CLAIMS

1. A method of downmixing a plurality of input audio signals containing input data into at least one output audio signal,

wherein maximal downmix coefficients are predefined, at least one in-range condition on said at least one output signal is predefined and the input signals are partitioned into predefined subgroups,

the in-range condition on said at least one output signal being an upper bound on the at least one output signal or a lower bound on the at least one output signal or a requirement for the at least one output signal to remain in an interval having a lower and an upper bound,

the method comprising:

determining downmix coefficients as products of said maximal downmix coefficients and a limiting factor which is common within each subgroup in order to satisfy, in view of the input data, an in-range condition on said at least one output signal; and

applying the downmix coefficients to downmix the plurality of input audio signals into at least two output audio signals corresponding to spatially related channels,

wherein the downmix coefficients are determined as products of said maximal downmix coefficients and the limiting factor, the limiting factor being common within each subgroup and all output signals, in order to jointly satisfy the in-range condition on each of said at least two spatially related output signals,

wherein said determining downmix coefficients includes the substeps of:

determining, for each of the output signals to which the input signals in a subgroup contribute, a downmix coefficient as a product of the maximal downmix coefficient and a preliminary limiting factor; and

determining the limiting factor common within the subgroup by selecting the minimum of the preliminary limiting factors.

2. The method of claim 1, wherein at least one of said subgroups of input signals comprises two or more input signals.

3. The method of claim 1, wherein input signals in a subgroup correspond to spatially related audio channels.

4. The method of claim 3, wherein a subgroup comprises a left and a right channel.

5. The method of claim 4, wherein a subgroup comprises a left, a right and a centre channel.

6. The method of claim 1, wherein the downmix coefficients are determined in such manner that the in-range condition will be satisfied by at most 20 per cent margin, preferably at most 10 per cent margin, most preferably at most 5 per cent margin.

7. The method of claim 1, wherein the output signal is partitioned into time segments, and wherein a segment-wise set of downmix coefficients is determined for each of a plurality of time segments as products of said maximal downmix coefficients and a limiting factor which is common within each subgroup in order to satisfy, independently in view of the input data in this time segment, an upper output-signal bound.

8. The method of claim 7, wherein a segment-wise set of downmix coefficients is determined for each of a plurality of time segments as products of said maximal downmix coefficients and a limiting factor which is common within each subgroup in order to jointly satisfy an in-range condition on each of said at least two spatially related output signals, independently in view of the input data in this time segment.

9. The method of claim 8, further comprising:

defining a sequence of segment-wise values of a downmix coefficient from said segment-wise sets of downmix coefficients;

smoothing the sequence of segment-wise values of the downmix coefficient; and

applying the smoothed segment-wise values to downmix the input signals.

10. The method of claim 9, wherein the sequence of segment-wise values is smoothed by applying an upper rate-of-change bound.

11. The method of claim 10, wherein the sequence of segment-wise values is smoothed by maintaining or decreasing the segment-wise values in order to satisfy the upper rate-of-change bound.

12. The method of claim 1, wherein at least one subgroup is associated with a lower bound on the limiting factor for that subgroup.

13. The method of claim 12, wherein a primary and secondary subgroup are defined, and a lower bound on the limiting factor associated with the primary subgroup is greater than a lower bound on the limiting factor associated with the secondary subgroup.

14. The method of claim 1, wherein a primary and a secondary subgroup are predefined and the primary subgroup is associated with an upper bound on the limiting factor, and

wherein said determining downmix coefficients includes favouring the upper bound on the limiting factor for the primary subgroup as a value of the limiting factor for the primary subgroup.

15. The method of claim 14, wherein a primary and a secondary subgroup are predefined and each is associated with a respective lower bound and a respective upper bound on the limiting factors ($L_1 \le \alpha_1 \le U_1, L_2 \le \alpha_2 \le U_2$), and

wherein said determining downmix coefficients includes the substeps of:

initially attempting to satisfy the in-range condition on said at least one output signal in the subspace of limiting factors such that the primary-subgroup limiting factor is equal to its upper bound ($\alpha_1 = U_1, L_2 \le \alpha_2 \le U_2$);

further, if the initial attempt fails, attempting to satisfy the in-range condition on said at least one output signal in the subspace of limiting factors such that the secondary-subgroup limiting factor is equal to its lower bound ($L_1 \le \alpha_1 \le U_1, \alpha_2 = L_2$).

