

(19)



(11)

EP 1 754 222 B1

(12)

EUROPEAN PATENT SPECIFICATION

(45) Date of publication and mention of the grant of the patent:
14.11.2007 Bulletin 2007/46

(51) Int Cl.:
G10L 19/00 (2006.01)

(21) Application number: **06724214.9**

(86) International application number:
PCT/EP2006/003284

(22) Date of filing: **10.04.2006**

(87) International publication number:
WO 2006/111294 (26.10.2006 Gazette 2006/43)

(54) **ENERGY DEPENDENT QUANTIZATION FOR EFFICIENT CODING OF SPATIAL AUDIO PARAMETERS**

ENERGIEABHÄNGIGE QUANTISIERUNG FÜR EFFIZIENTE KODIERUNG RÄUMLICHER AUDIOPARAMETER

AMELIORATION DU CODAGE DES VALEURS D'AUDIOMETRIE TRIDIMENSIONNELLE PAR DES MESURES SUR LA BASE DE L'ENERGIE

(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

- **BREEBAART, Jeroen**
NL-5621 BA Eindhoven (NL)
- **SCHUIJERS, Erik**
NL-5621 BA Eindhoven (NL)
- **VAN DE PAR, Steven**
NL-5621 BA Eindhoven (NL)
- **HILPERT, Johannes**
90411 Nuernberg (DE)
- **HERRE, Jürgen**
91054 Buckenhof (DE)

(30) Priority: **19.04.2005 US 672943 P**

(43) Date of publication of application:
21.02.2007 Bulletin 2007/08

- (73) Proprietors:
- **Coding Technologies AB**
113 52 Stockholm (SE)
 - **Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e.V.**
80686 München (DE)
 - **Koninklijke Philips Electronics N.V.**
5621 BA Eindhoven (NL)

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

- (72) Inventors:
- **ROEDEN, Jonas**
S-169 55 Solna (SE)
 - **ENGDEGARD, Jonas**
S-115 43 Stockholm (SE)
 - **PURNHAGEN, Heiko**
S-172 65 Sundbyberg (SE)

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- **PURNHAGEN H: "Low complexity parametric stereo coding in mpeg-4" PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON DIGITAL AUDIO EFFECTS, NAPLES (ITALY), 5 October 2004 (2004-10-05), pages 163-168, XP002364489**

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DescriptionField of the invention

5 **[0001]** The present invention relates to quantization of spatial audio parameters and in particular to a concept to allow for a more efficient compression without significantly reducing the perceptual quality of an audio signal reconstructed using the quantized spatial audio parameters.

Background of the invention and prior art

10 **[0002]** Recently, multi-channel audio reproduction techniques are becoming more and more important. In the view of an efficient transmission of multi-channel audio signals having 5 or more separate audio channels, several ways of compressing a stereo or multi-channel signal have been developed. Recent approaches for the parametric coding of multi-channel audio signals (parametric stereo (PS), "Binaural Cue Coding" (BCC) etc.) represent a multi-channel audio
15 signal by means of a down-mix signal (could be monophonic or comprise several channels) and parametric side information, also referred to as "spatial cues", characterizing its perceived spatial sound stage.

[0003] A multi-channel encoding device generally receives - as input - at least two channels, and outputs one or more carrier channels and parametric data. The parametric data is derived such that, in a decoder, an approximation of the original multi-channel signal can be calculated. Normally, the carrier channel (channels) will include subband samples, spectral coefficients, time domain samples, etc., which provide a comparatively fine representation of the underlying
20 signal, while the parametric data do not include such samples of spectral coefficients but include control parameters for controlling a certain reconstruction algorithm instead. Such a reconstruction could comprise weighting by multiplication, time shifting, frequency shifting, phase shifting, etc. Thus, the parametric data includes only a comparatively coarse representation of the signal or the associated channel.

25 **[0004]** The binaural cue coding (BCC) technique is described in a number of publications, as in "Binaural Cue Coding applied to Stereo and Multi-Channel Audio Compression", C. Faller, F. Baumgarte, AES convention paper 5574, May 2002, Munich, in the 2 ICASSP publications "Estimation of auditory spatial cues for binaural cue coding", and "Binaural cue coding: a normal and efficient representation of spatial audio", both authored by C. Faller, and F. Baumgarte, Orlando, FL, May 2002.

30 **[0005]** In BCC encoding, a number of audio input channels are converted to a spectral representation using a DFT (Discrete Fourier Transform) based transform with overlapping windows. The resulting uniform spectrum is then divided into nonoverlapping partitions. Each partition has a bandwidth proportional to the equivalent rectangular bandwidth (ERB). Then, spatial parameters called ICLD (Inter-Channel Level Difference) and ICTD (Inter-Channel Time Difference) are estimated for each partition. The ICLD parameter describes a level difference between two channels and the ICTD
35 parameter describes the time difference (phase shift) between two signals of different channels. The level differences and the time differences are normally given for each channel with respect to a reference channel. After the derivation of these parameters, the parameters are quantized and finally encoded for transmission.

