(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 964 442 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication and mention of the grant of the patent:
17.02.2010 Bulletin 2010/07

(21) Application number: **05822900.6**

(22) Date of filing: **20.12.2005**

(51) Int Cl.:
H04S 3/00 *(2006.01)* ***H04S 5/00*** *(2006.01)*

(86) International application number:
PCT/EP2005/013738

(87) International publication number:
WO 2007/071270 (28.06.2007 Gazette 2007/26)

(54) **Apparatus and method for synthesizing three output channels using two input channels**

Vorrichtung und Verfahren zum Synthetisieren von drei Ausgangskanälen unter Verwendung von zwei Eingangskanälen

Appareil et procédé destinés à synthétiser trois canaux de sortie au moyen de deux canaux d'entrée

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HU IE IS IT LI LT LU LV MC NL PL PT RO SE SI SK TR

(43) Date of publication of application:
03.09.2008 Bulletin 2008/36

(73) Proprietor: **Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V.**
80686 München (DE)

(72) Inventors:
- **HELLMUTH, Oliver**
  91052 Erlangen (DE)
- **HERRE, Juergen**
  91054 Buckenhof (DE)
- **POPP, Harald**
  90587 Tuchenbach (DE)
- **WALTER, Andreas**
  96052 Bamberg (DE)

(74) Representative: **Zinkler, Franz et al**
Schoppe, Zimmermann, Stöckeler & Zinkler Patentanwälte
Postfach 246
82043 Pullach bei München (DE)

(56) References cited:
US-A1- 2004 037 440

- **JOT J M; AVENDANO C: "Spatial Enhancement of Audio Recordings" AES 23RD INTERNATIONAL CONFERENCE, COPENHAGEN, DENMARK, 23 May 2003 (2003-05-23), - 25 May 2003 (2003-05-25) pages 1-11, XP002401944 cited in the application**

Note: Within nine months of the publication of the mention of the grant of the European patent in the European Patent Bulletin, any person may give notice to the European Patent Office of opposition to that patent, in accordance with the Implementing Regulations. Notice of opposition shall not be deemed to have been filed until the opposition fee has been paid. (Art. 99(1) European Patent Convention).

EP 1 964 442 B1

Description

[0001] The present invention is related to multi-channel synthesizers and, particularly, to devices generating three or more output channels using two stereo input channels.

[0002] Multi-channel audio material is becoming more and more popular also in the consumer home environment. This is mainly due to the fact that movies on DVD offer 5.1 multi-channel sound and therefore even home users frequently install audio playback systems, which are capable of reproducing multi-channel audio. Such a setup consists e.g. of 3 speakers L, C, R in the front, 2 speakers Ls, Rs in the back and a low frequency enhancement channel LFE and provides several well-known advantages over 2-channel stereo reproduction, e.g.:

- improved front image stability even outside of the optimal central listening position due to the Center channel (larger "sweet-spot" = optimum listening position)

- increased sense of listener "involvement" created by the rear speakers.

[0003] Nevertheless, there exists a huge amount of legacy audio content, which consists only of two ("stereo") audio channels, e.g. on Compact Discs (CDs).

[0004] To play back two-channel legacy audio material over a 5.1 multi-channel setup there are two basic options:

1. Reproduce the left and right channel stereo signals over the L and R speakers, respectively, i.e., play it back in the legacy way. This solution does not take advantage of the extended loudspeaker setup (Center and rear loudspeakers).

2. One may use a method to convert the two channels of the content material to a multi-channel signal (this may happen "on the fly" or by means of preprocessing) that makes use of all the 5.1 speakers and in this way benefits from the previously discussed advantages of the multi-channel setup.

[0005] Solution #2 clearly has advantages over #1, but also contains some problems especially with respect to the conversion of the two front channels (Left and Right = LR) to three front channels (Multi-channel Left, Center and Right = L'C'R').

[0006] A good LR to L'C'R' conversion solution should fulfill the following requirements:

1) To recreate a similar, but more stable front image in the L'C'R' than in the LR playback case, The Center channel shall reproduce all the sound events which usually are perceived to come from the middle between the Left and Right loudspeaker, if the listener is in the "sweet spot". Furthermore, signals in left front positions shall be reproduced by L'C', and signals in the right front positions shall be reproduced by R'C', respectively (see J.M. Jot and C. Avendano, "Spatial Enhancement of Audio Recordings", AES 23rd Conference, Copenhagen, 2003).

2) The sum of the acoustical energy emitted by the channels L'C'R' should be equal to the sum of the acoustical energy of the source channels LR in order to achieve an equally loud sound impression for L'C'R' as for LR. Assuming equal characteristics in all reproduction channels, this translates into "the sum of the electrical energy of the channels L'C'R' should be equal to the sum of the electrical energy of the source channels LR."

[0007] Due to requirement #1 the signals of the Left and Right channels may be mixed into one (single) center channel. This is particularly true, if the Left and the Right channel signals are near identical, i.e. they represent a phantom sound source in the middle of the front sound stage. This phantom image is now replaced by a "real" image generated by the Center speaker. Due to requirement #2, this Center signal shall carry the sum of the Left and the Right energy. If the level of the Left or the Right channel signals is close to the maximum amplitude that can be transmitted by the channel (= 0 dBFS; dBFS = dB Full Scale), the sum of the levels of both channels will exceed the maximum level, which can be represented by the channel/system. This usually results in the undesirable effect of "clipping".

[0008] The clipping situation is shown in Fig. 6. Fig. 6 illustrates a time waveform of a signal 60 processed by a processor having a maximum positive threshold 61a and a maximum negative threshold 61b. Depending on the capability of the digital processor processing the digital signal, the maximum positive threshold and the maximum negative thresholds may be +1 and - 1. Alternatively, when a digital processor is used representing the numbers in integers, the maximum positive threshold will be 32767 corresponding to 2^{15}-1, and the maximum negative threshold will be -32768 corresponding to -2^{15}.

[0009] Since a time waveform signal is represented by a sequence of samples, each sample being a digital number between -32768 and +32767, it is easily clear that higher numbers can be obtained, when, for a certain time instance, the first channel has a quite high value and the second channel also has a quite high value, and when these quite high values are added together. Theoretically, the maximum number obtained by this adding together of two channels can be 65536. However, the digital signal processor is not able to represent this high number. Instead, the digital processor will only represent numbers equal to the maximum positive threshold or the maximum negative threshold. Therefore, the digital signal processor performs clipping in that a number higher

or equal to the maximum positive threshold or the maximum negative threshold is replaced by a number equal to the maximum positive threshold and the maximum negative threshold so that, with regard to Fig. 6., the illustrated situation appears. Within a clipping time portion 62, the waveform 60 does not have its natural (sine) shape, but is flattened or clipped. When this clipped waveform is evaluated from a spectral point of view, it becomes clear that this time domain clipping results in strong harmonic components caused by a high gradient magnitude at the beginning and the end of the clipping time portion 62.

[0010] This "digital clipping" is not related to the replay setup, i.e., the amplifier and the loudspeakers used for rendering the audio signal. However, each amplifier/loudspeaker combination also has only a limited linear range, and, when this linear range is exceeded by a processed signal, also a kind of clipping takes place, which can be avoided using the inventive concept.

[0011] In any case, the occurrence of clipping introduces heavy distortions in the audio signal, which degrade the perceived sound quality very much. Thus, the occurrence of clipping has to be avoided. This is even more due to the fact that the sound improvement by rendering a stereo signal by a multichannel setup such as a 5.1 speaker system is small compared to the very annoying clipping distortions. Therefore, when one cannot guaranty that clipping does not occur, one would prefer to only use the left and the right speakers of a multichannel setup for rendering a stereo signal.

[0012] There exist prior art solutions to overcome this clipping problem.

[0013] A simple solution to overcome this problem is to scale down all channels equally to a level where none of the channel signal (especially the Center signal) exceeds the 0 dBFS limit. This can be done statically by a predefined fixed value. In this case the fixed value must also be valid for worst case situations, where the Left and Right channel have maximum levels. For the average LR to L'C'R' conversion this leads to a significantly quieter L'C'R' version than the original stereo LR, which is undesirable, especially when users are switching between stereo and multi-channel reproduction. This behavior can be observed at commercially available matrix decoders (Dolby ProLogicII and Logic7 Decoder) that can be used as LR to L'C'R' converters. See Dolby Publication: "Dolby Surround Pro Logic II Decoder - Principles of Operation", htp: //www.dolby.com/ assets/pdf/ tech_ library/ 209 _Dolby_Surround_Pro_Logic_II Decoder_Principles_ of_Operation. pdf or Griesinger, D.: "Multichannel Matrix Surround Decoders for Two-Eared Listeners", 101st AES Convention, Los Angeles, USA, 1996, Preprint 4402.

