Claims

1. Apparatus for processing an encoded signal (110), the encoded signal comprising an encoded audio signal having information on a pitch delay, a pitch gain, and a bass post-filter control parameter (101), comprising:

an audio signal decoder (110) for decoding the encoded audio signal using the information on the pitch delay or the pitch gain to obtain a decoded audio signal (103);

a controllable bass post-filter (112) for filtering the decoded audio signal (103) to obtain a processed signal (113), wherein the controllable bass post-filter (112) has a variable bass post-filter characteristic controllable by the bass post-filter control parameter (101); and

a controller (114) for setting the variable bass post-filter characteristic in accordance with the bass post-filter control parameter (101) included in the encoded signal (102),

wherein the controllable bass post-filter (112) comprises a filter apparatus (209) comprising a long-term prediction filter (204), a gain stage (206) , a signal manipulator (208), and a subtractor (202) for subtracting an output of the filter apparatus (209) from the decoded audio signal (103),

wherein the bass post-filter control parameter (101) comprises a quantized gain value for the gain stage (206),

wherein the controller (114) is configured to set the gain stage (206) in accordance with the quantized gain value,

wherein the controller (114) comprises a block (210) for decoding or retrieving the information on a pitch delay and wherein the controller (114) is configured to set the long-term prediction filter (204) in accordance with the pitch delay,

wherein the controller is configured

to retrieve (500) the quantized gain value from the encoded signal to obtain the bass post-filter control parameter (101),

to scale (504) the pitch gain by a constant factor lower than 1 and greater than 0 to obtain a scaled pitch gain; and

to calculate (506) a setting of the gain stage using the scaled pitch gain and using the quantized gain value.

2. Apparatus of claim 1,

wherein the controllable bass post-filter (112) is configured to operate in a time domain,

wherein the signal manipulator (208) is implemented as a low-pass filter, an all-pass filter, a band-pass filter or a high-pass filter, and

wherein the bass post-filter control parameter comprises in addition to a gain value for the gain stage (206) a filter characteristic information for the signal manipulator (208) and, .
wherein the controller (114) is configured to set the signal manipulator (208) in accordance with the information on the filter characteristic.

3. Apparatus of claim 1 or 2,,

wherein the controllable bass post-filter (112) is configured to operate in a spectral domain,

wherein a first time-to-spectrum converter (300) for generating a spectral representation of the decoded audio signal (103) is provided,

wherein the controllable bass post-filter (112) a second time-to-spectrum converter (302) to generate subband signals for different subbands and a signal manipulator (304) for each subband, wherein the signal manipulator for a subband is configured for performing a weighting operation using a weighting factor (310, 312,

314, 316, 318), and wherein individual weighting factors (310-318) for signal manipulators (304) for individual subbands together implement a low-pass filter characteristic, an all-pass filter characteristic, a band-pass filter characteristic or a high-pass filter characteristic, wherein the subtractor is configured for subtracting an output of the filter apparatus for a subband from a corresponding subband generated by the first time-to-spectrum converter (300) to generate a subtracted subband signal; and

a spectrum-to-time converter (306) for converting subtracted subband signals into a time domain to obtain the processed signal (113);

wherein the bass post-filter control parameter comprises a gain value for the gain stage (206) and a filter characteristic information for the signal manipulator (208).

4. Apparatus of one of the preceding claims,

wherein the bass post-filter control parameter is quantized relative to the information on the pitch delay or the pitch gain included in the encoded audio signal, and

wherein the controller (114) is configured to set the variable bass post-filter characteristic in accordance with the information on the pitch delay or the information on the pitch gain and the bass post-filter control parameter.

5. Apparatus of claim 4,

wherein the controller (114) is configured to set the variable bass post-filter characteristic based on a product of the information on the pitch delay or the pitch gain and the bass post-filter characteristic (506).

6. Apparatus of claim 5,

wherein the controller is configured for calculating (506) a gain for the variable gain stage (206) using a product (504) between the bass post-filter control parameter and the pitch gain (502) and a constant factor lower than 1 and greater than 0.

7. Apparatus of one of the preceding claims,

wherein the controllable bass post-filter (112) comprises a long-term prediction filter (204) and a variable gain stage (206), wherein the long-term prediction filter (204) is controlled by the information on the pitch gain included in the encoded audio signal, and

wherein the controller (114) is configured to set a gain of the variable gain stage using the bass post-filter control parameter (101) alone or in combination with the information on the pitch gain.

8. Apparatus of claim 7,

wherein a low-pass filter (208) or a combination of a time-to-spectrum converter (302) and a subband weighter (304) is connected to an output of the variable gain stage (206) or an output of the long-term prediction filter (204).

