Claims

1. Apparatus for encoding a multi-channel signal comprising at least two channels, comprising:

a time-spectral converter for converting sequences of blocks of sampling values of the at least two channels into a frequency domain representation having sequences of blocks of spectral values for the at least two channels;

a multi-channel processor for applying a joint multi-channel processing to the sequences of blocks of spectral values to obtain at least one result sequence of blocks of spectral values comprising information related to the at least two channels;

a spectral-time converter for converting the result sequence of blocks of spectral values into a time domain representation comprising an output sequence of blocks of sampling values; and

a core encoder for encoding the output sequence of blocks of sampling values to obtain an encoded multi-channel signal,

wherein the core encoder is configured to operate in accordance with a first frame control to provide a sequence of frames, wherein a frame is bounded by a start frame border and an end frame border, and

wherein the time-spectral converter or the spectral-time converter are configured to operate in accordance with a second frame control being synchronized to the first frame control, wherein the start frame border or the end frame border of each frame of the sequence of frames is in a predetermined relation to a start instant or an end instant of an overlapping portion of a window used by the time-spectral converter for each block of the sequence of blocks of sampling values or used by the spectral-time converter for each block of the output sequence of blocks of sampling values.

2. Apparatus of claim 1, wherein an analysis window used by the time-spectral converter or a synthesis window used by the spectral-time converter each has an

increasing overlapping portion and a decreasing overlapping portion, wherein the core encoder comprises a time-domain encoder with a look-ahead or a frequency domain encoder with an overlapping portion of a core window, and

wherein the overlapping portion of the analysis window or the synthesis window is smaller than or equal to the look-ahead portion of the core encoder or the overlapping portion of the core window.

3. Apparatus of one of the preceding claims,

wherein the core encoder is configured to use a look-ahead portion when core encoding a frame derived from the output sequence of blocks of sampling values having associated the output sampling rate, the look-ahead portion being located in time subsequent to the frame,

wherein the time-spectral converter is configured to use an analysis window having an overlapping portion with a length in time being lower than or equal to a length in time of the look-ahead portion, wherein the overlapping portion of the analysis window is used for generating a windowed look-ahead portion.

4. Apparatus of claim 3,

wherein the spectral-time converter is configured to process an output look-ahead portion corresponding to the windowed look-ahead portion using a redress function, wherein the redress function is configured so that an influence of the overlapping portion of the analysis window is reduced or eliminated.

5. Apparatus of claim 4,

wherein the redress function is inverse to a function defining the overlapping portion of the analysis window.

6. Apparatus of claim 4 or 5,

wherein the overlapping portion is proportional to a square root of a sine function,

wherein the redress function is proportional to the inverse square root of the sine function, and

wherein the spectral-time converter is configured to use an overlapping portion being proportional to a a sin function at the power of 1.5.

7. Apparatus of one of the preceding claims,

wherein the spectral-time converter is configured to generate a first output block using a synthesis window and a second output block using the synthesis window, wherein a second portion of the second output block is an output look-ahead portion,

wherein the spectral-time converter is configured to generate sampling values of a frame using an overlap-add operation between the first output block and the portion of the second output block excluding the output look-ahead portion,

wherein the core encoder is configured to apply a look-ahead operation to the output look-ahead portion in order to determine coding information for core encoding the frame, and

wherein the core encoder is configured to core encode the frame using a result of the look-ahead operation.

8. Apparatus of claim 7,

wherein the spectral-time converter is configured to generate a third output block subsequent to the second output block using the synthesis window, wherein the spectral-time converter is configured to overlap a first overlap portion of the third output block with the second portion of the second output block windowed using the synthesis window to obtain samples of a further frame following the frame in time.

9. Apparatus of claim 7 or 8,

wherein the spectral-time converter is configured, when generating the second output block for the frame, to not window the output look-ahead portion or to redress the output look-ahead portion for at least partly undoing an influence of an analysis window used by the time-spectral converter, and

wherein the spectral-time converter is configured to perform an overlap-add operation between the second output block and the third output block for the further frame and to window the output look-ahead portion with the synthesis window.

10. Apparatus of any one of the preceding claims,

wherein the spectral-time converter is configured,

to use a synthesis window to generate a first block of output samples and a second block of output samples,

to overlap-add a second portion of the first block and a first portion of the second block to generate a portion of output samples,

wherein the core encoder is configured to apply a look-ahead operation to the portion of the output samples for core encoding the output samples located in time before the portion of the output samples, wherein the look-ahead portion does not include a second portion of samples of the second block.