[0014] Another simple solution is to use dynamic range compression in order to dynamically (depending on the signal) limit the peak signal, sometimes also called a "limiter". A disadvantage of this approach is that the true dynamic range of the audio program is not reproduced but subjected to compression (see Digital Audio Effects DAFX; Udo Zölzer, Editor; 2002; Wiley & Sons; p. 99ff: "Limiter").

[0015] The downscaling problem is undesirable, since it reduces the level or volume of a sound signal compared to the level of the original signal. In order to completely avoid any even theoretical occurrence of clipping, one would have to down-scale all channels by a scaling factor equal to 0.5. This results in a strongly reduced output level of the multi-channel signal compared to the original signal. When one only listens to this downscaled multi-channel signal, one can compensate for this level reduction by increasing the amplification of the sound amplifier. However, when one switches between several sources, the (legacy) stereo signal will appear to a listener very loud, when it is replayed using the same amplification setting of the amplifier a set for the multichannel reproduction.

[0016] Thus, a user would have to think about reducing the amplification setting of its amplifier before switching from a multi-channel representation of a stereo signal to a true stereo representation of the stereo signal in order to not damage her or his ears or equipment.

[0017] The other prior art method using dynamic range compression effectively avoids clipping. However, the audio signal itself is changed. Thus, the dynamic compression leads to a non-authentic audio signal, which, even when the introduced artifacts are not too annoying, is questionable from the authenticity point of view.

[0018] It is an object of the present invention to provide an improved concept for multi-channel synthesis using two input channels.

[0019] This object is achieved by an apparatus for synthesizing in accordance with claims 1 or 12, a method of synthesizing in accordance with claims 11 or 13, a computer program in accordance with claim 14.

[0020] The present invention is based on the finding that, for overcoming the clipping problem and for nevertheless achieving the advantages incurred by replaying a stereo signal using three or more channels of a multi-channel setup, the center channel is generated as usual, i.e., receives sound events located in the middle between the left and the right loudspeakers, which is also called a "real center" rendering. However, when the real center would come into the clipping range, only a portion of the energy of the signal components representing the events in the middle of the audio setup are fed into the center channel. The remainder of the energy of these sound events is fed back into the first and third (or left and right) channels or remains there from the beginning.

[0021] Thus, for a time frame, where clipping may occur, when the two/three upmix procedure is performed without modifications, the center channel is scaled down the level below or equal to the maximum level possible without clipping. Nevertheless, the missing part/energy of the signal, which cannot be rendered by the center channel is reproduced with the left channel and the right channel as a "virtual center" or "phantom center".

[0022] The signal of the real center and the virtual cent-

er is then acoustically combined during playback recreating an intended center without clipping. This "mixing" of the real center and the virtual center results in an improved more stable front image of a stereo audio signal, i.e., in an increased sweet spot, although the sweet spot is not as large as when there would not be a phantom center at all. However, the inventive process does not have any clipping artifacts, since the remainder of the energy not being processable within the second channel due to the clipping problem is not lost but is rendered by the original left and right channels.

[0023] It is noted here that, for any situations, the energy of the left and right channels in the multi-channel setup is lower than the energy in the original left and right channels, since the energy of the center channel is drawn from the left and right channels. Therefore, even when, in accordance with the present invention, a remaining part of the energy is fed back to the left and right output channels, there will never exist a clipping problem within these channels.

[0024] A further advantage of the present invention is that the inventive signal generation is performed in a way that, in a preferred embodiment, the total electrical or acoustical energy of the generated three output channels (and optionally generated additional output channels such as Ls, Rs, Cs, LFE, ...) is preserved with respect to the energy of the original stereo signal. The same overall loudness irrespective of the way of rendering the signal, i.e., whether the signal is rendered using a stereo setup having only two speakers or whether the signal is rendered using a multi-channel setup having more than two speakers, can be guaranteed.

[0025] Furthermore, the inventive signal generation and distribution of sound energy to the center channel and the left and right channels is dynamically applied only if clipping would be unavoidable, i.e., the second center channel is completely unchanged in situations, which are not effected by clipping, i.e., when sampling values of the second channel remain below or are only equal to the maximum threshold.

[0026] Furthermore, the resulting acoustic combination of the "real center" and the "phantom center" produces a signal which is much closer to the optimal three channel configuration, i.e., three channels without clipping or three channels in which sampling values without any min/max threshold are allowable. The inventive sound image is, therefore, in preferred embodiments neither different in level compared to the stereo input signal nor non-authentic as would be the case when using a limiter or a simple clipper.

[0027] Preferred embodiments of the present invention are subsequently explained with respect to the accompanying drawings, in which:

Fig. 1 illustrates an apparatus for synthesizing the upper channels in accordance with the preferred embodiment of the present invention;

Fig. 2a a preferred embodiment of the signal generator of Fig. 1 having a post processor;

Fig. 2b a preferred implementation of the post processor of Fig. 2a;

Fig. 3 a further embodiment of the inventive signal generator having an iterative upmixer control;

Fig. 4 a further embodiment of the inventive signal generator completely operating in the parameter domain;

Fig. 5 an example for a 5.1 sound system optionally also having a surround center channel C_s;

Fig. 6 an illustration of a clipped waveform;

Fig. 7 a schematic illustration of the energy situation of the original two-channel input signal and the three-channel output signal before and after clipping; and

Fig. 8 illustrates a preferred input channels analyzer.

[0028] Fig. 1 illustrates a preferred embodiment of an inventive apparatus for synthesizing three output channels using two input channels, wherein a second channel of the three output channels is intended for a speaker in an audio replay setup, which is positioned between two speakers, which are intended to receive the first output channel and the third output channel. The input channels are indicated by 10a, which channel can be for example the left channel L, and 10b for the second channel, which can be the right channel R. The output channels are indicated as 12a for the right channel, 12b for center channel and 12c for the left channel. Additional output channels can be generated such as a left surround output channel 14a, a right surround output channel 14b and a low frequency enhancement channel 14c. The arrangement of the corresponding speakers for these channels is shown in Fig. 5. In the middle of these speakers 12a, 12b, 12c, 14a, 14b is a sweet spot 50. When a listener is positioned within the sweet spot, then he or she will have an optimum sound impression.

[0029] Additionally, one might add a center surround channel 51 C_s, which is positioned between the left surround channel 14a and the right surround channel 14b. The signal for the center surround channel 51 can be calculated using the same process as calculating the signal for the center channel 12b. Additionally, the inventive methods can, therefore, also be applied to the calculation of the center surround channel in order to avoid clipping in the center surround channel.

[0030] It is to be noted that the inventive process is usable for each audio channel constellation, in which two input channels intended for two different spatial positions in a replay setup are used and in which three output chan-

nels are generated using these two input channels, wherein the second channel of the three channels is located between two additional speakers in the replay setup, which are provided with the first and the third input channel signals.

[0031] The inventive synthesizer apparatus of Fig. 1 includes an input channel analyzer 15 for analyzing the two input channels in order to determine signal components which occur in both input channels. These signal components which occur in both input channels can be used to build the real center channel, i. e. can be rendered via the center channel C shown in Fig. 5. Typically, a stereo signal includes a lot of such monophonic signal components such as a speaker person or, when music signals are considered, a singer or a solo instrument positioned in front of an orchestra and, therefore, positioned in front of the audience.

[0032] The inventive synthesizer apparatus additionally includes a time and frequency selective and, furthermore signal dependent signal generator 16 for generating the three output channels 12a, 12b, 12c using the two input channels 10a, 10b and information on detected signal components occurring in both input channels as provided via line 13. Particularly, the inventive signal generator is operative to feed detected signal components at least partly into the second channel. Furthermore, the generator is operative to only feed a portion of the detected signal components in the second channel, when there exists a situation, in which a complete feeding of the detected signal components would result in exceeding the maximum threshold.

[0033] Thus, the second output channel has a time portion, which only includes a part of the detected signal components to avoid clipping, while in a different portion of the second output channel, the complete detected signal components have been fed into the second output channel. The remainder of the detected signal components are included in the first and third output channels and, therefore, form the "phantom center" when these channels are rendered via the speaker setup for example shown in Fig. 5.

[0034] Depending on the implementation of the inventive concept, the "portion" of the detected signal components located in the second channel, and the remainder of the detected signal components located in the first and third channels can be an energy portion or frequency portion or any other portion, so that the second channel only includes a portion of the detected signal components and will not have any value above the maximum threshold and will, therefore, not induce any clipping distortions.

[0035] Fig. 2a illustrates a preferred embodiment of the inventive signal analyzer 16 of Fig. 1. Particularly, in the Fig. 2a embodiment, the signal analyzer includes a 2-3-upmixer 16 performing an upmixing process controlled by the input channels analyzer 15 of Fig. 1. The output of the 2-3-upmixer L, R, C are upmixed channels. However, channel C might be subject to clipping, since channel C is generated using an adding process, in which signal components from the left channel and from the right channel are added together.