9. Encoder for generating an encoded signal (608), comprising:

an audio signal encoder (600) for generating an encoded audio signal (601) having information on a pitch gain or a pitch delay from an original audio signal (603);

a decoder (602) for decoding the encoded audio signal to obtain a decoded audio signal;

a processor (604) for calculating a bass post-filter control parameter (607) fulfilling an optimization criterion using the decoded audio signal (605) and the original audio signal (603); and

an output interface (606) for outputting the encoded signal (608) having the encoded audio signal (601) comprising the information on the pitch gain or the pitch delay and the bass post-filter control parameter (607),

wherein the processor (604) further comprises a quantizer (708) for quantizing the bass post-filter control parameter to one of a predetermined number of quantization indices, and

wherein the processor (604) is configured to calculate the bass post-filter control parameter so that the optimization criterion is fulfilled for a quantized bass post-filter control parameter.

10. Encoder of claim 9,

wherein the processor (604) is configured to calculate the bass post-filter control parameter (607) so that a signal-to-noise ratio between the original audio signal (603) and a decoded and bass post-filtered audio signal is minimized.

11. Encoder of claim 9 or 10,

wherein the processor (604) comprises a long-term prediction filter (204), a low-pass filter (208) or a gain stage (206), and

wherein the processor (604) is configured to generate, as the bass post-filter control parameter (607), a pitch delay parameter, a low-pass filter characteristic information or a gain stage setting.

12. Encoder of any one of claims 9 to 11,

wherein the quantizer (708) is configured for quantizing the bass post-filter control parameter with respect to the information on the pitch gain or the information on the pitch delay.

13. Encoder of claim 12,

wherein the quantizer (708) is configured to quantize the bass post-filter control parameter using the following equation:

$$index = \min(2^k - 1, \max\left(0, \frac{2^k - 1}{\alpha_{max} - \alpha_{min}} \cdot \left(\frac{\tilde{\alpha}}{c g_{ltp}} - \alpha_{min}\right)\right)),$$

wherein *index* is the quantized bass post-filter control parameter (607), wherein min is a minimum function, wherein max is a maximum function, wherein k is the number of bits used to represent the index, wherein α_{min} is the minimum relative quantized gain, wherein α_{max} is the maximum relative quantized gain, wherein $\tilde{\alpha}$ is the non-quantized bass post-filter control parameter, wherein g_{ltp} is the information on the patch gain, and wherein c is a constant factor greater than 0 and lower than 1.

14. Encoder in accordance with one of the claims 9 to 13, wherein the processor (604) is configured for calculating (910) SNR values for a plurality of quantized or non-quantized bass post-filter control parameters and to select (920) the quantized or non-quantized bass post-filter control parameter resulting in an SNR value being among the five highest SNR values calculated, and

wherein the output interface (606) is configured for introducing the selected quantized or non-quantized bass post-filter control parameter into the encoded signal (608).

15. Method of processing an encoded signal (110), the encoded signal comprising an encoded audio signal having information on a pitch delay, a pitch gain, and a bass post-filter control parameter (101), comprising:

decoding (110) the encoded audio signal using the information on the pitch delay or the pitch gain to obtain a decoded audio signal (103);

filtering (112) the decoded audio signal (103) to obtain a processed signal (113) using a controllable bass post-filter (112) having a variable bass post-filter characteristic controllable by the bass post-filter control parameter (101); and

setting (114) the variable bass post-filter characteristic in accordance with the bass post-filter control parameter (101) included in the encoded signal (102),

wherein the controllable bass post-filter (112) comprises a filter apparatus (209) comprising a long-term prediction filter (204), a gain stage (206), a signal manipulator (208), and a subtractor (202) for subtracting an output of the filter apparatus (209) from the decoded audio signal (103),

wherein the bass post-filter control parameter (101) comprises a quantized gain value for the gain stage (206) or a filter characteristic information for the signal manipulator (208), and

wherein the setting (114) comprises setting the gain stage (206) in accordance with the quantized gain value, or setting the signal manipulator (208) in accordance with the information on the filter characteristic,

wherein the setting comprises decoding or retrieving the information on a pitch delay and wherein the long-term prediction filter (204) is set in accordance with the pitch delay,

wherein the setting comprises

retrieving (500) the quantized gain value from the encoded signal to obtain the bass post-filter control parameter (101),

scaling (504) the pitch gain by a constant factor lower than 1 and greater than 0 to obtain a scaled pitch gain; and

calculating (506) a setting of the gain stage using the scaled pitch gain and using the quantized gain value.

