequency, wherein said one or more second spectral lines have been encoded by a second group of one or more of the plurality of payload bits.

3. A decoder according to claim 2,

wherein the decoding module is configured to detect whether or not the current frame does not comprise any corrupted bits encoding said one or more first spectral lines of the spectrum of the audio signal which exhibit a frequency being smaller than or equal to the threshold frequency,

wherein the decoding module is configured to detect whether or not the current frame comprises one or more corrupted bits encoding said one or more second spectral lines of the spectrum of the audio signal which exhibit a frequency being greater than the threshold frequency,

wherein said one or more corrupted bits are one or more of the payload bits that are distorted or that are likely to be distorted, and

wherein, if the current frame does not comprise any corrupted bits encoding said one or more first spectral lines of the spectrum of the audio signal which exhibit a frequency being smaller than or equal to the threshold frequency and if the current frame comprises said one or more corrupted bits encoding said one or more second spectral lines of the spectrum of the audio signal which exhibit a frequency being greater than the threshold frequency, the decoding module is configured to conduct error concealment in the partial frame loss concealment mode by conducting error concealment for said one or more second spectral lines of the spectrum which are greater than the threshold frequency.

4. A decoder according to claim 3,

wherein, if the current frame does not comprise any corrupted bits encoding said one or more first spectral lines of the spectrum of the audio signal which exhibit a frequency being smaller than or equal to the threshold frequency and if the current frame comprises said one or more corrupted bits encoding said one or more second

spectral lines of the spectrum of the audio signal which exhibit a frequency being greater than the threshold frequency, the decoding module is configured to reconstruct the audio signal by decoding said first group of said one or more of the plurality of payload bits which encode said one or more first spectral lines of the spectrum of the audio signal which exhibit a frequency being smaller than or equal to the threshold frequency.

5. A decoder according to one of claims 2 to 4,

wherein the decoding module is configured to detect whether the current frame is lost,

wherein, if the decoder has detected that the current frame is lost, the decoding module is configured to reconstruct the audio signal

by conducting error concealment for said one or more second spectral lines of the spectrum of the audio signal which exhibit a frequency being greater than the threshold frequency, and

by decoding without conducting error concealment, said first group of said one or more of the plurality of payload bits which encode said one or more first spectral lines for said one or more first frequencies of the spectrum of the audio signal being smaller than or equal to the threshold frequency, wherein said first group of said one or more of the plurality of payload bits are one or more payload bits of a redundant frame being different from the current frame.

6. A decoder according to one of claims 2 to 5,

wherein, if the decoding module is configured to conduct error concealment in a full frame loss concealment mode, the decoding module is configured to conduct error concealment for all spectral lines of the spectrum.

7. A decoder according to claim 6,

wherein the plurality of payload bits is a plurality of current payload bits,

wherein, if the decoding module is in the partial frame loss concealment mode, the decoding module is configured to conduct error concealment for said one or more second spectral lines of the spectrum of the audio signal which exhibit a frequency being greater than the threshold frequency, using one or more stored spectral lines which have been encoded by one or more previous payload bits of the previous bitstream payload of the previous frame.

8. A decoder according to claim 7,

wherein the spectrum is a current quantized spectrum,

wherein, if the decoding module is conducting error concealment in the partial frame loss concealment mode, the decoding module is configured to conduct error concealment for said one or more second spectral lines of the spectrum of the audio signal which exhibit a frequency being greater than the threshold frequency, to obtain one or more intermediate spectral lines of said current quantized spectrum, wherein the decoding module is configured to rescale the one or more intermediate spectral lines using a rescaling factor to reconstruct the audio signal.

9. A decoder according to claim 8,

wherein the decoding module is configured to determine the rescaling factor depending on at least one of

a global gain being encoded within said current bitstream payload and

a global gain being encoded within said previous bitstream payload, and

an energy of a previous quantized spectrum of said previous frame, an energy of a previous decoded spectrum of said previous frame, and

an energy of said current quantized spectrum of said current frame.