11. Apparatus of any one of the preceding claims,

wherein the spectral-time converter is configured to use a synthesis window providing a time resolution being higher than two times a length of a core encoder frame,

wherein the spectral-time converter is configured to use the synthesis window for generating blocks of output samples and to perform an overlap-add operation, wherein all samples in a look-ahead portion of the core encoder are calculated using the overlap-add operation, or

wherein the spectral-time converter is configured to apply a look-ahead operation to the output samples for core encoding output samples located in time before the portion, wherein the look-ahead portion does not include a second portion of samples of the second block.

12. Apparatus of one of the preceding claims,

wherein a block of sampling values has an associated input sampling rate, and a block of spectral values of the sequences of blocks of spectral values has spectral values up to a maximum input frequency being related to the input sampling rate;

wherein the apparatus further comprises a spectral domain resampler for performing a resampling operation in the frequency domain on data input into the spectral-time converter or on data input into the multi-channel processor, wherein a block of a resampled sequence of blocks of spectral values has spectral values up to a maximum output frequency being different from the maximum input frequency;

wherein the output sequence of blocks of sampling values has an associated output sampling rate being different from the input sampling rate.

13. Apparatus of claim 12,

wherein the spectral domain resampler is configured for truncating the blocks for the purpose of downsampling or for zero padding the blocks for the purpose of upsampling.

14. Apparatus of claim 12 or 13,

wherein the spectral domain resampler is configured for scaling the spectral values of the blocks of the result sequence of blocks using a scaling factor depending on the maximum input frequency and depending on the maximum output frequency.

15. Apparatus of claim 14,

wherein the scaling factor is greater than one in the case of upsampling, wherein the output sampling rate is greater than the input sampling rate, or wherein the scaling factor is lower than one in the case of downsampling, wherein the output sampling rate is lower than the input sampling rate, or

wherein the time-spectral converter is configured to perform a time-frequency transform algorithm not using a normalization regarding a total number of spectral values of a block of spectral values, and wherein the scaling factor is equal to a quotient between the number of spectral values of a block of the resampled sequence and the number of spectral values of a block of spectral values before the resampling, and wherein the spectral-time converter is configured to apply a normalization based on the maximum output frequency.

16. Apparatus of one of the preceding claims,

wherein the time-spectral converter is configured to perform a discrete Fourier transform algorithm, or wherein the spectral-time converter is configured to perform an inverse discrete Fourier transform algorithm.

17. Apparatus of one of the preceding claims,

wherein the multi-channel processor is configured to obtain a further result sequence of blocks of spectral values, and

wherein the spectral-time converter is configured for converting the further result sequence of spectral values into a further time domain representation comprising a further output sequence of blocks of sampling values having associated an output sampling rate being equal to the input sampling rate.

18. Apparatus of one of the claims 12 to 17,

wherein the multi-channel processor is configured to provide and even further result sequence of blocks of spectral values,

wherein the spectral-domain resampler is configured for resampling the blocks of the even further result sequence in the frequency domain to obtain a further

resampled sequence of blocks of spectral values, wherein a block of the further resampled sequence has spectral values up to a further maximum output frequency being different from the maximum input frequency or being different from the maximum output frequency,

wherein the spectral-time converter is configured for converting the further resampled sequence of blocks of spectral values into an even further time domain representation comprising an even further output sequence of blocks of sampling values having associated a further output sampling rate being different from the input sampling rate or the output sampling rate.

19. Apparatus of one of the preceding claims,

wherein the multi-channel processor is configured to generate a mid-signal as the at least one result sequence of blocks of spectral values only using a downmix operation, or an additional side signal as a further result sequence of blocks of spectral values.

20. Apparatus of one of the claims 12 to 19,

wherein the multi-channel processor is configured to generate a mid-signal as the at least one result sequence, wherein the spectral domain resampler is configured to resample the mid-signal to two separate sequences having two different maximum output frequencies being different from the maximum input frequency,

wherein the spectral-time converter is configured to convert the two resampled sequences to two output sequences having different sampling rates, and

wherein the core encoder comprises a first preprocessor for preprocessing the first output sequence at a first sampling rate and a second preprocessor for preprocessing the second output sequence at the second sampling rate, and

wherein the core encoder is configured to core encode the first or the second preprocessed signal, or

wherein the multi-channel processor is configured to generate a side signal as the at least one result sequence, wherein the spectral domain resampler is configured to resample the side signal to two resampled sequences having two different maximum output frequencies being different from the maximum input frequency,

wherein the spectral-time converter is configured to convert the two resampled sequences to two output sequences having different sampling rates, and

wherein the core encoder comprises a first preprocessor and a second preprocessor for preprocessing the first and the second output sequences; and

wherein the core encoder is configured to core encode the first or the second preprocessed sequence.