16. The method of any one of claims 13 to 15, wherein:

the primary subgroup corresponds to channels from one of the following groups:

(i) channels for playback by audio sources located in a front half space with respect to a listener,

(ii) channels for playback by audio sources located at substantially the same height as a listener;

and

the secondary subgroup corresponds to channels other than (i) or (ii).

17. The method of claim 16, wherein:

the primary subgroup corresponds to channels from one of the following groups:

(iii) front channels,

(iv) centre channels,

(v) wide channels;

and

the secondary subgroup corresponds to channels other than (iii), (iv) or (v).

18. The method of claim 1, wherein at least one subgroup is associated with an upper bound on the limiting factor.

19. The method of claim 18, wherein two or more subgroups are associated with a common upper bound on the limiting factor.

20. The method of claim 1, wherein said spatially related channels, to which the output signals correspond, belong to one of the following channel groups:

front, surround, rear surround, direct surround, wide, centre, side, high, vertical high.

21. A method of encoding a plurality of audio signals as a bit stream, comprising:

receiving a plurality of audio signals;

downmixing the audio signals into a downmix signal according to the downmixing method of any one of the preceding claims; and

encoding the downmix signal as a bit stream.

22. A method of decoding a bit stream containing a plurality of encoded audio signals and at least one downmix specification, wherein the downmix specification was generated according to the downmixing method of any one of claims 1 to 20, the method comprising:

receiving the bit stream; and

decoding the bit stream,

wherein the step of decoding comprises downmixing the audio signals into a downmix signal in accordance with the downmix specification.

23. A method of decoding a bit stream containing a plurality of encoded audio signals partitioned into predefined subgroups and at least one downmix specification,

wherein the downmix specification includes a plurality of sets of downmix coefficients, wherein ratios between downmix coefficients to be applied to audio signals within each subgroup are constant while a ratio between downmix coefficients to be applied to audio signals in different subgroups is variable,

said decoding method comprising:

receiving the bit stream; and

decoding the bit stream,

wherein the step of decoding comprises downmixing the audio signals into a downmix signal in accordance with the downmix specification.

24. A data carrier storing computer-executable instructions for performing the method of any one of the preceding claims.

25. A mixing system (400) comprising:

an input port (461) for receiving a plurality of input audio signals containing input data;

a configuring section (420) for receiving

maximal downmix coefficients,

an in-range condition on at least one output signal, and

a partition of the input signals into subgroups;

the in-range condition on said at least one output signal being an upper bound on the at least one output signal or a lower bound on the at least one output signal or a requirement for the at least one output signal to remain in an interval having a lower and an upper bound,

a controller (440) for determining downmix coefficients as products of said maximal coefficients and a limiting factor which is common within each subgroup in order to satisfy, in view of the input data, an in-range condition on said at least one output signal; and

a mixer (462) for applying the downmix coefficients determined by the controller (440) to downmix said plurality of input audio signals into at least two spatially related output audio signals;

the controller (440) being adapted to determine the downmix coefficients as products of said maximal downmix coefficients and the limiting factor, the limiting factor being common within each subgroup and all of said output signals, in order to jointly satisfy the in-range condition on each of said output signals;

wherein the controller (440) comprises:

means (442, 443) for determining, for each of the output signals to which the input signals in a subgroup contribute, a downmix coefficient as a product of the maximal downmix coefficient and a preliminary limiting factor; and

a minimum extractor (444, 445) for determining the limiting factor common within the subgroup by selecting the minimum of the preliminary limiting factors.

26. The system of claim 25, wherein at least one of said subgroups of input signals comprises two or more input signals.

27. The system of claim 25, wherein input signals in a subgroup correspond to spatially related audio channels.

28. The system of claim 27, wherein a subgroup comprises a left and a right channel.

29. The system of claim 28, wherein a subgroup comprises a left, a right and a centre channel.

30. The system of claim 25, wherein the controller (440) is adapted to determine the downmix coefficients in such manner that the in-range condition will be satisfied by at most 20 per cent margin, preferably at most 10 per cent margin, most preferably at most 5 per cent margin.