[0036] The center channel C is input into a clipping detector 16b, which feeds a post processor 16c, which also receives information on detected signal components. Particularly, the clipping detector 16b is operative to examine the time wave form of the center channel 12c.

[0037] Depending on the implementation, the clipping detector can be constructed in different ways. When it is assumed that the Fig. 2a signal generator can process numbers having a magnitude being higher than a predetermined maximum threshold, then the clipping detector 16b simply examines the time waveform to see, whether there are higher numbers than the maximum threshold of the subsequent processing stage. When such a situation is detected, the post processor 16c is activated via activation line 16d to start post processing such that the energy of the center channel is reduced and the energy of the left and right channels is increased so that the three output channels 12a, 12b, 12c are finally output by the post processor 16c. Thus, in accordance with the Fig. 2a embodiment, the LR to LCR conversion process is done as usual. The internal first-stage center channel signal 20b is analyzed to check, whether clipping would occur if it has to be output as an external signal such as in an AES/EBU or as SPDIF format. When this happens, a part of the signal 20b is removed in the post processor 16c resulting in a modified center channel signal 12b and distributed instead to the intermediate left and right channels 20a, 20c as a "phantom center" contribution. After the postprocessing, the center channel signal 12b is again below 0 dBFS.

[0038] A preferred embodiment of the post processor 16c is shown in Fig. 2b. The center channel 20b after the upmixer 16a is input into a part extractor 25. The part extractor receives information 13 on detected signal components and a control signal via line 16d from the clipping detector, which may also include an indication of an amount of extraction. Alternatively, the amount of extraction per iteration step may be fixed independent of any occurring clipping, and an iterative trial/error process can be applied to extract increasing amounts of the detected signal components in a step-by-step fashion until the clipping detector 16b does not detect any clipping anymore. Then, the modified center channel 12b is output by the part extractor, and the remainder of the detected signal components corresponding to the extracted part have to be re-distributed to the left and right channels 20c, 20a output by the upmixer after multiplying by 0.5. To this end, the post processor includes two multipliers 26 in each branch or a single multiplier before branching, and a left adder 27a and a right adder 27b.

[0039] When the detection of the signal components occurring in both input channels has been perfect, then the left and right channels 20a, 20c do not include any "phantom center". However, by adding the extracted components (after multiplication by 0.5) to these channels, a phantom center is added to the left and right chan-

nels.

[0040] Subsequently, a further embodiment of the present invention and, particularly, of the signal generator 16 of Fig. 1 is discussed in connection with Fig. 3. The input channels are input into a controllable 2-3-upmixer receiving information on detected signal components for generating three output channels in a first iteration step controlled by an iteration controller 30. The first step will be equal to the upmixer operation in Fig. 2a, i.e., the center channel 20b can have clipping problems. Such a clipping situation will be detected by a clipping detector 16b. In contrast to the Fig. 2a embodiment, the clipping detector 16b controls the upmixer 16a in a feed-back way via the upmixer control line 31 to change the upmixing rule in a certain way so that the generated center channel 20b receives, after one or more iteration steps as controlled by the iteration controller 30, only an allowed portion of the detected signal components so that no clipping occurs anymore.

[0041] Thus, the Fig. 3 embodiment illustrates an iterative process. In a first pass of the iterative process, the up-mixer operation is done as usual. At the output, a detector 16b checks, whether clipping occurs. When clipping is detected, this time frame is processed again, now using the re-mapping process and using re-routing of a part of the center signal energy to the left and right channels as a phantom center contribution.

[0042] The Fig. 4 embodiment completely operates in the parameter domain. To this end, an up-mixer parameter calculator 40 is provided, which is connected to a parameter changer 41. Additionally, a clipping detector 42 is provided, which is operative to examine the original left and right channels or the calculated up-mixer parameters to find out, whether clipping will occur or not after a straight forward up-mix process. When the clipping detector 42 detects a clipping danger, it controls a parameter change 41 via a control line 44 to provide changed up-mix parameters, which are then provided to a straightforward up-mixer 16a, which then generates the first, second, and third output channels so that no clipping occurs in the second channel and, for a time frame, in which the clipping detector 42 has originally detected a clipping problem, the left and right channels 12c, 12a, have a phantom center contribution.

[0043] In contrast to the Fig. 2 and Fig. 3 embodiments, the inventive process is carried out based on processing parameters that are used for deriving the output signals 20a, 20b, 20c, or 12a, 12b, 12c from the input stereo signals. Thus, in order to provide implementations with still lower computational complexity, also the clipping detection and the manipulation of signal levels or part of it are based on the processing parameters. This is in contrast to the Fig. 2 and 3 embodiments, in which the inventive process is carried out on actual audio channel signals that were already created for the center channel after a possible clipping could be detected.

[0044] The inventive clipping detection/control can be performed by a post-processing. Thus, the intended conversion parameters are analyzed and modified according to the inventive concept to avoid clipping after the synthesis of the actual output audio signals. An alternative way to control the parameter change 41 is via an iterative way. Intended conversion parameters are analyzed. When, after the synthesis of the real audio signal, clipping may occur, the conversion parameters are modified. Then, the process is again started and finally, the output channel signals are synthesized without any clipping and with real center and phantom center contributions in the corresponding channels.

[0045] Subsequently, a preferred implementation of the input channels analyzer will be discussed. To this end, reference is made to Fig. 8, which illustrates such a preferred input channels analyzer 15. First of all, subsequent or overlapping frames following each other are generated using a windowing block 80 so that, at the output of block 80, there is, on line 81a, a block of values of the left channel and, on line 81b, a block of values of the right channel. Then, a frequency analysis is performed for each block individually. To this end, a frequency analyzer 82 is provided for each channel.

[0046] The frequency analyzer can be any device for generating a frequency domain representation of a time domain signal. Such a frequency analyzer can include a short-time Fourier transform, an FFT algorithm, or an MDCT transform or any other transform device. Alternatively, the frequency analyzer block 82 may also include a subband filter bank for generating for example 32 subband channels or a higher or lower number of subband channels from a block of input signal values. Depending on the implementation of the subband filter bank, the functionality of the framing device 80 and the frequency analysis block 82 can be implemented in a single digitally implemented subband filter bank.

[0047] Then, a band-wise cross correlation is performed as indicated by device 84. Thus, the cross-correlator determines a cross correlation measure between corresponding bands, i.e., bands having the same frequency index. The cross correlation measure determined by block 84 can have a value between 0 and 1, wherein 0 indicates no correlation, and wherein 1 indicates full correlation. When the device 84 outputs a low cross correlation measure, this means that the left and right signal components in the respective band are different from each other so that this band does not include signal components occurring in both bands, which should be inserted into a center channel. When, however, the cross correlation measure is high, indicating that the signals in both bands are very similar to each other, then this band has a signal component occurring in the left and right channels so that this band should be inserted into the center channel.

[0048] A further criterion for deciding whether signals in bands are similar to each other is the signal energy. Therefore, the preferred embodiment of the inventive input channels analyzer includes a band-wise energy calculator 85, which calculates the energy in each band and

which outputs an energy similarity measure indicating, whether the energies in the corresponding bands are similar to each other or different from each other.

[0049] The energy similarity measure output by device 85 and the cross correlation measure output by device 84 are both input into a final decision stage 86, which comes to a conclusion that, in a certain frame, a certain band i occurs in both channels or not. When the decision stage 86 determines that the signal occurs in both channels, then this signal portion is fed into the center channel to generate a "real center".

[0050] Fig. 8 shows an embodiment for implementing the input channels analyzer. Additional embodiments are known in the art and, for example, illustrated in "Spatial enhancement of audio recordings", Jot and Avendano, 23rd International AES Conference, Copenhagen, Denmark, May 23-25, 2003. Particularly, other methods of analyzing two channels to find signal components in these channels include statistical or analytical analyzing methods such as the principle component analysis or the independent subspace analysis or other methods known in the art of audio analysis. All these methods have in common that they detect signal components occurring in both channels, which should be fed into a center channel to generate a real center.

[0051] Subsequently, reference is made to Fig. 7 to illustrate an energy situation before and after a two-three upmix process has been implemented by the two-three upmixer 16a in the Figures. A left input channel L illustrated at 70 in Fig. 7 has a certain energy. In this example, the right input channel of the two stereo input channels has a different (lower) energy as illustrated at 71. It is assumed that the channel analyzer has found out that there are signal components occurring in both channels. These signal components occurring in both channels have an energy as illustrated at 72 in Fig. 7. When the whole energy 72 would be fed into the center channel as shown at 73, the energy of the center channel would be above an energy limit, wherein the energy limit at least roughly illustrates that the signal having such a high energy has amplitude values above the amplitude maximum threshold. Therefore, only a portion of the energy 72 is input into the real center, while the exceeding portion is equally (re-) distributed to the synthesized left and right channels L' and R' as illustrated by arrows 76.