10. A decoder according to claim 8 or 9,

wherein the decoding module is configured to determine the rescaling factor depending on whether or not

a mean energy of spectral bins of the previous decoded spectrum of the previous frame starting from a first spectral bin that cannot be reconstructed without conducting error concealment up to a top of the spectrum is greater than or equal to a mean energy of spectral bins of the previous decoded spectrum of the previous frame starting from zero up to said last spectral bin that can be reconstructed without conducting error concealment, or

an energy of spectral bins of said current quantized spectrum of the current frame starting from zero up to said last spectral bin that can be reconstructed without conducting error concealment is greater than or equal to an energy of spectral bins of the previous quantized spectrum of the previous frame starting from zero up to said last spectral bin that can be reconstructed without conducting error concealment.

11. A decoder according to claim 10,

wherein,

if the mean energy of the spectral bins of the previous decoded spectrum of the previous frame starting from said first spectral bin that cannot be reconstructed without conducting error concealment up to a top of the spectrum is smaller than the mean energy of the spectral bins of the previous decoded spectrum of the previous frame starting from zero up to said last spectral bin that can be reconstructed without conducting error concealment, and

if the energy of spectral bins of said current quantized spectrum of the current frame starting from zero up to said last spectral bin that can be reconstructed without conducting error concealment is smaller than the energy of the spectral bins of the previous quantized spectrum of the previous frame starting from zero up to said last spectral bin that can be reconstructed without conducting error concealment,

the decoding module is configured to determine the rescaling factor such that the rescaling factor is equal to the square root of the ratio of

the energy of the spectral bins of the current quantized spectrum starting from zero up to said last spectral bin that can be reconstructed without conducting error concealment multiplied with the square of a gain factor of the current frame,

to

the energy of the spectral bins of the previous quantized spectrum starting from zero up said last spectral bin that can be reconstructed without conducting error concealment multiplied with the square of a gain factor of the previous frame.

12. A decoder according to one of claims 9 to 11,

wherein the decoding module is configured to determine the rescaling factor, being a total rescaling factor, depends on a global gain rescaling factor,

wherein the decoding module is configured to determine the global gain rescaling factor according to

$$fac_{gg} = \frac{gg_{prev}}{gg} \quad ,$$

wherein gg indicates said global gain being encoded within said current bitstream payload, and

wherein gg_{prev} indicates said global gain being encoded within said previous bitstream payload, and

wherein fac_{gg} is the global gain rescaling factor.

13. A decoder according to claim 12,

wherein,

if $\frac{1}{k_{be}} \sum_{k=0}^{k_{be}-1} \hat{X}_{prev}(k)^2 \leq \frac{1}{N_F - k_{be}} \sum_{k=k_{be}}^{N_F-1} \hat{X}_{prev}(k)^2$, or

if $gg_{prev}^2 \cdot \sum_{k=0}^{k_{be}-1} \widehat{X_{q,lG}}(k)^2 \leq gg^2 \cdot \sum_{k=0}^{k_{be}-1} \widehat{X_q}(k)^2$,

the decoding module is configured to determine that the total rescaling factor is equal to the global gain rescaling factor,

wherein k indicates a spectral bin, wherein k_{be} indicates a first spectral bin that could not be recovered, wherein N_F indicates a number of spectral lines, wherein $\widehat{X_{q,lG}}(k)$ indicates the previous quantized spectrum of the previous frame being a last non-full frame loss concealment frame, wherein $\widehat{X_q}(k)$ indicates the current quantized spectrum of the current frame, wherein $\hat{X}_{prev}(k)$ indicates the previous decoded spectrum of the previous frame being said last non-full frame loss concealment frame.

14. A decoder according to claim 12 or 13,

wherein,

if $\frac{1}{k_{be}}\sum_{k=0}^{k_{be}-1}\hat{X}_{prev}(k)^2 > \frac{1}{N_F-k_{be}}\sum_{k=k_{be}}^{N_F-1}\hat{X}_{prev}(k)^2$, and

if $gg_{prev}^2 \cdot \sum_{k=0}^{k_{be}-1}\widehat{X_{q,lG}}(k)^2 > gg^2 \cdot \sum_{k=0}^{k_{be}-1}\widehat{X_q}(k)^2$,

the decoding module is configured to determine that the total rescaling factor moreover depends on an energy rescaling factor

$$fac_{ener} = \sqrt{\frac{gg^2 \cdot \sum_{k=0}^{k_{be}-1}\widehat{X_q}(k)^2}{{gg_{prev}}^2 \cdot \sum_{k=0}^{k_{be}-1}\widehat{X_{q,lG}}(k)^2}} \quad ,$$

wherein fac_{ener} indicates the energy rescaling factor,

wherein k indicates a spectral bin, wherein k_{be} indicates a first spectral bin that could not be recovered, wherein N_F indicates a number of spectral lines, wherein $\widehat{X_{q,lG}}(k)$ indicates the previous quantized spectrum of the previous frame being a last non-full frame loss concealment frame, wherein $\widehat{X_q}(k)$ indicates the current quantized spectrum of the current frame, wherein $\hat{X}_{prev}(k)$ indicates the previous decoded spectrum of the previous frame being said last non-full frame loss concealment frame.

