Claims

1. Apparatus for generating a frequency enhancement signal (140), comprising:

a calculator (500) for calculating a value describing an energy distribution with respect to frequency in a core signal (110, 120);

a signal generator (200) for generating an enhancement signal (130) comprising an enhancement frequency range not included in the core signal, from the core signal (502), and

wherein the signal generator (200) is configured for shaping the enhancement signal or the core signal so that a spectral envelope of the enhancement signal or of the core signal depends on the value (501) describing the energy distribution with respect to frequency in the core signal,

wherein the signal generator (200) is configured to shape the enhancement signal or the core signal so that a first spectral envelope decrease from a first frequency in the enhancement frequency range to a second higher frequency in the enhancement frequency range is obtained for a first value describing a first energy distribution, and so that a second spectral envelope decrease from the first frequency in the enhancement range to the second frequency in the enhancement range is obtained for a second value describing a second energy distribution,

wherein the second frequency is greater than the first frequency,

wherein the second spectral envelope decrease is greater than the first spectral envelope decrease, and

wherein the first value indicates that the core signal has an energy concentration at a higher frequency of the core signal compared to the second value.

2. Apparatus of claim 1, further comprising a combiner (300) for combining the enhancement signal (130) and the core signal (120) to obtain the frequency enhancement signal (300, 140).

3. Apparatus of one of the preceding claims,

wherein the calculator (500) is configured to calculate a measure for a spectral centroid of a current frame as the value on the energy distribution,

wherein the signal generator (200) is configured to shape, in accordance with the value for the spectral centroid, so that the spectral centroid at a higher frequency results in a more shallow slope of the spectral envelope than a spectral centroid at a lower frequency.

4. Apparatus in accordance with one of the preceding claims, wherein the calculator (500) is configured to calculate the information on the energy distribution using only a frequency portion of the core signal, the frequency portion of the core signal starting at a first frequency (410) and ending at a second frequency higher than the first frequency (410), wherein the first frequency is higher than a lowest frequency of the core signal or the second frequency is the highest frequency of the core signal.

5. Apparatus in accordance with one of the preceding claims,

wherein the value describing an energy distribution is calculated using the following equation:

$$sp = \frac{\sum_{i=start}^{xover} i * E(i)}{(xover - start + 1) * \sum_{i=start}^{xover} E(i)},$$

wherein *sp* is the value describing the energy distribution, wherein *xover* is a crossover frequency (420), wherein *E*(*i*) is an energy of a subband *i* and wherein start is the subband index referring to a frequency (410) being higher than a lowest frequency of the core signal, and wherein *i* is an integer subband index.

6. Apparatus in accordance with one of the preceding claims,

wherein the signal generator is configured for applying a shaping factor to an input signal, wherein the shaping factor is calculated based on the following equation:

$$att = p\,(sp);$$

wherein *att* is a value influencing a shaping factor, and p is a polynomial, and *sp* is the value on the frequency distribution calculated by the calculator (500).

7. Apparatus in accordance with one of the preceding claims, wherein the signal generator (200) is configured for performing the shaping using the following equation:

$$\widehat{Qr}(t, xover + f) = Qr(t, xover + f) * att^f; f = 1..nBands, \text{ or}$$
$$\widehat{Qi}(t, xover + f) = Qi(t, xover + f) * att^f; f = 1..nBands,$$

wherein $\widehat{Qr}$ is a real part of a shaped subband sample, *t* is a time index, *xover* is a crossover frequency (420), *f* is a frequency index and *att* is a constant derived from the value on the spectral distribution, Q_r is a real part of a subband sample before shaping, and Q_i is an imaginary part of a subband sample before shaping.

8. Apparatus in accordance with one of the preceding claims,

wherein the core signal comprises a plurality of core signal subbands,

wherein the calculator (500) is configured to calculate individual energies of core signal bands and to calculate the information on the energy distribution using the individual energies (604).

9. Apparatus in accordance with one of the preceding claims,

wherein the core signal comprises a plurality of core signal bands,

wherein the signal generator (200) is configured to copy-up or to mirror (202) one or a plurality of core signal bands to obtain a plurality of enhancement signal bands forming the enhancement frequency range.