16. Method for generating an encoded signal (608), comprising:

generating (600) an encoded audio signal (601) having information on a pitch gain or a pitch delay from an original audio signal (603);

decoding (602) the encoded audio signal to obtain a decoded audio signal;

calculating (604) a bass post-filter control parameter (607) fulfilling an optimization criterion using the decoded audio signal (605) and the original audio signal (603); and

outputting (606) the encoded signal (608) having the encoded audio signal (601) comprising the information on the pitch gain or the pitch delay and the bass post-filter control parameter (607),

wherein the calculating (604) further comprises quantizing the bass post-filter control parameter to one of a predetermined number of quantization indices, and

wherein the bass post-filter control parameter is calculated so that the optimization criterion is fulfilled for a quantized bass post-filter control parameter.

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

Claims

1. Apparatus for processing an encoded signal, the encoded signal comprising an encoded audio signal having information on a pitch delay, a pitch gain, and a bass post-filter control parameter, comprising:

an audio signal decoder for decoding the encoded audio signal using the information on the pitch delay or the pitch gain to obtain a decoded audio signal;

a controllable bass post-filter for filtering the decoded audio signal to obtain a processed signal, wherein the controllable bass post-filter has a variable bass post-filter characteristic controllable by the bass post-filter control parameter; and

a controller for setting the variable bass post-filter characteristic in accordance with the bass post-filter control parameter included in the encoded signal,

wherein the controllable bass post-filter comprises a filter apparatus comprising a long-term prediction filter, a gain stage , a signal manipulator, and a subtractor for subtracting an output of the filter apparatus from the decoded audio signal,

wherein the bass post-filter control parameter comprises a quantized gain value for the gain stage,

wherein the controller is configured to set the gain stage in accordance with the quantized gain value,

wherein the controller comprises a block for decoding or retrieving the information on a pitch delay and wherein the controller is configured to set the long-term prediction filter in accordance with the pitch delay,

wherein the controller is configured

to retrieve the quantized gain value from the encoded signal to obtain the bass post-filter control parameter,

to scale the pitch gain by a constant factor lower than 1 and greater than 0 to obtain a scaled pitch gain; and

to calculate a setting of the gain stage using the scaled pitch gain and using the quantized gain value.

2. Apparatus of claim 1,

wherein the controllable bass post-filter is configured to operate in a time domain,

wherein the signal manipulator is implemented as a low-pass filter, an all-pass filter, a band-pass filter or a high-pass filter, and

wherein the bass post-filter control parameter comprises in addition to a gain value for the gain stage a filter characteristic information for the signal manipulator and,

wherein the controller is configured to set the signal manipulator in accordance with the information on the filter characteristic.

3. Apparatus of claim 1 or 2,

wherein the controllable bass post-filter is configured to operate in a spectral domain,

wherein a first time-to-spectrum converter for generating a spectral representation of the decoded audio signal is provided,

wherein the controllable bass post-filter a second time-to-spectrum converter to generate subband signals for different subbands and a signal manipulator for each subband, wherein the signal manipulator for a subband is configured for performing a weighting operation using a weighting factor,

and wherein individual weighting factors for signal manipulators for individual subbands together implement a low-pass filter characteristic, an all-pass filter characteristic, a band-pass filter characteristic or a high-pass filter characteristic, wherein the subtractor is configured for subtracting an output of the filter apparatus for a subband from a corresponding subband generated by the first time-to-spectrum converter to generate a subtracted subband signal; and

a spectrum-to-time converter for converting subtracted subband signals into a time domain to obtain the processed signal;

wherein the bass post-filter control parameter comprises a gain value for the gain stage and a filter characteristic information for the signal manipulator.

4. Apparatus of one of the preceding claims,

wherein the bass post-filter control parameter is quantized relative to the information on the pitch delay or the pitch gain included in the encoded audio signal, and

wherein the controller is configured to set the variable bass post-filter characteristic in accordance with the information on the pitch delay or the information on the pitch gain and the bass post-filter control parameter.

5. Apparatus of claim 4,

wherein the controller is configured to set the variable bass post-filter characteristic based on a product of the information on the pitch delay or the pitch gain and the bass post-filter characteristic.

6. Apparatus of claim 5,

wherein the controller is configured for calculating a gain for the variable gain stage using a product between the bass post-filter control parameter and the pitch gain and a constant factor lower than 1 and greater than 0.

7. Apparatus of one of the preceding claims,

wherein the controllable bass post-filter comprises a long-term prediction filter and a variable gain stage, wherein the long-term prediction filter is controlled by the information on the pitch gain included in the encoded audio signal, and

wherein the controller is configured to set a gain of the variable gain stage using the bass post-filter control parameter alone or in combination with the information on the pitch gain.

8. Apparatus of claim 7,

wherein a low-pass filter or a combination of a time-to-spectrum converter and a subband weighter is connected to an output of the variable gain stage or an output of the long-term prediction filter.