15. A decoder according to claim 14,

wherein,

if $\frac{1}{k_{be}}\sum_{k=0}^{k_{be}-1}\hat{X}_{prev}(k)^2 > \frac{1}{N_F-k_{be}}\sum_{k=k_{be}}^{N_F-1}\hat{X}_{prev}(k)^2$, and

if $gg_{prev}^2 \cdot \sum_{k=0}^{k_{be}-1}\widehat{X_{q,lG}}(k)^2 > gg^2 \cdot \sum_{k=0}^{k_{be}-1}\widehat{X_q}(k)^2$,

the decoding module is configured to determine the total rescaling factor fac according to

$$fac = fac_{gg} \cdot fac_{ener} \quad ,$$

or according to

$$fac = \sqrt{\frac{\sum_{k=0}^{k_{be}-1}\widehat{X_q}(k)^2}{\sum_{k=0}^{k_{be}-1}\widehat{X_{q,lG}}(k)^2}} \quad ,$$

or according to

$$fac = \frac{gg_{prev}}{gg} \cdot \sqrt{\frac{gg^2 \cdot \sum_{k=0}^{k_{be}-1}\widehat{X_q}(k)^2}{gg_{prev}{}^2 \cdot \sum_{k=0}^{k_{be}-1}\widehat{X_{q,lG}}(k)^2}} \quad .$$

16. A decoder according to one of the preceding claims,

wherein, if error concealment is conducted by the decoding module, the decoding module is configured to reconstruct a current spectrum of the audio signal by conducting error concealment using a plurality of signs of a previous spectrum of the audio signal, said plurality of signs being encoded within the previous frame, wherein the decoding module is configured to conduct error concealment in a way that depends on whether or not said previous frame encodes a signal component which is tonal or harmonic.

17. A decoder according to claim 16,

wherein said previous frame is a last received frame, which has been decoded by the decoding module without conducting error concealment, or

wherein said previous frame is a last received frame, which has been decoded by the decoding module without conducting error concealment in a full frame loss concealment mode, or

wherein said previous frame is a last received frame, which has been decoded by the decoding module without conducting error concealment in a partial frame loss concealment mode or in a full frame loss concealment mode.

18. A decoder according to claim 16 or 17,

wherein, if error concealment is conducted by the decoding module, and if the previous bitstream payload of the previous frame encodes a signal component which is tonal or harmonic, the decoding module is configured to flip one or more signs of the plurality of signs of the previous spectrum to reconstruct the current spectrum, wherein a percentage value p, indicating a probability for a sign of the plurality of signs of the previous spectrum to be flipped by the decoding module to reconstruct the current spectrum, is between 0 % ≤ p ≤ 50 %, wherein the decoding module is configured to determine the percentage value p.

19. A decoder according to claim 18,

wherein the decoding module is configured to increase the percentage value p depending on a number of subsequent frames;

wherein said number of subsequent frames indicates for how many subsequently partially or fully lost frames error concealment has been conducted by the decoding module; or wherein said number of subsequent frames indicates for how many subsequent frames error concealment in a particular error concealment mode has been conducted by the decoding module.

20. A decoder according to claim 19,

wherein the decoding module is configured to determine the percentage value p depending on a function which depends on said number of subsequent frames, said number of subsequent frames being an argument of said function.

21. A decoder according to claim 20,

wherein the decoding module is configured to determine the percentage value p,

such that p is 0 %, if said number of subsequent frames is smaller than a first threshold value;

such that 0 % ≤ p ≤ 50 %, if said number of subsequent frames is greater than or equal to the first threshold value and smaller than a second threshold value, and

such that p = 50 %, if said number of subsequent frames is greater than the second threshold value.