31. The system of claim 25, wherein the output signal is partitioned into time segments; and

the controller (400) is further adapted to determine a segment-wise set of downmix coefficients for each of plurality of time segments as products of said maximal downmix coefficients and a limiting factor which is common within each subgroup in order to satisfy, independently in view of the input data in this time segment, an upper output-signal bound.

32. The system of claim 31, wherein:

the controller (440) is adapted to determine a segment-wise set of downmix coefficients for each of a plurality of time segments as products of said maximal downmix coefficients and a limiting factor which is common within each subgroup in order to jointly satisfy an in-range condition on each of said at least two spatially related output signals, independently in view of the input data in this time segment.

33. The system of claim 32, wherein the controller (440) comprises:

a memory (448, 449) for buffering a sequence of segment-wise values of one of said downmix coefficients; and

a regulariser (446, 447) for providing, based on the sequence of segment-wise values, a smoothed sequence of segment-wise values of the downmix coefficients to be applied by the mixer (462).

34. The system of claim 33, wherein the regulariser (446, 447) is adapted to provide a smoothed sequence of segment-wise values of the downmix coefficient satisfying an upper rate-of-change bound.

35. The system of claim 34, wherein the regulariser (446, 447) is adapted to compute said smoothed sequence by maintaining or decreasing each value in said sequence in order to satisfy the upper rate-of-change bound.

36. The system of claim 25, wherein the controller (440) is adapted to satisfy, for at least one subgroup, a lower bound on the limiting factor for that subgroup.

37. The system of claim 36, wherein the controller (440) is adapted to distinguish between input signals in a primary and a secondary subgroup by satisfying a lower bound on the limiting factor for the primary subgroup which is greater than a lower bound on the limiting factor for the secondary subgroup.

38. The system of claim 25, wherein the controller (440) is adapted to distinguish between input signals in a primary and a secondary subgroup by:

satisfying an upper bound on the limiting factor for the primary subgroup; and

favouring the upper bound on the limiting factor for the primary subgroup as a value of the limiting factor for the primary subgroup.

39. The system of claim 38, wherein the controller (440) is adapted to distinguish between input signals in a primary and a secondary subgroup by:

satisfying a respective lower bound and a respective upper bound on the limiting factors ($L_1 \le \alpha_1 \le U_1, L_2 \le \alpha_2 \le U_2$);

initially attempting to satisfy the in-range condition on said at least one output signal in the subspace of limiting factors such that the primary-subgroup limiting factor is equal to its upper bound ($\alpha_1 = U_1, L_2 \le \alpha_2 \le U_2$); and

further, if the initial attempt fails, attempting to satisfy the in-range condition on said at least one output signal in the subspace of limiting factors such that the secondary-subgroup limiting factor is equal to its lower bound ($L_1 \le \alpha_1 \le U_1, \alpha_2 = L_2$).

40. The system of any one of claims 37 to 39, wherein:

the primary subgroup corresponds to channels from one of the following groups:

(i) channels for playback by audio sources located in a front half space with respect to a listener,

(ii) channels for playback by audio sources located at substantially the same height as a listener;

and

the secondary subgroup corresponds to channels other than (i) or (ii).

41. The system of claim 40, wherein:

the primary subgroup corresponds to channels from one of the following groups:

(iii) front channels,

(iv) centre channels,

(v) wide channels;

and

the secondary subgroup corresponds to channels other than (iii), (iv) or (v).

42. The system of claim 25, wherein the controller (440) is adapted to satisfy, for at least one subgroup, an upper bound on the limiting factor for that subgroup.

43. The system of claim 42, wherein the controller (440) is adapted to satisfy, for two or more subgroups, a common upper bound on the limiting factors for those subgroups.

44. The system of claim 25, wherein said spatially related channels, to which the output signals correspond, belong to one of the following channel groups:

front, surround, rear surround, direct surround, wide, centre, side, high, vertical high.

45. An encoding system for encoding a plurality of audio signals as a bit stream, comprising:

a mixing system of any one of claims 25 to 44, adapted to receive said plurality of audio signals; and

an encoder for encoding an output signal obtained from said mixing system as a bit stream.