[0052] In this context, it is to be noted that there are different ways of redistributing energy from the center channel back to the left and right channels or for introducing a correct amount of energy from an original left channel and an original right channel into the center channel. One could, for example, scale down all detected signal components by a certain downscaling factor and introduce the downscaled signal into the center channel. This would have equal consequences for the signal components in each band, when a frequency-selective analysis was applied. Alternatively, one could also perform a band-wise energy control. This means that when there have been detected e.g. 10 bands having detected signal components, one could introduce only 5 bands into the center channel and leave the remaining 5 bands in the left and right channels in order to reduce the energy in the center channel.

[0053] Depending on certain implementation requirements of the inventive methods, the inventive method can be implemented in hardware or in software. The implementation can be performed using a digital storage medium, in particular a disk or a CD having electronically readable control signals stored thereon, which can cooperate with a programmable computer system such that the inventive method is performed. Generally, the present invention is, therefore, a computer program product with a program code stored on a machine-readable carrier, the program code being configured for performing the inventive method, when the computer program product runs on a computer. In other words, the invention is also a computer program having a program code for performing the inventive method, when the computer program runs on a computer.

Claims

1. Apparatus for synthesizing three output channels (12a, 12b, 12c) using two input channels (10a, 10b), wherein a second channel of the three output channels is feedable to a speaker in an intended audio rendering scheme, which is positioned between two speakers being feedable with the first output channel and the third output channel, comprising:

an analyzer (15) for analyzing the two input channels for detecting signal components occurring in both input channels to obtain detected signal components; and

a signal generator (16) for generating the three output channels (12a, 12b, 12c) using the two input channels (10a, 10b), wherein the signal generator comprises:

a two-three up-mixer (16a) for generating at least a second intermediate channel (12b) including at least a portion of the detected signal components;

a clipping detector (16b) for detecting a portion of the second channel having an amplitude above the maximum threshold; and

a two-three up-mixer controller (30, 31) for controlling the two-three up-mixer (16a) so that only a portion of the detected signal components is fed to the second channel and a remainder of the signal components remains positioned in the first and the third output channels, when a complete feeding of the detected signal components would result in exceeding a maximum threshold (61a, 61b) for the second channel.

2. Apparatus in accordance with claim 1, in which the signal generator (16) is operative to generate the three output channels such that, for a certain time period, a total energy of the three output channels and potentially generated additional output channels is equal to an electrical or acoustical energy of the two input channels.

3. Apparatus in accordance with claim 1 or 2, in which the signal generator (16) is operative to generate the second output channel such that the portion of the detected signal components fed into the second channel is as large as possible so that an energy of the second output channel, which includes only the portion of the detected signal components always has a maximum amplitude below or equal to the maximum threshold (61a, 61b).

4. Apparatus in accordance with any one of the preceding claims, in which the signal generator (16) is adapted so that a remainder (73) of the detected signal components, which is not in the second channel, is included in the first and the third channels.

5. Apparatus in accordance with any one of the preceding claims, in which the maximum threshold (61a, 61b) is a full-scale amplitude determined by the apparatus for synthesizing or a digital or an analog processing device connected to the apparatus for synthesizing.

6. Apparatus in accordance with claim 5, in which the maximum threshold (61a, 61b) is equal to a maximum allowable positive or negative sampling value of a time domain waveform of a signal.

7. Apparatus in accordance with any one of the preceding claims, in which the analyzer (15) is operative to determine (84) a measure for a cross-correlation between at least a portion of the first input channel and the second input channel and to detect (86) a portion having a cross-correlation measure above a similarity threshold.

8. Apparatus in accordance with any one of the preceding claims, in which the analyzer (15) is operative to detect (85) an energy of a portion of the first channel and a portion of the second channel and to detect (86) portions of the channels having energies being equal or differing by less than an equality threshold.

9. Apparatus in accordance with any one of the preceding claims, in which the analyzer (15) and the signal generator (16) are operative to perform a frequency selective or time selective analysis and synthesis.

10. Apparatus in accordance with any one of the preceding claims, in which the first and the second channels are a left channel (L) and a right channel (R) of a stereo representation of an audio signal, and
in which the three output channels are a front-left channel (L'), a center channel (C'), and a front-right channel (R'), or a rear-left channel (L_s), a rear-center channel (C_s) , and a rear-right channel (C_s) .

11. Method of synthesizing three output channels (12a, 12b, 12c) using two input channels (10a, 10b), wherein a second channel (12b) of the three output channels is feedable to a speaker in an intended audio rendering scheme, which is positioned between two speakers being feedable with the first output channel and the third output channel, comprising:

analyzing (15) the two input channels for detecting signal components occurring in both input channels; and
generating (16) the three output channels using the two input channels, wherein the step of generating comprises:

generating (16a) at least a second intermediate channel (12b) including at least a portion of the detected signal components;
detecting (16b) a portion of the second channel having an amplitude above the maximum threshold; and
controlling (30, 31) the step of generating so that only a portion of the detected signal components is fed to the second channel and a remainder of the signal components remains positioned in the first and the third output channels, when a complete feeding of the detected signal components would result in exceeding a maximum threshold for the second channel.

12. Apparatus for synthesizing three output channels (12a, 12b, 12c) using two input channels (10a, 10b), wherein a second channel of the three output channels is feedable to a speaker in an intended audio rendering scheme, which is positioned between two speakers being feedable with the first output channel and the third output channel, comprising:

an analyzer (15) for analyzing the two input channels for detecting signal components occurring in both input channels to obtain detected signal components; and
a signal generator (16) for generating the three output channels (12a, 12b, 12c) using the two input channels (10a, 10b), wherein the signal generator comprises:

a clipping detector (42) for determining a portion of the input channels, in which there

is a clipping probability;
a two-three up-mixer (16a) for generating three intermediate channels, wherein a second intermediate channel includes at least a portion of the detected signal components; and
a controller (41) for controlling the two-three up-mixer (16a) so that a generation parameter for up-mixing the portion determined by the clipping detector is controlled such that the second channel always has an amplitude below or equal to the maximum threshold.

13. Method of synthesizing three output channels (12a, 12b, 12c) using two input channels (10a, 10b), wherein a second channel (12b) of the three output channels is feedable to a speaker in an intended audio rendering scheme, which is positioned between two speakers being feedable with the first output channel and the third output channel, comprising:

analyzing (15) the two input channels for detecting signal components occurring in both input channels; and
generating (16) the three output channels using the two input channels, wherein the step of generating comprises:

determining (42) a portion of the input channels, in which there is a clipping probability;
generating (16a) three intermediate channels, wherein a second intermediate channel includes at least a portion of the detected signal components; and
controlling (41) the step of generating (16a) so that a generation parameter for up-mixing the portion determined by the clipping detector is controlled such that the second channel always has an amplitude below or equal to the maximum threshold.

14. Computer program for performing, when running on a computer, a method of synthesizing in accordance with claim 11 or 13.

Patentansprüche

1. Vorrichtung zum Synthetisieren dreier Ausgangskanäle (12a, 12b, 12c) unter Verwendung zweier Eingangskanäle (10a, 10b), wobei ein zweiter Kanal der drei Ausgangskanäle in einem beabsichtigten Audiowiedergabeschema einem Lautsprecher zuführbar ist, der zwischen zwei Lautsprechern positioniert ist, denen der erste Ausgangskanal und der dritte Ausgangskanal zuführbar sind, die folgende Merkmale aufweist:

einen Analysierer (15) zum Analysieren der zwei Eingangskanäle zum Erfassen von Signalkomponenten, die in beiden Eingangskanälen auftreten, um erfasste Signalkomponenten zu erhalten; und
einen Signalerzeuger (16) zum Erzeugen der drei Ausgangskanäle (12a, 12b, 12c) unter Verwendung der zwei Eingangskanäle (10a, 10b), wobei der Signalerzeuger folgende Merkmale aufweist:

einen Zwei-Drei-Aufwärtsmischer (16a) zum Erzeugen zumindest eines zweiten Zwischenkanals (12b), der zumindest einen Abschnitt der erfassten Signalkomponenten umfasst;
einen Begrenzungserfasser (16b) zum Erfassen eines Abschnitts des zweiten Kanals mit einer Amplitude oberhalb der maximalen Schwelle; und

eine Zwei-Drei-Aufwärtsmischer-Steuerung (30, 31) zum Steuern des Zwei-Drei-Aufwärtsmischers (16a), so dass nur ein Abschnitt der erfassten Signalkomponenten dem zweiten Kanal zugeführt wird und ein Rest der Signalkomponenten in dem ersten und dem dritten Ausgangssignal positioniert bleibt, wenn ein vollständiges Zuführen der erfassten Signalkomponenten zu einem Überschreiten einer maximalen Schwelle (61 a, 61 b) für den zweiten Kanal führen würde.

2. Vorrichtung gemäß Anspruch 1, bei der der Signalerzeuger (16) wirksam ist, um die drei Ausgangskanäle derart zu erzeugen, dass für einen bestimmten Zeitraum eine Gesamtenergie der drei Ausgangskanäle und möglicherweise erzeugter zusätzlicher Ausgangskanäle gleich einer elektrischen oder akustischen Energie der zwei Eingangskanäle ist.