9. Encoder for generating an encoded signal, comprising:

an audio signal encoder for generating an encoded audio signal having information on a pitch gain or a pitch delay from an original audio signal;

a decoder for decoding the encoded audio signal to obtain a decoded audio signal;

a processor for calculating a bass post-filter control parameter fulfilling an optimization criterion using the decoded audio signal and the original audio signal; and

an output interface for outputting the encoded signal having the encoded audio signal comprising the information on the pitch gain or the pitch delay and the bass post-filter control parameter,

wherein the processor further comprises a quantizer for quantizing the bass post-filter control parameter to one of a predetermined number of quantization indices, and

wherein the processor is configured to calculate the bass post-filter control parameter so that the optimization criterion is fulfilled for a quantized bass post-filter control parameter.

10. Encoder of claim 9,

wherein the processor is configured to calculate the bass post-filter control parameter so that a signal-to-noise ratio between the original audio signal and a decoded and bass post-filtered audio signal is minimized.

11. Encoder of claim 9 or 10,

wherein the processor comprises a long-term prediction filter, a low-pass filter or a gain stage, and

wherein the processor is configured to generate, as the bass post-filter control parameter, a pitch delay parameter, a low-pass filter characteristic information or a gain stage setting.

12. Encoder of any one of claims 9 to 11,

wherein the quantizer is configured for quantizing the bass post-filter control parameter with respect to the information on the pitch gain or the information on the pitch delay.

13. Encoder of claim 12,

wherein the quantizer is configured to quantize the bass post-filter control parameter using the following equation:

$$index = \min(2^k - 1, \max\left(0, \frac{2^k - 1}{\alpha_{max} - \alpha_{min}} \cdot \left(\frac{\tilde{\alpha}}{c g_{ltp}} - \alpha_{min}\right)\right)),$$

wherein *index* is the quantized bass post-filter control parameter, wherein min is a minimum function, wherein max is a maximum function, wherein k is the number of bits used to represent the index, wherein α_{min} is the minimum relative quantized gain, wherein α_{max} is the maximum relative quantized gain, wherein $\tilde{\alpha}$ is the non-quantized bass post-filter control parameter, wherein g_{ltp} is the information on the patch gain, and wherein c is a constant factor greater than 0 and lower than 1.

14. Encoder in accordance with one of the claims 9 to 13, wherein the processor is configured for calculating SNR values for a plurality of quantized or non-quantized bass post-filter control parameters and to select the quantized or non-quantized bass post-filter control parameter resulting in an SNR value being among the five highest SNR values calculated, and

wherein the output interface is configured for introducing the selected quantized or non-quantized bass post-filter control parameter into the encoded signal.

15. Method of processing an encoded signal, the encoded signal comprising an encoded audio signal having information on a pitch delay, a pitch gain, and a bass post-filter control parameter, comprising:

decoding the encoded audio signal using the information on the pitch delay or the pitch gain to obtain a decoded audio signal;

filtering the decoded audio signal to obtain a processed signal using a controllable bass post-filter having a variable bass post-filter characteristic controllable by the bass post-filter control parameter; and

setting the variable bass post-filter characteristic in accordance with the bass post-filter control parameter included in the encoded signal,

wherein the controllable bass post-filter comprises a filter apparatus comprising a long-term prediction filter, a gain stage, a signal manipulator, and a subtractor for subtracting an output of the filter apparatus from the decoded audio signal,

wherein the bass post-filter control parameter comprises a quantized gain value for the gain stage or a filter characteristic information for the signal manipulator, and

wherein the setting comprises setting the gain stage in accordance with the quantized gain value, or setting the signal manipulator in accordance with the information on the filter characteristic,

wherein the setting comprises decoding or retrieving the information on a pitch delay and wherein the long-term prediction filter is set in accordance with the pitch delay,

wherein the setting comprises

retrieving the quantized gain value from the encoded signal to obtain the bass post-filter control parameter,

scaling the pitch gain by a constant factor lower than 1 and greater than 0 to obtain a scaled pitch gain; and

calculating a setting of the gain stage using the scaled pitch gain and using the quantized gain value.

16. Method for generating an encoded signal, comprising:

generating an encoded audio signal having information on a pitch gain or a pitch delay from an original audio signal;

decoding the encoded audio signal to obtain a decoded audio signal;

calculating a bass post-filter control parameter fulfilling an optimization criterion using the decoded audio signal and the original audio signal; and

outputting the encoded signal having the encoded audio signal comprising the information on the pitch gain or the pitch delay and the bass post-filter control parameter,

wherein the calculating further comprises quantizing the bass post-filter control parameter to one of a predetermined number of quantization indices, and

wherein the bass post-filter control parameter is calculated so that the optimization criterion is fulfilled for a quantized bass post-filter control parameter.

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