46. A decoding system for decoding a bit stream containing a plurality of encoded audio signals and at least one downmix specification, wherein the downmix specification was generated by an input port, a configuring section and a controller according to any one of claims 25 to 44,

the decoding system comprising:

a decoder for decoding the bit stream as decoded audio signals; and

a mixer according to any one of claims 25 to 44 for downmixing said plurality of audio signals into a downmix signal.

47. A decoding system for decoding a bit stream, comprising:

an input port for receiving a bit stream containing a plurality of encoded audio signals partitioned into predefined subgroups and at least one downmix specification, wherein the downmix specification includes a plurality of sets of downmix coefficients, wherein ratios between downmix coefficients to be applied to audio signals within each subgroup are constant while a ratio between downmix coefficients to be applied to audio signals in different subgroups is variable;

a decoder for decoding the bit stream as decoded audio signals; and

a mixer for applying the downmix coefficients to downmix said plurality of audio signals into a downmix signal.

What is claimed is

1. A method for downmixing a plurality of input audio signals containing input data into at least one output audio signal,

wherein maximal downmix coefficients are predefined, at least one in-range condition on said at least one output audio signal is predefined and the input audio signals are partitioned into predefined subgroups,

the method, being restricted in that, said in-range condition for said at least one output audio signal is an upper bound to said at least one output audio signal, a lower bound to said at least one output audio signal, or said at least one output audio signal is maintained in a range having an upper bound and a lower limit, the method comprising:

determining downmix coefficients as products of said maximal downmix coefficients and a limiting factor which is common within each subgroup in order to satisfy, in view of the input data, an in-range condition on said at least one output signal; and

applying the downmix coefficients to downmix the plurality of input audio signals into at least two output audio signals corresponding with spatially related channels,

wherein said downmixing coefficients are determined as products of all output audio signals, a limiting factor which is common within each subgroup, and said maximal downmix coefficients, in order to commonly satisfy an in-range condition of each of at least two output audio signals corresponding with said spatially related channels,

the step of determining said downmixing coefficients comprising:

determining, for each of the output audio signals to which the input audio signals in a sub-group contribute, a downmix coefficient as a product of the maximal downmix coefficient and a preliminary limiting factor; and

determining a limiting factor common within the subgroup by selecting the minimum of the preliminary limiting factors.

2. The method of claim 1, wherein at least one of said subgroups of input audio signals comprises two or more input audio signals.

3. The method of claim 1, wherein input audio signals in a subgroup correspond to spatially related audio channels.

4. The method of claim 1, wherein the downmix coefficients are determined in such manner that the in-range condition will be satisfied by at most 20 per cent margin.

5. The method of claim 1, wherein the output audio signal is partitioned into time segments, and wherein a segment-wise set of downmix coefficients is determined for each of a plurality of time segments as products of said maximal downmix coefficients and a limiting factor which is common within each subgroup in order to satisfy, independently in view of the input data in this time segment, an upper output-signal bound.

6. The method of claim 5, wherein a segment-wise set of downmix coefficients is determined for each of a plurality of time segments as products of said maximal downmix coefficients and a limiting factor which is common within each subgroup in order to jointly satisfy an in-range condition on each of said at least two output audio signals corresponding with spatially related channels, independently in view of the input data within a time segment.

7. The method of claim 6, comprising the steps of:

defining a sequence of segment-wise values of a downmix coefficient from said segment-wise sets of downmix coefficients;

smoothing the sequence of segment-wise values of the downmix coefficient; and

applying the smoothed segment-wise values to downmix the plurality of input audio signals.

8. The method of claim 7, wherein the sequence of segment-wise values is smoothed by applying an upper rate-of-change bound.

9. The method of claim 1, wherein at least one subgroup is associated with a lower bound on the limiting factor for that subgroup.

10. The method of claim 9, wherein a primary and secondary subgroup are defined, and a lower bound on the limiting factor associated with the primary subgroup is greater than a lower bound on the limiting factor associated with the secondary subgroup.

11. The method of claim 1, wherein a primary and a secondary subgroup are pre-defined and the primary subgroup is associated with an upper bound on the limiting factor, and

wherein said step of determining downmix coefficients includes setting the upper bound on the limiting factor for the primary subgroup as a value of the limiting factor for the primary subgroup.