3. Vorrichtung gemäß Anspruch 1 oder 2, bei der der Signalerzeuger (16) wirksam ist, um den zweiten Ausgangskanal derart zu erzeugen, dass der Abschnitt der erfassten Signalkomponenten, der in den zweiten Kanal zugeführt wird, so groß wie möglich ist, so dass eine Energie des zweiten Ausgangskanals, der nur den Abschnitt der erfassten Signalkomponenten umfasst, immer eine maximale Amplituden unterhalb von oder gleich der maximalen Schwelle (61a, 61b) aufweist.

4. Vorrichtung gemäß einem der vorhergehenden Ansprüche, bei der der Signalerzeuger (16) angepasst ist, so dass ein Rest (73) der erfassten Signalkomponenten, der nicht in dem zweiten Kanal ist, in dem ersten und dem dritten Kanal beinhaltet ist.

5. Vorrichtung gemäß einem der vorhergehenden Ansprüche, bei der die maximale Schwelle (61a, 61b) eine Vollausschlag-Amplitude ist, die durch die Vorrichtung zum Synthetisieren oder ein digitales oder ein analoges Verarbeitungsbauelement, das mit der Vorrichtung zum Synthetisieren verbunden ist, bestimmt wird.

6. Vorrichtung gemäß Anspruch 5, bei der die maximale Schwelle (61a, 61b) gleich einem maximalen erlaubten positiven oder negativen Abtastwert eines Zeitbereichssignalverlaufs eines Signals ist.

7. Vorrichtung gemäß einem der vorhergehenden Ansprüche, bei der der Analysierer (15) wirksam ist, um ein Maß für eine Kreuzkorrelation zwischen zumindest einem Abschnitt des ersten Eingangskanals und des zweiten Eingangskanals zu bestimmen (84) und einen Abschnitt mit einem Kreuzkorrelationsmaß oberhalb einer Ähnlichkeitsschwelle zu erfassen (86).

8. Vorrichtung gemäß einem der vorhergehenden Ansprüche, bei der der Analysierer (15) wirksam ist, um eine Energie eines Abschnitts des ersten Kanals und eines Abschnitts des zweiten Kanals zu erfassen (85) und Abschnitte der Kanäle mit Energien, die gleich sind oder sich um weniger als eine Gleichheitsschwelle unterscheiden, zu erfassen (86).

9. Vorrichtung gemäß einem der vorhergehenden Ansprüche, bei der der Analysierer (15) und der Signalerzeuger (16) wirksam sind, um eine frequenzselektive oder zeitselektive Analyse und Synthese durchzuführen.

10. Vorrichtung gemäß einem der vorhergehenden Ansprüche, bei der der erste und der zweite Kanal ein linker Kanal (L) und ein rechter Kanal (R) einer Stereodarstellung eines Audiosignals sind, und
bei der die drei Ausgangskanäle ein Vorne-Links-Kanal (L'), ein Mitte-Kanal (C') und ein Vorne-Rechts-Kanal (R') oder ein Hinten-Links-Kanal (L_s), ein Hinten-Mitte-Kanal (C_s) und ein Hinten-Rechts-Kanal (C_s) sind.

11. Verfahren zum Synthetisieren dreier Ausgangskanäle (12a, 12b, 12c) unter Verwendung zweier Eingangskanäle (10a, 10b), wobei ein zweiter Kanal (12b) der drei Ausgangskanäle in einem beabsichtigten Audiowiedergabeschema einem Lautsprecher zuführbar ist, der zwischen zwei Lautsprechern positioniert ist, denen der erste Ausgangskanal und der dritte Ausgangskanal zuführbar sind, das folgende Schritte aufweist:

Analysieren (15) der zwei Eingangskanäle zum Erfassen von Signalkomponenten, die in beiden Eingangskanälen auftreten; und
Erzeugen (16) der drei Ausgangskanäle unter Verwendung der zwei Eingangskanäle, wobei der Schritt des Erzeugens folgende Schritte aufweist:

Erzeugen (16a) zumindest eines zweiten Zwischenkanals (12b), der zumindest einen Abschnitt der erfassten Signalkomponenten umfasst;
Erfassen (16b) eines Abschnitts des zweiten Kanals mit einer Amplitude oberhalb der maximalen Schwelle; und
Steuern (30, 31) des Schritts des Erzeugens, so dass nur ein Abschnitt der erfassten Signalkomponenten dem zweiten Kanal zugeführt wird und ein Rest der Signalkomponenten in dem ersten und dem dritten Ausgangskanal positioniert bleibt, wenn ein vollständiges Zuführen der erfassten Signalkomponenten zu einem Überschreiten einer maximalen Schwelle für den zweiten Kanal führen würde.

12. Vorrichtung zum Synthetisieren dreier Ausgangskanäle (12a, 12b, 12c) unter Verwendung zweier Eingangskanäle (10a, 10b), wobei ein zweiter Kanal der drei Ausgangskanäle in einem beabsichtigten Audiowiedergabeschema einem Lautsprecher zuführbar ist, der zwischen zwei Lautsprechern positioniert ist, denen der erste Ausgangskanal und der dritte Ausgangskanal zuführbar sind, die folgende Merkmale aufweist:

einen Analysierer (15) zum Analysieren der zwei Eingangskanäle zum Erfassen von Signalkomponenten, die in beiden Eingangskanälen auftreten, um erfasste Signalkomponenten zu erhalten; und
einen Signalerzeuger (16) zum Erzeugen der drei Ausgangskanäle (12a, 12b, 12c) unter Verwendung der zwei Eingangskanäle (10a, 10b), wobei der Signalerzeuger folgende Merkmale aufweist:

einen Begrenzungserfasser (42) zum Bestimmen eines Abschnitts der Eingangskanäle, in dem eine Begrenzungswahrscheinlichkeit vorliegt;
einen Zwei-Drei-Aufwärtsmischer (16a) zum Erzeugen dreier Zwischenkanäle, wobei ein zweiter Zwischenkanal zumindest einen Abschnitt der erfassten Signalkomponenten umfasst; und
eine Steuerung (41) zum Steuern des Zwei-Drei-Aufwärtsmischers (16a), so dass ein Erzeugungsparameter zum Aufwärtsmischen des Abschnitts, der durch den Be-

grenzungsdetektor bestimmt ist, derart gesteuert wird, dass der zweite Kanal immer eine Amplitude unterhalb von oder gleich der maximalen Schwelle aufweist.

13. Verfahren zum Synthetisieren dreier Ausgangskanäle (12a, 12b, 12c) unter Verwendung zweier Eingangskanäle (10a, 10b), wobei ein zweiter Kanal (12b) der drei Ausgangskanäle in einem beabsichtigten Audiowiedergabeschema einem Lautsprecher zuführbar ist, der zwischen zwei Lautsprechern positioniert ist, denen der erste Ausgangskanal und der dritte Ausgangskanal zuführbar sind, das folgende Schritte aufweist:

Analysieren (15) der zwei Eingangskanäle zum Erfassen von Signalkomponenten, die in beiden Eingangskanälen auftreten; und
Erzeugen (16) der drei Ausgangskanäle unter Verwendung der zwei Eingangskanäle, wobei der Schritt des Erzeugens folgende Schritte aufweist:

Bestimmen (42) eines Abschnitts der Eingangskanäle, in dem eine Begrenzungswahrscheinlichkeit vorliegt;
Erzeugen (16a) dreier Zwischenkanäle, wobei ein zweiter Zwischenkanal zumindest einen Abschnitt der erfassten Signalkomponenten umfasst; und
Steuern (41) des Schritts des Erzeugens (16a), so dass ein Erzeugungsparameter zum Aufwärtsmischen des Abschnitts, der durch den Begrenzungsdetektor bestimmt wird, derart gesteuert wird, dass der zweite Kanal immer eine Amplitude unterhalb von oder gleich der maximalen Schwelle aufweist.

14. Computerprogramm zum Durchführen eines Verfahrens zum Synthetisieren gemäß Anspruch 11 oder 13, wenn dasselbe auf einem Computer läuft.