10. Apparatus in accordance with claim 1,

wherein the calculator (500) is configured to calculate the value based on the following equation:

$$sp = \frac{\sum_{i=start}^{xover} ai * E(i)}{bi * \sum_{i=start}^{xover} E(i)}$$

wherein a_i is a constant parameter for a band i of the core signal, wherein E(i) is an energy in the band i, wherein bi is a constant parameter for a band i of the core signal and values of bi are lower than values ai, and wherein the constant parameters are such that a parameter for a band having a higher index i is greater than a parameter for a band having a lower index i.

11. Apparatus in accordance with one of the preceding claims,

wherein the signal generator (200) is configured to perform, subsequent to or concurrent to the shaping (204) of the enhancement signal or the core signal, a temporal smoothing operation (206), the temporal smoothing operation comprising finding a decision about a smoothing intensity and applying the smoothing operation to the enhancement frequency range or the core signal based on the decision.

12. Apparatus in accordance with one of the preceding claims,

wherein the signal generator (200) is configured to apply a band-wise energy limitation (208) subsequent to the shaping (204) or the temporal smoothing (206) or concurrent to the shaping (204) or the temporal smoothing (206).

13. Method of generating a frequency enhancement signal (140), comprising:

calculating (500) a value describing an energy distribution with respect to frequency in a core signal (110, 120);

generating (200) an enhancement signal (130) comprising an enhancement frequency range not included in the core signal, from the core signal (502), and

wherein the generating (200) comprises shaping the enhancement signal or the core signal so that a spectral envelope of the enhancement signal or of the core signal depends on the value (501) describing the energy distribution with respect to frequency in the core signal,

wherein the generating (200) comprises shaping the enhancement signal or the core signal so that a first spectral envelope decrease from a first frequency in the enhancement frequency range to a second higher frequency in the enhancement frequency range is obtained for a first value describing a first energy distribution, and so that a second spectral envelope decrease from the first frequency in the enhancement range to the second frequency in the enhancement range is obtained for a second value describing a second energy distribution,

wherein the second frequency is greater than the first frequency,

wherein the second spectral envelope decrease is greater than the first spectral envelope decrease, and

wherein the first value indicates that the core signal has an energy concentration at a higher frequency of the core signal compared to the second value.

14. System for processing audio signals, comprising:

an encoder (1500) for generating an encoded core signal (110); and

an apparatus for generating a frequency enhancement signal of any one of claims 1 to 12.

15. Method for processing audio signals, comprising:

generating (1500) an encoded core signal (110); and

generating a frequency enhancement signal in accordance with the method of claim 13.

16. Computer program for performing, when running on a computer or a processor, a method of claim 13 or claim 15.

Claims

1. Apparatus for generating a frequency enhancement signal, comprising:

a calculator for calculating a value describing an energy distribution with respect to frequency in a core signal;

a signal generator for generating an enhancement signal comprising an enhancement frequency range not included in the core signal, from the core signal, and

wherein the signal generator is configured for shaping the enhancement signal or the core signal so that a spectral envelope of the enhancement signal or of the core signal depends on the value describing the energy distribution with respect to frequency in the core signal,

wherein the signal generator is configured to shape the enhancement signal or the core signal so that a first spectral envelope decrease from a first frequency in the enhancement frequency range to a second higher frequency in the enhancement frequency range is obtained for a first value describing a first energy distribution, and so that a second spectral envelope decrease from the first frequency in the enhancement range to the second frequency in the enhancement range is obtained for a second value describing a second energy distribution,

wherein the second frequency is greater than the first frequency,

wherein the second spectral envelope decrease is greater than the first spectral envelope decrease, and

wherein the first value indicates that the core signal has an energy concentration at a higher frequency of the core signal compared to the second value.

2. Apparatus of claim 1, further comprising a combiner for combining the enhancement signal and the core signal to obtain the frequency enhancement signal.

3. Apparatus of one of the preceding claims,

wherein the calculator is configured to calculate a measure for a spectral centroid of a current frame as the value on the energy distribution,

wherein the signal generator is configured to shape, in accordance with the value for the spectral centroid, so that the spectral centroid at a higher frequency results in a more shallow slope of the spectral envelope than a spectral centroid at a lower frequency.

4. Apparatus in accordance with one of the preceding claims, wherein the calculator is configured to calculate the information on the energy distribution using only a frequency portion of the core signal, the frequency portion of the core signal starting at a first frequency and ending at a second frequency higher than the first frequency, wherein the first frequency is higher than a lowest frequency of the core signal or the second frequency is the highest frequency of the core signal.