21. Apparatus of one of the preceding claims,

wherein the spectral-time converter is configured to convert the at least one result sequence into a time domain representation without any spectral domain resampling, and

wherein the core encoder is configured to core encode the non-resampled output sequence to obtain the encoded multi-channel signal, or

wherein the spectral-time converter is configured to convert the at least one result sequence into a time domain representation without any spectral domain resampling without the side signal, and

wherein the core encoder is configured to core encode the non-resampled output sequence for the side signal to obtain the encoded multi-channel signal, or

wherein the apparatus further comprises a specific spectral domain side signal encoder, or

wherein the input sampling rate is at least one sampling rate of a group of sampling rates comprising 8 kHz, 16 kHz, 32 kHz, or

wherein the output sampling rate is at least one sampling rate of a group of sampling rates comprising 8 kHz, 12.8 kHz, 16 kHz, 25.6 kHz and 32 kHz.

22. Apparatus of one of the preceding claims,

wherein the spectral-time converter is configured to apply an analysis window,

wherein the spectral-time converter is configured to apply a synthesis window,

wherein the length in time of the analysis window is equal or an integer multiple or integer fraction of the length in time of the synthesis window, or

wherein the analysis window and the synthesis window each has a zero padding portion at an initial portion or an end portion thereof, or

wherein the analysis window and the synthesis window are so that the window size, an overlap region size and a zero padding size each comprise an integer number of samples for at least two sampling rates of the group of sampling rates comprising 12.8 kHz, 16 kHz, 26.6 kHz, 32 kHz, 48 kHz, or

wherein a maximum radix of a digital Fourier transform in a split radix implementation is lower than or equal to 7, or wherein a time resolution is fixed to a value lower than or equal to a frame rate of the core encoder.

23. Apparatus of one of the preceding claims,

wherein the multi-channel processor is configured to process the sequence of blocks to obtain a time alignment using a broadband time alignment parameter and to obtain a narrow band phase alignment using a plurality of narrow band phase alignment parameters, and to calculate a mid-signal and a side signal as the result sequences using aligned sequences.

24. Method of encoding a multi-channel signal comprising at least two channels, comprising:

converting sequences of blocks of sampling values of the at least two channels into a frequency domain representation having sequences of blocks of spectral values for the at least two channels;

applying a joint multi-channel processing to the sequences of blocks of spectral values to obtain at least one result sequence of blocks of spectral values comprising information related to the at least two channels;

converting the result sequence of blocks of spectral values into a time domain representation comprising an output sequence of blocks of sampling values; and

core encoding the output sequence of blocks of sampling values to obtain an encoded multi-channel signal,

wherein the core encoding operates in accordance with a first frame control to provide a sequence of frames, wherein a frame is bounded by a start frame border and an end frame border, and

wherein the time-spectral converting or the spectral-time converting operates in accordance with a second frame control being synchronized to the first frame control, wherein the start frame border or the end frame border of each frame of the sequence of frames is in a predetermined relation to a start instant or an end instant of an overlapping portion of a window used by the time-spectral converting for each block of the sequence of blocks of sampling values or used by the spectral-time converting for each block of the output sequence of blocks of sampling values.

25. Apparatus for decoding an encoded multi-channel signal, comprising:

a core decoder for generating a core decoded signal;

a time-spectral converter for converting a sequence of blocks of sampling values of the core decoded signal into a frequency domain representation having a sequence of blocks of spectral values for the core decoded signal;

a multi-channel processor for applying an inverse multi-channel processing to a sequence comprising the sequence of blocks to obtain at least two result sequences of blocks of spectral values; and

a spectral-time converter for converting the at least two result sequences of blocks of spectral values into a time domain representation comprising at least two output sequences of blocks of sampling values,

wherein the core decoder is configured to operate in accordance with a first frame control to provide a sequence of frames, wherein a frame is bounded by a start frame border and an end frame border,

wherein the time-spectral converter or the spectral-time converter is configured to operate in accordance with a second frame control being synchronized to the first frame control,

wherein the time-spectral converter or the spectral-time converter are configured to operate in accordance with a second frame control being synchronized to the first frame control, wherein the start frame border or the end frame border of each frame of the sequence of frames is in a predetermined relation to a start instant or an end instant of an overlapping portion of a window used by the time-spectral converter for each block of the sequence of blocks of sampling values or used by the spectral-time converter for each block of the at least two output sequences of blocks of sampling values.