Revendications

1. Appareil pour synthétiser trois canaux de sortie (12a, 12b, 12c) à l'aide de deux canaux d'entrée (10a, 10b), dans lequel un deuxième canal parmi les trois canaux de sortie peut être alimenté vers un haut-parleur dans un schéma de rendu audio prévu qui est positionné entre deux haut-parleurs pouvant être alimentés par le premier canal de sortie et le troisième canal de sortie, comprenant:

un analyseur (15) destiné à analyser les deux canaux d'entrée pour détecter des composantes de signal se présentant dans les deux canaux d'entrée, pour obtenir des composantes de signal détectées; et
un générateur de signal (16) destiné à générer les trois canaux de sortie (12a, 12b, 12c) à l'aide des deux canaux d'entrée (10a, 10b), où le générateur de signal comprend:

un mélangeur vers le haut deux-trois (16a) destiné à générer au moins un deuxième canal intermédiaire (12b) comportant au moins une partie des composantes de signal détectées;
un détecteur d'écrêtage (16b) destiné à détecter une partie du deuxième canal ayant une amplitude au-dessus du seuil maximum; et

une commande de mélangeur vers le haut deux-trois (30; 31) destiné à commander le mélangeur vers le haut deux-trois de sorte que seule une partie des composantes de signal détectées soit alimentée vers le deuxième canal et qu'un reste des composantes de signal reste positionné dans les premier et troisième canaux de sortie lorsqu'une alimentation complète des composantes de signal détectées aurait pour conséquence que soit excédé un seuil maximum (61a, 61b) pour le deuxième canal.

2. Appareil selon la revendication 1, dans lequel le générateur de signal (16) est opérationnel pour générer les trois canaux de sortie de sorte que, pendant un certain laps de temps, une énergie totale des trois canaux de sortie et de canaux de sortie additionnels potentiellement générés soit égale à une énergie électrique ou acoustique des deux canaux d'entrée.

3. Appareil selon la revendication 1 ou 2, dans lequel le générateur de signal (16) est opérationnel pour générer le deuxième canal de sortie de sorte que la partie des composantes de signal détectées alimentée vers le deuxième canal soit aussi grande que possible, de sorte qu'une énergie du deuxième canal de sortie qui ne comporte que la partie des composantes de signal détectées ait toujours une amplitude maximale inférieure ou égale au seuil maximum (61a, 61b).

4. Appareil selon l'une quelconque des revendications précédentes, dans lequel le générateur de signal (16) est adapté de sorte qu'un reste (73) des composantes de signal détectées qui ne se situe pas dans le deuxième canal soit inclus dans les premier et troisième canaux.

5. Appareil selon l'une quelconque des revendications précédentes, dans lequel le seuil maximum (61a, 61b) est une amplitude d'échelle complète détermi-

née par l'appareil pour synthétiser ou un dispositif de traitement numérique ou analogique connecté à l'appareil pour synthétiser.

6. Appareil selon la revendication 5, dans lequel le seuil maximum (61a, 61b) est égal à une valeur d'échantillonnage positive ou négative admissible maximale d'une forme d'onde dans le domaine du temps d'un signal.

7. Appareil selon l'une quelconque des revendications précédentes, dans lequel l'analyseur (15) est opérationnel pour déterminer (84) une mesure d'une corrélation croisée entre au moins une partie du premier canal d'entrée et le deuxième canal d'entrée et pour détecter (86) une partie ayant une mesure de corrélation croisée au-dessus d'un seuil de similitude.

8. Appareil selon l'une quelconque des revendications précédentes, dans lequel l'analyseur (15) est opérationnel pour détecter (85) une énergie d'une partie du premier canal et une partie du deuxième canal et pour détecter (86) des parties des canaux ayant des énergies égales ou différentes de moins d'un seuil d'égalité.

9. Appareil selon l'une quelconque des revendications précédentes, dans lequel l'analyseur (15) et le générateur de signal (16) sont opérationnels pour effectuer une analyse et une synthèse sélectives en fréquence ou sélectives dans le temps.

10. Appareil selon l'une quelconque des revendications précédentes, dans lequel les premier et deuxième canaux sont un canal gauche (L) et un canal droit (R) d'une représentation stéréo d'un signal audio, et dans lequel les trois canaux de sortie sont un canal avant gauche (L'), un canal central (C'), et un canal avant droit (R'), ou un canal arrière gauche (L_s), un canal central arrière (C_s), et un canal arrière droit (C_s).

11. Procédé pour synthétiser trois canaux de sortie (12a, 12b, 12c) à l'aide de deux canaux d'entrée (10a, 10b), dans lequel un deuxième canal (12b) parmi les trois canaux de sortie peut être alimenté vers un haut-parleur dans un schéma de rendu audio prévu qui est positionné entre deux haut-parleurs pouvant être alimentés par le premier canal de sortie et le troisième canal de sortie, comprenant:

analyser (15) les deux canaux d'entrée pour détecter des composantes de signal se présentant dans les deux canaux d'entrée; et
générer (16) les trois canaux de sortie à l'aide des deux canaux d'entrée, où l'étape de génération comprend:

générer (16a) au moins un deuxième canal intermédiaire (12b) comportant au moins une partie des composantes de signal détectées;
détecter (16b) une partie du deuxième canal ayant une amplitude au-dessus du seuil maximum; et
commander (30; 31) l'étape de génération de sorte que seule une partie des composantes de signal détectées soit alimentée vers le deuxième canal et qu'un reste des composantes de signal reste positionné dans les premier et troisième canaux de sortie lorsqu'une alimentation complète des composantes de signal détectées aurait pour conséquence que soit excédé un seuil maximum pour le deuxième canal.

12. Appareil pour synthétiser trois canaux de sortie (12a, 12b, 12c) à l'aide de deux canaux d'entrée (10a, 10b), dans lequel un deuxième canal parmi les trois canaux de sortie peut être alimenté vers un haut-parleur dans un schéma de rendu audio prévu qui est positionné entre deux haut-parleurs pouvant être alimentés par le premier canal de sortie et le troisième canal de sortie, comprenant:

un analyseur (15) destiné à analyser les deux canaux d'entrée pour détecter les composantes de signal se présentant dans les deux canaux d'entrée, pour obtenir des composantes de signal détectées; et
un générateur de signal (16) destiné à générer les trois canaux de sortie (12a, 12b, 12c) à l'aide des deux canaux d'entrée (10a, 10b), où le générateur de signal comprend:

un détecteur d'écrêtage (42) destiné à déterminer une partie des canaux d'entrée dans laquelle existe une probabilité d'écrêtage;
un mélangeur vers le haut deux-trois (16a) destiné à générer trois canaux intermédiaires, où un deuxième canal intermédiaire comporte au moins une partie des composantes de signal détectées; et
une commande (41) destinée à commander le mélangeur vers le haut deux-trois (16a) de sorte qu'un paramètre de génération pour le mélange vers le haut de la partie déterminée par le détecteur d'écrêtage soit commandé de sorte que le deuxième canal ait toujours une amplitude inférieure ou égale au seuil maximum.

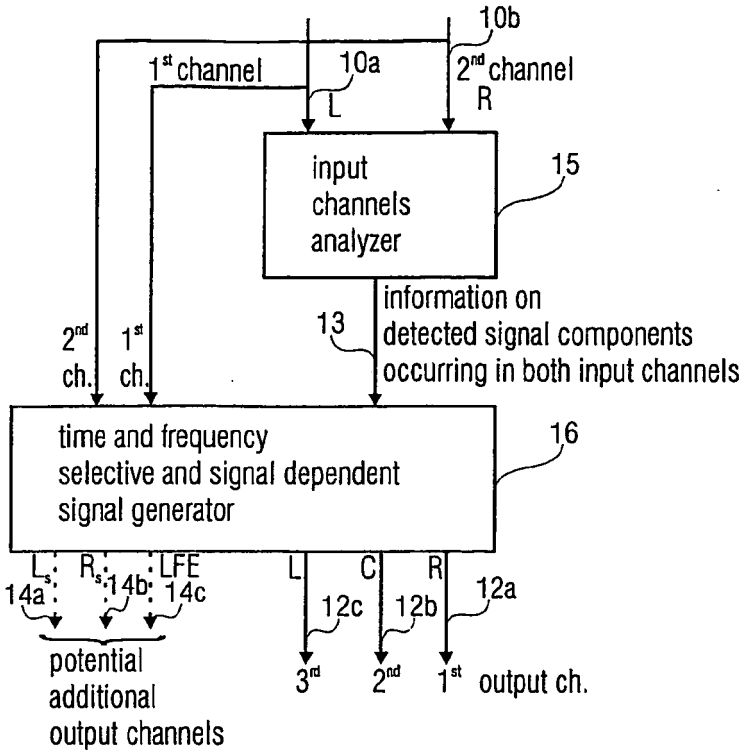
13. Procédé pour synthétiser trois canaux de sortie (12a, 12b, 12c) à l'aide de deux canaux d'entrée (10a, 10b), dans lequel un deuxième canal parmi les trois

canaux de sortie peut être alimenté vers un haut-parleur dans un schéma de rendu audio prévu qui est positionné entre deux haut-parleurs pouvant être alimentés par le premier canal de sortie et le troisième canal de sortie, comprenant:

analyser (15) les deux canaux d'entrée pour détecter les composantes de signal se présentant dans les deux canaux d'entrée; et
générer (16) les trois canaux de sortie à l'aide des deux canaux d'entrée, où l'étape de génération comprend:

déterminer (42) une partie des canaux d'entrée dans laquelle existe une probabilité d'écrêtage;
générer (16a) trois canaux intermédiaires, où un deuxième canal intermédiaire comporte au moins une partie des composantes de signal détectées; et
commander (41) l'étape de génération (16a) de sorte qu'un paramètre de génération pour le mélange vers le haut de la partie déterminée par le détecteur d'écrêtage soit commandé de sorte que le deuxième canal ait toujours une amplitude inférieure ou égale au seuil maximum.