5. Apparatus in accordance with one of the preceding claims,

wherein the value describing an energy distribution is calculated using the following equation:

$$sp = \frac{\sum_{i=start}^{xover} i * E(i)}{(xover - start + 1) * \sum_{i=start}^{xover} E(i)},$$

wherein *sp* is the value describing the energy distribution, wherein *xover* is a crossover frequency, wherein $E(i)$ is an energy of a subband i and wherein start is the subband index referring to a frequency being higher than a lowest frequency of the core signal, and wherein i is an integer subband index.

6. Apparatus in accordance with one of the preceding claims,

wherein the signal generator is configured for applying a shaping factor to an input signal, wherein the shaping factor is calculated based on the following equation:

$$att = p\ (sp);$$

wherein *att* is a value influencing a shaping factor, and p is a polynomial, and *sp* is the value on the frequency distribution calculated by the calculator.

7. Apparatus in accordance with one of the preceding claims, wherein the signal generator is configured for performing the shaping using the following equation:

$$\widehat{Qr}(t, xover + f) = Qr(t, xover + f) * att^f; f = 1..nBands, \text{ or}$$
$$\widehat{Qi}(t, xover + f) = Qi(t, xover + f) * att^f; f = 1..nBands,$$

wherein $\widehat{Qr}$ is a real part of a shaped subband sample, *t* is a time index, *xover* is a crossover frequency, *f* is a frequency index and *att* is a constant derived from the value on the spectral distribution, Q_r is a real part of a subband sample before shaping, and Q_i is an imaginary part of a subband sample before shaping.

8. Apparatus in accordance with one of the preceding claims,

wherein the core signal comprises a plurality of core signal subbands,

wherein the calculator is configured to calculate individual energies of core signal bands and to calculate the information on the energy distribution using the individual energies.

9. Apparatus in accordance with one of the preceding claims,

wherein the core signal comprises a plurality of core signal bands,

wherein the signal generator is configured to copy-up or to mirror one or a plurality of core signal bands to obtain a plurality of enhancement signal bands forming the enhancement frequency range.

10. Apparatus in accordance with claim 1,

wherein the calculator is configured to calculate the value based on the following equation:

$$sp = \frac{\sum_{i=start}^{xover} ai * E(i)}{bi * \sum_{i=start}^{xover} E(i)}$$

wherein a_i is a constant parameter for a band i of the core signal, wherein E(i) is an energy in the band i, wherein bi is a constant parameter for a band i of the core signal and values of bi are lower than values ai, and wherein the constant parameters are such that a parameter for a band having a higher index i is greater than a parameter for a band having a lower index i.

11. Apparatus in accordance with one of the preceding claims,

wherein the signal generator is configured to perform, subsequent to or concurrent to the shaping of the enhancement signal or the core signal, a temporal smoothing operation, the temporal smoothing operation comprising finding a decision about a smoothing intensity and applying the smoothing operation to the enhancement frequency range or the core signal based on the decision.

12. Apparatus in accordance with one of the preceding claims,

wherein the signal generator is configured to apply a -wise energy limitation subsequent to the shaping or the temporal smoothing or concurrent to the shaping or the temporal smoothing.

13. Method of generating a frequency enhancement signal, comprising:

calculating a value describing an energy distribution with respect to frequency in a core signal;

generating an enhancement signal comprising an enhancement frequency range not included in the core signal, from the core signal, and

wherein the generating comprises shaping the enhancement signal or the core signal so that a spectral envelope of the enhancement signal or of the core signal depends on the value describing the energy distribution with respect to frequency in the core signal,

wherein the generating comprises shaping the enhancement signal or the core signal so that a first spectral envelope decrease from a first frequency in the enhancement frequency range to a second higher frequency in the enhancement frequency range is obtained for a first value describing a first energy distribution, and so that a second spectral envelope decrease from the first frequency in the enhancement range to the second frequency in the enhancement range is obtained for a second value describing a second energy distribution,

wherein the second frequency is greater than the first frequency,

wherein the second spectral envelope decrease is greater than the first spectral envelope decrease, and

wherein the first value indicates that the core signal has an energy concentration at a higher frequency of the core signal compared to the second value.

14. System for processing audio signals, comprising:

an encoder for generating an encoded core signal; and

an apparatus for generating a frequency enhancement signal of any one of claims 1 to 12.

15. Method for processing audio signals, comprising:

generating an encoded core signal; and

generating a frequency enhancement signal in accordance with the method of claim 13.

16. Computer program for performing, when running on a computer or a processor, a method of claim 13 or claim 15.