12. The method of claim 11, wherein a primary and a secondary subgroup are predefined and each is associated with a respective lower bound and a respective upper bound on the limiting factors ($L_1 \leq a_1 \leq U_1$, $L_2 \leq a_2 \leq U_2$), and

the step of determining said downmixing coefficients comprises the substeps of:

initially attempting to satisfy the in-range condition on said at least one output audio signal in the subspace of limiting factors such that the primary-subgroup limiting factor is equal to its upper bound ($a_1 = U_1$, $L_2 \leq a_2 \leq U_2$); and

further, if the initial attempt fails, attempting to satisfy the in-range condition on said at least one output audio signal in the subspace of limiting factors such that the secondary-subgroup limiting factor is equal to its lower bound ($L_1 \leq a_1 \leq U_1$, $a_2 = L_2$).

13. The method of any one of claims 10, wherein the primary subgroup corresponds to channels from one of the following groups:

(i) channels for playback by audio sources located in a front half space with respect to a listener, and

(ii) channels for playback by audio sources located at substantially the same height as a listener; and

the secondary subgroup corresponds to channels other than (i) or (ii).

14. The method of any one of claims 13, wherein the primary subgroup corresponds to channels from one of the following groups:

(iii) front channels,

(iv) center channels, and

(v) wide channels; and

the secondary subgroup corresponds to channels other than (iii), (iv) or (v).

15. The method of claim 1, wherein at least one subgroup is associated with an upper bound on the limiting factor.

16. The method of claim 15, wherein two or more subgroups are associated with a common upper bound on the limiting factor.

17. The method of claim 1, wherein said spatially related channels belong to one of the following channel groups: front, surround, rear surround, wide, center, and side channel.

18. A method for encoding a plurality of audio signals as a bit stream, comprising the steps of:

receiving a plurality of audio signals;

downmixing the audio signals into a downmix signal according to the downmixing method of claim 1; and

encoding the downmix signal as a bit stream.

19. A data carrier storing computer-executable instructions for performing the method of any one of the claim 1 through claim 17 and claim 18.

20. A method for decoding, comprising the steps of:

receiving a bit stream containing a plurality of encoded audio signals and a mixing matrix obtained from the downmixing coefficients determined by any one method of claim 1 to claim 17;

decoding said encoded audio signals to generate decoded audio signals; and

mixing said decoded audio signals into one or more output audio signals according to said mixing matrix.

21. A data carrier storing computer-executable instructions for performing the decoding method of claim 20.

22. A mixing system (400), comprising:

an input port (461) for receiving a plurality of input audio signals containing input data;

a configuring section (420), for receiving

maximal downmix coefficients,

an in-range condition on said at least one output signal, and

a partition of the subgroups of said plurality of input audio signals;

said configuring section (420), being restricted in that, said in-range condition for said at least one output audio signal is an upper bound to said at least one output audio signal, a lower bound to said at least one output audio signal, or said at least one output audio signal is maintained in a range having an upper bound and a lower limit,

a controller (440) for determining downmix coefficients as products of said maximal downmixing coefficients and a limiting factor which is common within each subgroup in order to satisfy, in view of the input data, an in-range condition on said at least one output audio signal; and

a mixer (462) for applying the downmix coefficients determined by the controller (440) to downmix said plurality of input audio signals into at least two spatially related output audio signals;

wherein the controller (440) is adapted to determine the downmix coefficients as products of said maximal downmixing coefficients and said limiting factor in order to jointly satisfy the in-range conditions pertinent to each of said output audio signals, said limiting factor is common within all output audio signals and each subgroup,
said controller (440) comprising:

the means (442, 443) for determining, for each of the output audio signals to which the input audio signals in a subgroup contribute, a downmix coefficient as a

product of the maximal downmix coefficient and a preliminary limiting factor; and

a minimal extractor (444, 445) determining a limiting factor common within the subgroup by selecting the minimum value of the preliminary limiting factors.

23. A decoding system, comprising:

an input port receiving a bit stream containing a plurality of encoded audio signals and a mixing matrix obtained from the downmixing coefficients determined by any one method of claim 1 to claim 17;

a decoder decoding said encoded audio signals to generate decoded audio signals; and

a mixer mixing said decoded audio signals into one or more output audio signals according to said mixing matrix.