14. Programme d'ordinateur pour réaliser, lorsqu'il est exécuté sur un ordinateur, un procédé pour synthétiser selon la revendication 11 ou 13.



2nd output channel has a portion only indicating a part of the detected signal comp.

Fig. 1

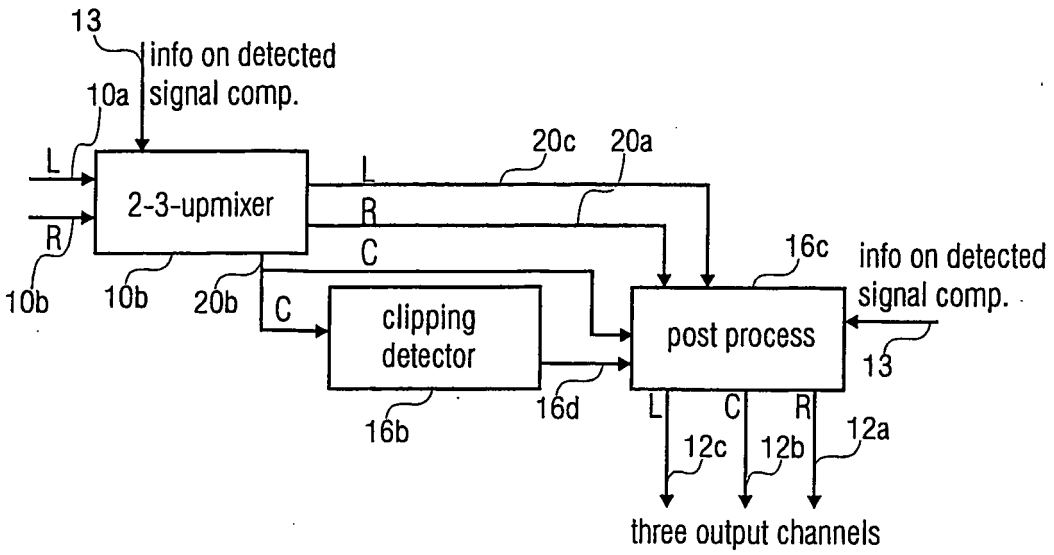

13
info on detected
signal comp.
10a
L
R
10b
10b
2-3-upmixer
L
R
C
20b
C
clipping
detector
16b
16d
20c
20a
16c
info on detected
signal comp.
13
post process
L
C
R
12c
12b
12a
three output channels

Fig. 2a

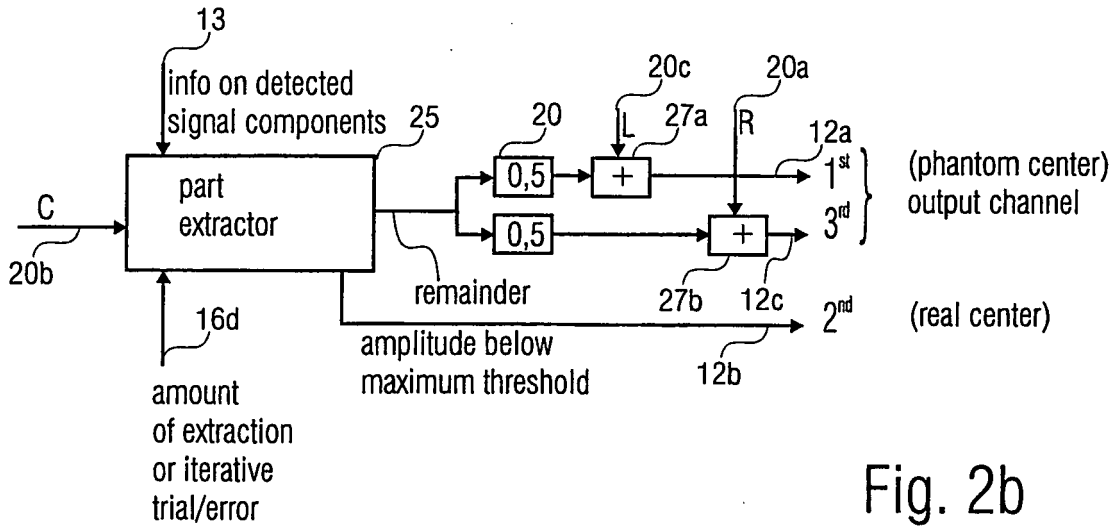

13
info on detected
signal components
25
C
20b
part
extractor
16d
amount
of extraction
or iterative
trial/error
20
0,5
0,5
20c
L
27a
20a
R
12a
+
+
1st
3rd
(phantom center)
output channel
remainder
amplitude below
maximum threshold
27b
12c
12b
2nd
(real center)

Fig. 2b

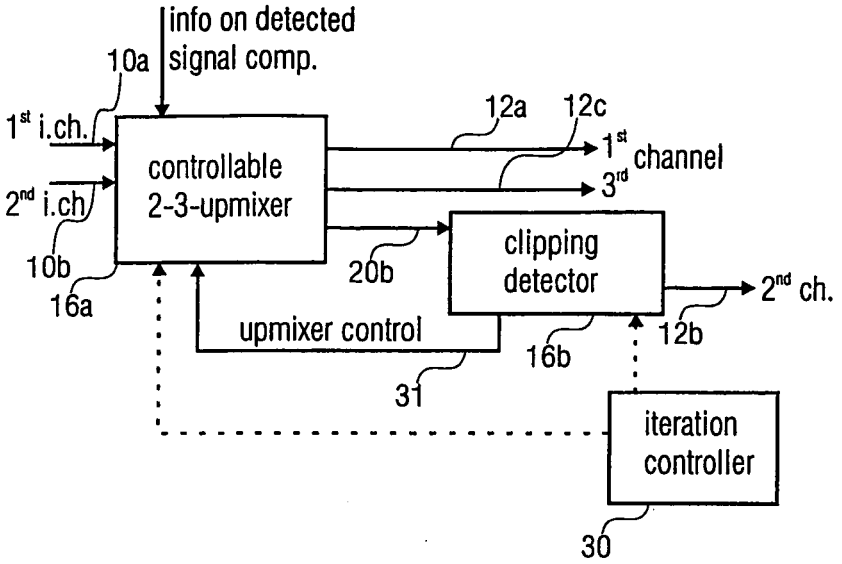

info on detected
signal comp.
10a
1st i.ch.
2nd i.ch
10b
16a
controllable
2-3-upmixer
12a
12c
1st channel
3rd
clipping
detector
20b
2nd ch.
12b
upmixer control
16b
31
iteration
controller
30

Fig. 3

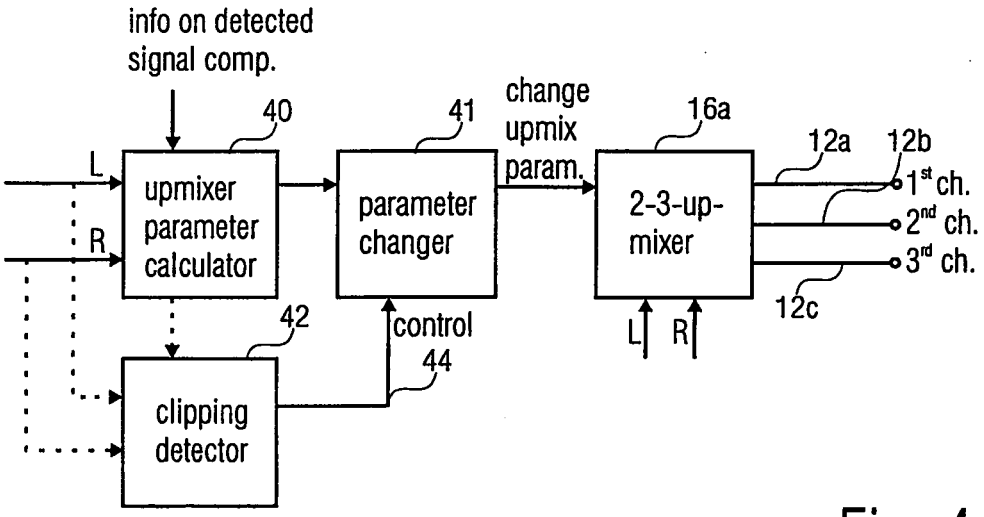

info on detected
signal comp.
40
41
change
upmix
param.
16a
12a
12b
L
R
upmixer
parameter
calculator
parameter
changer
2-3-up-
mixer
1st ch.
2nd ch.
3rd ch.
12c
42
control
44
L
R
clipping
detector