26. Apparatus of claim 25,

wherein the core decoded signal has the sequence of frames, a frame having the start frame border and the end frame border,

wherein an analysis window used by the time-spectrum converter for windowing the frame of the sequence of frames has an overlapping portion ending before the end frame border leaving a time gap between an end of the overlapping portion and the end frame border, and

wherein the core decoder is configured to perform a processing to samples in the time gap in parallel to the windowing of the frame using the analysis window, or wherein a core decoder post-processing is performed to the samples in the time gap in parallel to the windowing of the frame using the analysis window.

27. Apparatus of one of claims 25 to 26,

wherein the core decoded signal has the sequence of frames, a frame having the start frame border and the end frame border,

wherein a start of a first overlapping portion of an analysis window coincides with the start frame border, and wherein an end of a second overlapping portion of the analysis window is located before the stop frame border, so that a time gap exists between the end of the second overlapping portion and the stop frame border, and

wherein the analysis window for a following block of the core decoded signal is located so that a middle non-overlapping portion of the analysis window is located within the time gap.

28. Apparatus of one of claims 25 to 27,

wherein the analysis window used by the time-spectral converter has the same shape and length in time as the synthesis window used by the spectrum-time converter.

29. Apparatus of one of claims 25 to 28,

wherein the core decoded signal has the sequence of frames, wherein a frame having a length, wherein the length of window excluding any zero padding portions applied by the time-spectral converter is smaller than or equal to half a length of the frame.

30. Apparatus of one of claims 25 to 29,

wherein the spectral-time converter is configured

to apply a synthesis window for obtaining a first output block of windowed samples for a first output sequence of the at least two output sequences;

to apply the synthesis window for obtaining a second output block of windowed samples for the first output sequence of the at least two output sequences;

to overlap-add the first output block and the second output block to obtain a first group of output samples for the first output sequence;

wherein the spectral-time converter is configured

to apply a synthesis window for obtaining a first output block of windowed samples for a second output sequence of the at least two output sequences;

to apply the synthesis window for obtaining a second output block of windowed samples for the second output sequence of the at least two output sequences;

to overlap-add the first output block and the second output block to obtain a second group of output samples for the second output sequence;

wherein the first group of output samples for the first sequence and the second group of output samples for the second sequence are related to the same time portion of the decoded multi-channel signal or are related to the same frame of the core decoded signal.

31. Apparatus of one of the claims 25 to 30,

a core decoder for generating a core decoded signal;

wherein a block of sampling values has an associated input sampling rate, and wherein a block of spectral values has spectral values up to a maximum input frequency being related to the input sampling rate;

wherein the apparatus further comprises a spectral domain resampler for performing a resampling operation in the frequency domain on data input into the spectral-time converter or on data input into the multi-channel processor, wherein

a block of a resampled sequence has spectral values up to a maximum output frequency being different from the maximum input frequency;

wherein the at least two output sequences of blocks of sampling values have associated an output sampling rate being different from the input sampling rate.

32. Apparatus of claim 31,

wherein the spectral domain resampler is configured for truncating the blocks for the purpose of downsampling or for zero padding the blocks for the purpose of upsampling.

33. Apparatus of claim 31 or 32,

wherein the spectral domain resampler is configured for scaling the spectral values of the blocks of the result sequence of blocks using a scaling factor depending on the maximum input frequency and depending on the maximum output frequency.

34. Apparatus of one of claims 31 to 33,

wherein the scaling factor is greater than one in the case of upsampling, wherein the output sampling rate is greater than the input sampling rate, or wherein the scaling factor is lower than one in the case of downsampling, wherein the output sampling rate is lower than the input sampling rate, or

wherein the time-spectral converter is configured to perform a time-frequency transform algorithm not using a normalization regarding a total number of spectral values of a block of spectral values, and wherein the scaling factor is equal to a quotient between the number of spectral values of a block of the resampled sequence and the number of spectral values of a block of spectral values before the resampling, and wherein the spectral-time converter is configured to apply a normalization based on the maximum output frequency.

35. Apparatus of one of claims 25 to 34,

wherein the time-spectral converter is configured to perform a discrete Fourier transform algorithm, or wherein the spectral-time converter is configured to perform an inverse discrete Fourier transform algorithm.

