

CLAIMS

1. A method for performing high frequency reconstruction of an audio signal, the method comprising:
 - 5 receiving an encoded audio bitstream, the encoded audio bitstream including audio data representing a lowband portion of the audio signal and high frequency reconstruction metadata;
 - decoding the audio data to generate a decoded lowband audio signal;
 - extracting from the encoded audio bitstream the high frequency reconstruction
 - 10 metadata, the high frequency reconstruction metadata including operating parameters for a high frequency reconstruction process, the operating parameters including a patching mode parameter located in a backward-compatible extension container of the encoded audio bitstream, wherein a first value of the patching mode parameter indicates spectral translation and a second value of the patching mode parameter
 - 15 indicates harmonic transposition by phase-vocoder frequency spreading;
 - filtering the decoded lowband audio signal to generate a filtered lowband audio signal;
 - regenerating a highband portion of the audio signal using the filtered lowband audio signal and the high frequency reconstruction metadata, wherein the
 - 20 regenerating includes spectral translation if the patching mode parameter is the first value and the regenerating includes harmonic transposition by phase-vocoder frequency spreading if the patching mode parameter is the second value; and
 - combining the filtered lowband audio signal with the regenerated highband portion to form a wideband audio signal,
 - 25 wherein the filtering, regenerating, and combining are performed as a post-processing operation with a delay of 3010 samples per audio channel.
2. The method of claim 1 wherein the encoded audio bitstream further includes a fill element with an identifier indicating a start of the fill element and fill data after the
- 30 identifier, wherein the fill data includes the backward-compatible extension container.
3. The method of claim 2 wherein the identifier is a three bit unsigned integer transmitted most significant bit first and having a value of 0x6.

4. The method of claim 2 or claim 3, wherein the fill data includes an extension payload, the extension payload includes spectral band replication extension data, and the extension payload is identified with a four bit unsigned integer transmitted most significant bit first and having a value of '1101' or '1110', and, optionally,
- 5 wherein the spectral band replication extension data includes:
an optional spectral band replication header,
spectral band replication data after the header, and
a spectral band replication extension element after the spectral band replication data, and wherein the flag is included in the spectral band replication extension element.
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5. The method of any one of claims 1-4 wherein the high frequency reconstruction metadata includes envelope scale factors, noise floor scale factors,
- 15 time/frequency grid information, or a parameter indicating a crossover frequency.
6. The method of any one of claims 1-5 wherein the backward-compatible extension container further includes a flag indicating whether additional preprocessing is used to avoid discontinuities in a shape of a spectral envelope of the highband portion when the patching mode parameter equals the first value, wherein a first value of the flag enables the additional preprocessing and a second value of the flag disables the additional preprocessing.
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7. The method of claim 6 wherein the additional preprocessing includes calculating a pre-gain curve using a linear prediction filter coefficient.
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8. The method of any one of claims 1-5 wherein the backward-compatible extension container further includes a flag indicating whether signal adaptive frequency domain oversampling is to be applied when the patching mode parameter equals the second value, wherein a first value of the flag enables the signal adaptive frequency domain oversampling and a second value of the flag disables the signal adaptive frequency domain oversampling.
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9. The method of claim 8 wherein the signal adaptive frequency domain oversampling is applied only for frames containing a transient.

10. The method of any one of the previous claims wherein the harmonic transposition by phase-vocoder frequency spreading is performed with an estimated complexity at or below 4.5 million of operations per second and 3 kWords of memory.

11. The method of any one of the previous claims wherein filtering the decoded lowband audio signal to generate a filtered lowband audio signal comprises filtering the decoded lowband audio signal into a plurality of subbands using a complex QMF analysis filter bank; and combining the filtered lowband audio signal with the regenerated highband portion to form a wideband audio signal comprises using a complex QMF synthesis filter bank.

12. The method of claim 11, wherein analysis filters $h_k(n)$ of the complex QMF analysis filter bank and synthesis filters $f_k(n)$ of the complex QMF synthesis filter bank are defined by:

$$h_k(n) = f_k(n) = p_0(n) \exp \left\{ i \frac{\pi}{M} \left(k + \frac{1}{2} \right) \left(n - \frac{N}{2} \right) \right\}, 0 \leq n \leq N; 0 \leq k < M$$

where $p_0(n)$ is a real-valued prototype filter, M denotes a number of channels and N is a prototype filter order.

13. A computer program product having instructions which, when executed by a computing device or system, cause said computing device or system to execute the method of any of the claims 1-12.

14. An audio processing unit for performing high frequency reconstruction of an audio signal, the audio processing unit comprising:

an input interface for receiving an encoded audio bitstream, the encoded audio bitstream including audio data representing a lowband portion of the audio signal and high frequency reconstruction metadata;

a core audio decoder for decoding the audio data to generate a decoded lowband audio signal;

- a deformatter for extracting from the encoded audio bitstream the high frequency reconstruction metadata, the high frequency reconstruction metadata including operating parameters for a high frequency reconstruction process, the operating parameters including a patching mode parameter located in a backward-compatible extension container of the encoded audio bitstream, wherein a first value of the patching mode parameter indicates spectral translation and a second value of the patching mode parameter indicates harmonic transposition by phase-vocoder frequency spreading;
- an analysis filterbank for filtering the decoded lowband audio signal to generate a filtered lowband audio signal;
- a high frequency regenerator for reconstructing a highband portion of the audio signal using the filtered lowband audio signal and the high frequency reconstruction metadata, wherein the reconstructing includes a spectral translation if the patching mode parameter is the first value and the reconstructing includes harmonic transposition by phase-vocoder frequency spreading if the patching mode parameter is the second value; and
- a synthesis filterbank for combining the filtered lowband audio signal with the regenerated highband portion to form a wideband audio signal,
- wherein the analysis filterbank, high frequency regenerator, and synthesis filterbank are performed in a post-processor with a delay of 3010 samples per audio channel.
15. The audio processing unit of claim 14 wherein the harmonic transposition by phase-vocoder frequency spreading is performed with an estimated complexity at or below 4.5 million of operations per second and 3 kWords of memory.