22. A decoder according to claim 21,

wherein the decoding module is configured to determine the percentage value p, such that the percentage value p increases linearly in the range between the first threshold value and the second threshold value depending on the number of subsequent frames.

23. A decoder according to one of claims 18 to 22,

wherein, if error concealment is conducted by the decoding module, and if the previous bitstream payload of the previous frame does not encode a signal component which is tonal or harmonic, the decoding module is configured to flip 50 % of the plurality of signs of the previous spectrum to reconstruct the current spectrum.

24. A decoder according to one of the preceding claims,

wherein, if error concealment is conducted by the decoding module, the decoding module is configured to reconstruct a current spectrum of the audio signal by conducting error concealment using a plurality of amplitudes of the previous spectrum of the audio signal depending on whether or not the previous frame encodes a signal component which is tonal or harmonic, said plurality of amplitudes being encoded within the previous frame.

25. A decoder according to claim 24,

wherein, if error concealment is conducted by the decoding module, the decoding module is configured to attenuate the plurality of amplitudes of the previous spectrum according to a non-linear attenuation characteristic to reconstruct the current spectrum, wherein the non-linear attenuation characteristic depends on whether or not the previous frame encodes a signal component which is tonal or harmonic.

26. A decoder according to claim 24 or 25,

wherein, if error concealment is conducted by the decoding module, and if the previous bitstream payload of the previous frame encodes a signal component which is tonal or harmonic, the decoding module is configured to attenuate the plurality of amplitudes of the previous spectrum depending on a stability factor, wherein said stability factor indicates a similarity between the current spectrum and the previous spectrum; or wherein the stability factor indicates a similarity between the previous spectrum and a pre-previous spectrum of a pre-previous frame preceding the previous frame.

27. A decoder according to claim 26,

wherein said pre-previous frame is a last received frame before the previous frame, which has been decoded by the decoding module without conducting error concealment, or

wherein said pre-previous frame is a last received frame before the previous frame, which has been decoded by the decoding module without conducting error concealment in a full frame loss concealment mode, or

wherein said pre-previous frame is a last received frame before the previous frame, which has been decoded by the decoding module without conducting error concealment in a partial frame loss concealment mode or in a full frame loss concealment mode.

28. A decoder according to claim 26 or 27,

wherein said stability factor indicates said similarity between the current spectrum and the previous spectrum, if the decoding module is set to conduct partial frame loss concealment;

wherein said stability factor indicates said similarity between the previous spectrum and the pre-previous spectrum, if the decoding module is set to conduct full frame loss concealment.

29. A decoder according to one of claims 26 to 28,

wherein the decoding module is configured to determine an energy of a spectral bin of the previous spectrum;

wherein the decoding module is configured to determine whether or not said energy of said spectral bin is smaller than an energy threshold;

wherein, if said energy is smaller than said energy threshold, the decoding module is configured to attenuate an amplitude of the plurality of amplitudes being assigned to said spectral bin with a first fading factor,

wherein, if said energy is greater than or equal to said energy threshold, the decoding module is configured to attenuate said amplitude of the plurality of amplitudes being assigned to said spectral bin with a second fading factor, being smaller than the first fading factor,

wherein the decoding module is configured to conduct attenuation such that by using a smaller fading factor for the attenuation of one of the plurality of amplitudes, the attenuation of said one of the amplitudes is increased.

30. A decoder according to one of claims 26 to 28,

wherein the decoding module is configured to determine an energy of a spectral band comprising a plurality of spectral bins of the previous spectrum;

wherein the decoding module is configured to determine whether or not said energy of said spectral band is smaller than an energy threshold;

wherein, if said energy is smaller than said energy threshold, the decoding module is configured to attenuate an amplitude of the plurality of amplitudes being assigned to said spectral bin of said spectral band with a first fading factor,

wherein, if said energy is greater than or equal to said energy threshold, the decoding module is configured to attenuate said amplitude of the plurality of amplitudes being assigned to said spectral bin of said spectral band with a second fading factor, being smaller than the first fading factor,

wherein the decoding module is configured to conduct attenuation such that by using a smaller fading factor for the attenuation of one of the plurality of amplitudes, the attenuation of said one of the amplitudes is increased.