36. Apparatus of one of claims 25 to 35,

wherein the core decoder is configured to generate a further core decoded signal having a further sampling rate being different from the input sampling rate,

wherein the time-spectral converter is configured to convert the further core decoded signal into a frequency domain representation having a further sequence of blocks of values for the further core decoded signal, wherein a block of sampling values of the further core decoded signal has spectral values up to a further maximum input frequency being different from the maximum input frequency and related to the further sampling rate,

wherein the spectral domain resampler is configured to resample the further sequence of blocks for the further core decoded signal in the frequency domain to obtain a further resampled sequence of blocks of spectral values, wherein a block of spectral values of the further resampled sequence has spectral values up to the maximum output frequency being different from the further maximum input frequency; and

a combiner for combining the resampled sequence and the further resampled sequence to obtain the sequence to be processed by the multi-channel processor.

37. Apparatus of one of claims 25 to 36,

wherein the core decoder is configured to generate an even further core decoded signal having a further sampling rate being equal to the output sampling rate,

wherein the time-spectral converter is configured to convert the even further sequence into a frequency domain representation,

wherein the apparatus further comprises a combiner for combining the even further sequence of blocks of spectral values and the resampled sequence of blocks in a

process of generating the sequence of blocks processed by the multi-channel processor.

38. Apparatus of one of claims 25 to 37,

wherein the core decoder comprises at least one of an MDCT based decoding portion, a time domain bandwidth extension decoding portion, an ACELP decoding portion and a bass post-filter decoding portion.

wherein the MDCT-based decoding portion or the time domain bandwidth extension decoding portion is configured to generate the core decoded signal having the output sampling rate, or

wherein the ACELP decoding portion or the bass post-filter decoding portion is configured to generate a core decoded signal at a sampling rate being different from the output sampling rate.

39. Apparatus of one of claims 25 to 38,

wherein the time-spectral converter is configured to apply an analysis window to at least two of a plurality of different core decoded signals, the analysis windows having the same size in time or having the same shape with respect to time,

wherein the apparatus further comprises a combiner for combining at least one resampled sequence and any other sequence having blocks with spectral values up to the maximum output frequency on a block-by-block basis to obtain the sequence processed by the multi-channel processor.

40. Apparatus of one of claims 25 to 39,

wherein the sequence processed by the multi-channel processor corresponds to a mid-signal, and

wherein the multi-channel processor is configured to additionally generate a side signal using information on a side signal included in the encoded multi-channel signal, and

wherein the multi-channel processor is configured to generate the at least two result sequences using the mid-signal and the side signal.

41. Apparatus of one of claims 25 to 40,

wherein the multi-channel processor is configured to convert the sequence into a first sequence for a first output channel and a second sequence for a second output channel using a gain factor per parameter band;

to update a first sequence and the second sequence using a decoded side signal or to update the first sequence and the second sequence using a side signal predicted from an earlier block of the sequence of blocks for the mid-signal using a stereo filling parameter for a parameter band;

to perform a phase de-alignment and an energy scaling using information on the plurality of narrowband phase alignment parameters; and

to perform a time-de-alignment using information on a broadband time-alignment parameter to obtain the at least two result sequences.

42. Method of decoding an encoded multi-channel signal, comprising:

generating a core decoded signal;

converting a sequence of blocks of sampling values of the core decoded signal into a frequency domain representation having a sequence of blocks of spectral values for the core decoded signal;

applying an inverse multi-channel processing to a sequence comprising the sequence of blocks to obtain at least two result sequences of blocks of spectral values; and

converting the at least two result sequences of blocks of spectral values into a time domain representation comprising at least two output sequences of blocks of sampling values,

wherein the generating the core decoded signal operates in accordance with a first frame control to provide a sequence of frames, wherein a frame is bounded by a start frame border and an end frame border,

wherein the time spectral converting or the spectral time converting operates in accordance with a second frame control being synchronized to the first frame control,

wherein the time-spectral converting or the spectral-time converting operate in accordance with a second frame control being synchronized to the first frame control, wherein the start frame border or the end frame border of each frame of the sequence of frames is in a predetermined relation to a start instant or an end instant of an overlapping portion of a window used by the time spectral converting for each block of the sequence of blocks of sampling values or used by the spectral time converting for each block of the at least two output sequences of blocks of sampling values.

43. Computer program for performing, when running on a computer or processor, the method of claim 24 or the method of claim 42.