[0006] Although ICLD and ICTD parameters represent the most important sound source localization parameters, a spatial representation using these parameters can be enhanced by introducing additional parameters.

40 **[0007]** A related technique, called "parametric stereo" describes the parametric coding of a two-channel stereo signal based on a transmitted mono signal plus parameter side information. There, 3 types of spatial parameters, referred to as inter-channel intensity difference (IIDs), inter-channel phase differences (IPDs), and inter-channel coherence (IC) are introduced. The extension of the spatial parameter set with a coherence parameter (correlation parameter) enables a parametrization of the perceived spatial "diffuseness" or spatial "compactness" of the sound stage. Parametric stereo
45 is described in more detail in: "Parametric Coding of stereo audio", J. Breebaart, S. van de Par, A. Kohlrausch, E. Schuijers (2005) Eurasip, J. Applied Signal Proc. 9, pages 1305-1322", in "High-Quality Parametric Spatial Audio Coding at Low Bitrates", J. Breebaart, S. van de Par, A. Kohlrausch, E. Schuijers, AES 116th Convention, Preprint 6072, Berlin, May 2004, and in "Low Complexity Parametric Stereo Coding", E. Schuijers, J. Breebaart, H. Purnhagen, J. Engdegard, AES 116th Convention, Preprint 6073, Berlin, May 2004.

50 **[0008]** The international publication WO 2004/008805 A1 teaches, how a multi-channel audio signal can be advantageously compressed by combining several parametric stereo modules, thus realizing a hierarchical structure to derive a representation of the original multi-channel audio signal comprising a down-mix signal and parametric side information.

[0009] Within the BCC and parametric stereo (PS) approach, a representation of the level differences (also called intensity differences ICLD or energy differences IID) between audio channels is a vital part of a parametric representation
55 of a stereophonic/multi-channel audio signal. Such information and other spatial parameters are transmitted from the encoder to the decoder for each time/frequency slot. In the view of coding efficiency, it is therefore of high interest to represent these parameters as compactly as possible while preserving audio quality.

[0010] In BCC coding, the level differences are represented relative to a so-called "reference channel" and are quan-

tized on a uniform scale in units of dB relative to a reference channel. This does not optimally exploit the fact that channels with low level with respect to the reference channel are subject to a significant masking effect when listened to by human listeners. In the extreme case of a channel having no signal at all, the bandwidth used by parameters describing this particular channel is completely wasted. In the more common case, where one channel is much fainter than another channel, that is a listener can hardly hear the faint channel during the playback, a less precise reproduction of the faint channel would also lead to the same perceptual quality of the listener, as the faint signal is mainly masked by the stronger signal.

[0011] To explain the situation and the problems arising when encoding a multi-channel signal, reference is made to Fig. 10a where a commonly used 5-channel signal is illustrated. The 5-channel configuration is having a left rear channel 101 (A, having a signal $a(t)$), a left front channel 102 (B, having a signal $b(t)$), a center channel 103 (C, having a signal $c(t)$), a right front channel 104 (D, having a signal $d(t)$) and a right back channel 105 (E, having a signal $e(t)$). Intensity relations between single channels or channel pairs are marked with arrows. Hence, the intensity distribution between the front left channel 102 and the front right channel 104 is marked r_1 (110), the intensity distribution between the left back channel and the right back channel is marked r_4 (112). The intensity distribution between the combination of the left front channel 102 and the right front channel 104 and the center channel 103 is marked r_2 (114) and the intensity distribution between the combination of the back channels and the combination of the front channels is marked r_3 (116).

[0012] When, for example, a simple monologue is recorded, most of the energy would be contained in the center channel 103. In this example, especially the back channels will contain only little (or 0) energy. Therefore, parameters describing the properties of the back channels are merely wasted in this example, since mainly the center channel 102 or the front channels will be active during the play back.

[0013] Based on Fig. 10a, ways of computing the energy distribution between channels or channel combinations are described within the following paragraph.