31. A decoder according to claim 30, further depending on claim 19,

wherein the decoding module is configured to determine the first fading factor such that, depending on said number of subsequent frames, the first fading factor becomes smaller, and

wherein the decoding module is configured to determine the second fading factor such that, depending on said number of subsequent frames, the second fading factor becomes smaller.

32. A decoder according to claim 31,

wherein the decoding module is configured to determine the first fading factor and the second fading factor, so that

`cum_fading_slow = 1,` and
`cum_fading_fast = 1,`

if the current frame is a first frame among the subsequent frames, and so that

if the current frame is one of the frames succeeding the first frame among the subsequent frames, the first fading factor and the second fading factor are determined depending on said number of subsequent frames according to:

```
cum_fading_slow  = cum_fading_slow  * slow;
cum_fading_fast  = cum_fading_fast  * fast;
```

wherein `cum_fading_slow` on the right side of the formula is the first fading factor of the previous frame,

wherein `cum_fading_slow` on the left side of the formula is the first fading factor of the current frame,

wherein `cum_fading_fast` on the right side of the formula is the second fading factor of the previous frame,

wherein `cum_fading_fast` on the left side of the formula is the second fading factor of the current frame,

wherein 1 > slow > fast > 0.

33. A decoder according to claim 32, wherein 1 > slow > fast > 0.3.

34. A decoder according to one of claims 29 to 33, further depending on claim 19,

wherein the decoding module is configured to determine said energy threshold,

such that said energy threshold is equal to a first energy value, if said number of subsequent frames is smaller than a third threshold value;

such that said energy threshold is smaller than said first energy value and is greater than a second energy value, if said number of subsequent frames is greater than or equal to the third threshold value and smaller than a fourth threshold value; and

such that said energy threshold is equal to said second energy value, if said number of subsequent frames is greater than the fourth threshold value.

35. A decoder according to claim 34,

wherein the decoding module is configured to determine the energy threshold, such that the energy threshold decreases linearly in the range between the third threshold

value and the fourth threshold value depending on the number of subsequent frames.

36. A decoder according to claim 1 or according to one of claims 15 to 35,

wherein the decoding module comprises a decoded spectrum storage module configured for storing a decoded spectrum of the audio signal, wherein the decoded spectrum storage module is configured to provide a last non-full frame loss concealment decoded spectrum, and

wherein the decoding module comprises a fade-out and sign scrambling module being configured for fade-out and sign scrambling on spectral lines of the spectrum.

37. A decoder according to claim 36,

wherein the decoding module comprises a quantized spectrum storage module configured for storing a quantized spectrum of the audio signal, wherein the quantized spectrum storage module is configured to provide a last non-full frame loss concealment quantized spectrum, and

wherein the decoding module comprises a partial frame repetition & rescaling module configured for partial frame repetition and rescaling, wherein the partial frame repetition & rescaling module is configured to complement the spectrum by adding spectral lines, which could not be decoded by the decoding module, wherein the partial frame repetition & rescaling module is configured to re-scale said spectral lines.

38. A decoder according to one of claims 2 to 14,

wherein the decoding module comprises a quantized spectrum storage module configured for storing a quantized spectrum of the audio signal, wherein the quantized spectrum storage module is configured to provide a last non-full frame loss concealment quantized spectrum, and

wherein the decoding module comprises a decoded spectrum storage module configured for storing a decoded spectrum of the audio signal, wherein the decoded spectrum storage module is configured to provide a last non-full frame loss concealment decoded spectrum.

39. A method for decoding a current frame to reconstruct an audio signal, wherein the audio signal is encoded within the current frame, wherein the current frame comprises a current bitstream payload, wherein the current bitstream payload comprises a plurality of payload bits, wherein the plurality of payload bits encodes a plurality of spectral lines of a spectrum of the audio signal, wherein each of the payload bits exhibits a position within the bitstream payload, wherein the method comprises:

reconstructing the audio signal, wherein, in an error concealment mode, reconstructing the audio signal is conducted by conducting error concealment for those spectral lines of the spectrum of the audio signal, which exhibit a frequency being greater than a threshold frequency; and/or wherein, if error concealment is conducted, error concealment is conducted in a way that depends on whether or not a previous bitstream payload of a previous frame preceding the current frame encodes a signal component of the audio signal which is tonal or harmonic; and

outputting the audio signal.

40. A computer program for implementing the method of claim 39 when being executed on a computer or signal processor.