Fig. 4

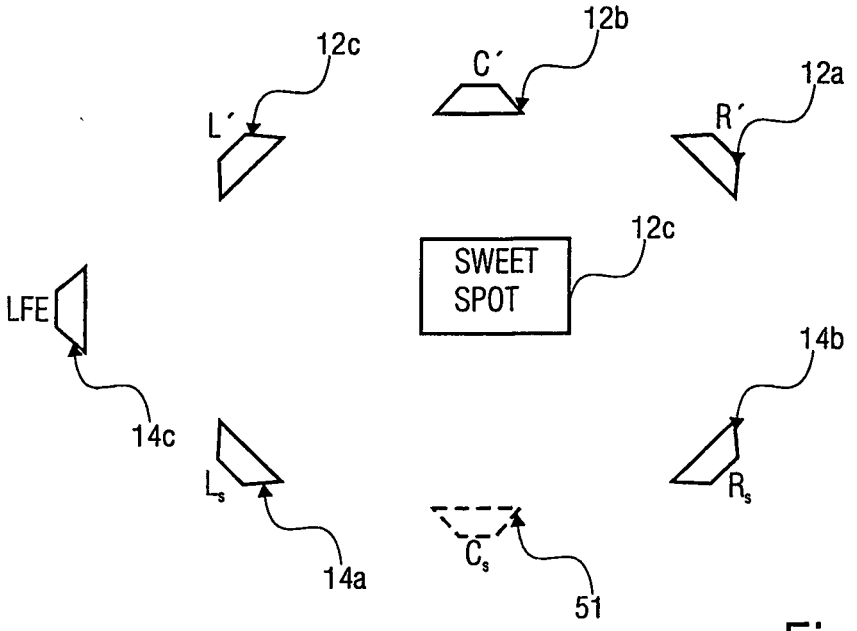

12c
L´
12b
C´
12a
R´
SWEET
SPOT
12c
LFE
14b
14c
L_s
R_s
C_s
14a
51

Fig. 5

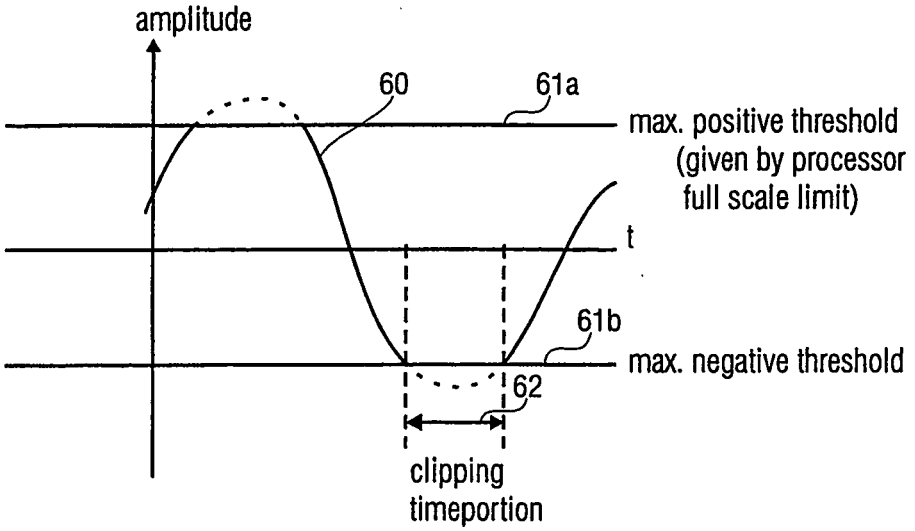

amplitude
60
61a
max. positive threshold
(given by processor
full scale limit)
t
61b
max. negative threshold
62
clipping
timeportion

Fig. 6

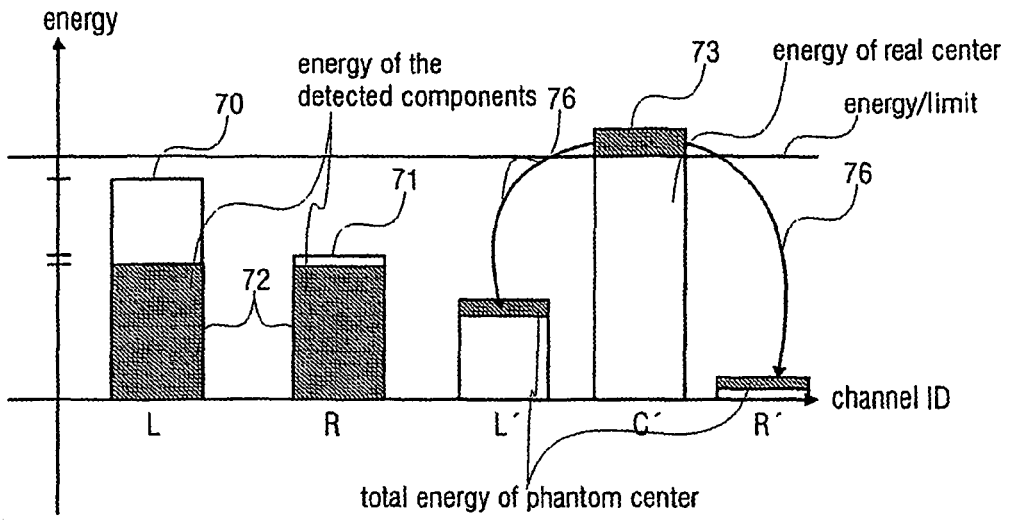

energy
energy of the
detected components
70
76
73
energy of real center
energy/limit
71
76
72
channel ID
L
R
L´
C´
R´
total energy of phantom center
energy of the complete
output signal is equal
to the energy of the complete
input signal

Fig. 7

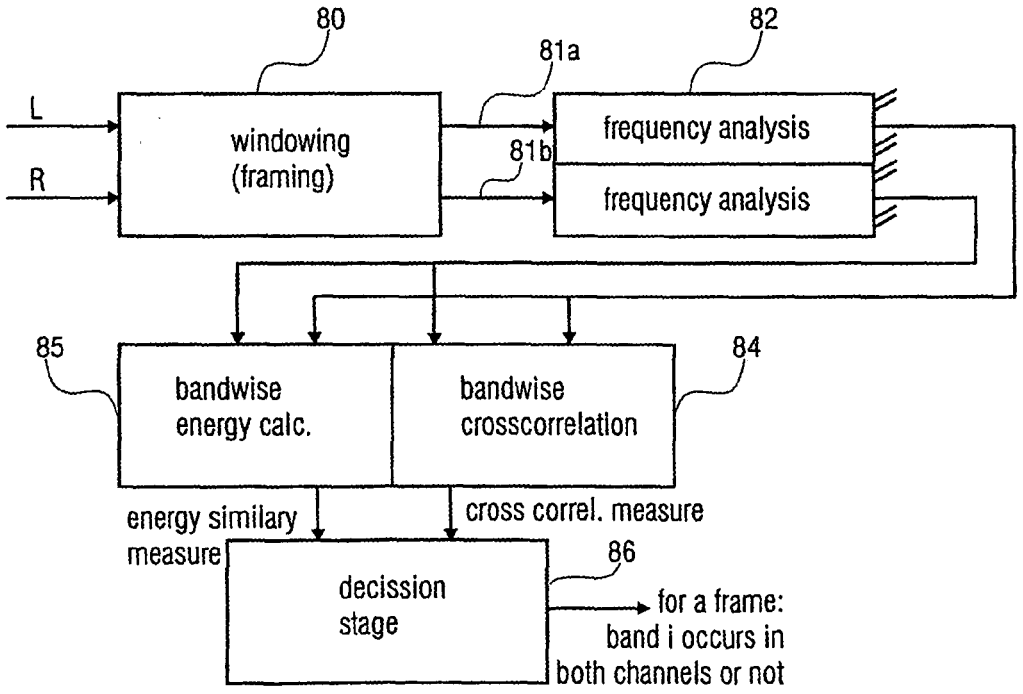

80
81a
82
L
R
windowing
(framing)
81b
frequency analysis
frequency analysis
85
84
bandwise
energy calc.
bandwise
crosscorrelation
energy similary
measure
cross correl. measure
86
decission
stage
for a frame:
band i occurs in
both channels or not

Fig. 8

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Non-patent literature cited in the description

- **J.M. Jot ; C. Avendano.** Spatial Enhancement of Audio Recordings. *AES 23rd Conference, Copenhagen,* 2003 **[0006]**
- **Griesinger, D.** Multichannel Matrix Surround Decoders for Two-Eared Listeners. *101st AES Convention, Los Angeles, USA,* 1996 **[0013]**
- Digital Audio Effects DAFX. Wiley & Sons, 2002, 99ff **[0014]**
- **Jot ; Avendano.** Spatial enhancement of audio recordings. *23rd International AES Conference, Copenhagen, Denmark,* 23 May 2003 **[0050]**