[0014] Fig. 10a illustrates a multi channel parameterization for a five channel speaker set-up where the different audio channels are indicated by 101 to 105; $a(t)$ 101 represents signal of the left surround channel, $b(t)$ 102 represents the signal of the left front channel, $c(t)$ 103 represents the signal of the center channel, $d(t)$ 104 represents the signal of the right front channel, $e(t)$ 105 represents the signal of the right surround channel. The speaker set-up is divided into a front part and a back part. The energy distribution between the entire front channel set-up (102, 103 and 104) and the back channels (101 and 105) are illustrated by the arrow in Fig. 10a and indicated by the r_3 parameter. The energy distribution between the center channel 103 and the left front 102 and right front 103 channels are indicated by r_2 . The energy distribution between the left surround channel 101 and the right surround channel 105 is illustrated by r_4 . Finally, the energy distribution between the left front channel 102 and the right front channel 104 is given by r_1 . Since r_1 to r_4 are parameterizations of different regions it is also clear that beside energy distribution also other essential region properties can be parameterized, as for example the correlation between the regions. Additionally for each parameter r_1 to r_4 a local energy can be calculated. For example the local energy of r_4 is the summed energy of channel A 101 and E 105.

$$LocalEnergy_{r_4} = E[a^2(t)] + E[e^2(t)] .$$

[0015] Where $E[.]$ is the expected value as defined by

$$E[f(x)] = \frac{1}{T} \int_0^T f(x(t)) dt .$$

[0016] Fig. 10b shows a multi-channel audio decoder built by hierarchically ordering parametric stereo modules, as for example described in WO 2004/008805 A1. Here, the audio channels 101 to 105, as introduced in Fig. 10a, are reproduced step by step from a single monophonic down-mix signal 120 (M) and corresponding side information by a first two-channel decoder 122, a second two-channel decoder 124, a third two-channel decoder 126, and a fourth two-channel decoder 128. As can be seen, in the treelike structure in Fig. 10b, the first two-channel decoder decomposes the monophonic down-mix signal 120 into two signals fed into the second and the third two-channel decoders 124 and 126. Therein, the channel fed into the third two-channel decoder 126 is a combined channel, being combined from the left back channel 101 and the right back channel 105. The channel fed into the second two-channel decoder 124 is a

combination of the center channel 103 and a combined channel which is again being a combination of the front left channel 102 and of the front right channel 104.

[0017] Thus, after the second step of the hierarchical decoding, the left back channel 101, the right back channel 105, the center channel 103, and a combined channel, being a combination of the front left channel 102 and the front right channel 104 are reconstructed, using the transmitted spatial parameters, that are comprising a level parameter for use by each of the two-channel decoders 122, 124, and 126.

[0018] In the third step of the hierarchical decoding, the fourth two-channel decoder 128 derives the front left channel 102 and the front right channel 104, using a level information transmitted as side information for the fourth two-channel decoder 128. Using a prior art hierarchical decoder as shown in Fig. 10b, the desired energy for each single output channel follows from various different parametric stereo modules between the input signal and each output signal. In other words, the energy of a specific output channel can depend on the IID/ICLD parameters of multiple parametric stereo modules. In such a treelike structure of connected parametric stereo modules, also a non-uniform quantization of IID parameters can be applied within each parametric stereo module to produce IID values, which are then used by a decoder as part of the side information. This would exploit the benefits of non-uniform IID quantization locally (i.e. within each parametric stereo module individually), nonetheless it is sub-optimum because quantization in each module ("leaves") is carried out independently of the energies/level of other audio channels that may be high in relative level and, therefore, produce masking.

[0019] This is possible, since "leaf" modules are not aware of the global level distribution at a higher tree level (e.g. the "root" module). Each leaf has its own corresponding IID/ICLD parameter, which indicates the energy distribution from its input toward output channels. For example, the IID/ICLD parameter of leaf "r₃" (processed by the first two-channel decoder 122) may indicate that 90 % of the incoming energy should be sent to leaf r₂, while the remaining energy (10 %) should be sent to leaf r₄. This process is repeated for each leaf in the tree. Since each energy distribution parameter is represented with limited accuracy, the deviation between the desired and the actual energy of each output channel A to E depends on the quantization errors in the IID/ICLD parameters, as well as on the energy distribution (and hence propagation of quantization errors). In other words, as the same quantization table is used for a certain parameter type, e.g. ICC or IID, within all parameterization stages r₁ to r₄, the IID/ICLD quantization is performed optimal only locally. This means that for each parameterization stage r₁ to r₄, the error in output energy of the (local) output channels is maximum for the weakest output channel in prior art implementations.

[0020] As detailed in the previous paragraphs, the quantization of level parameters (IID or ICLD) or other parameters such as ICC, phase differences or time differences describing the spatial perception of a multi-channel audio signal is still sub-optimal, since bandwidth may be wasted for spatial parameters describing channels that are mainly masked due to low energy within the channel.

Summary of the invention

[0021] It is the object of the present invention to provide an improved concept for quantization of spatial parameters of a multi-channel audio signal.

[0022] According to a first aspect of the present invention this object is achieved by a parameter quantizer for quantizing an input parameter, wherein the input parameter is a measure for a characteristic of a single channel or a pair of channels with respect to another single channel or a pair of channels of a multi-channel signal, comprising: a quantization rule generator for generating a quantization rule based on a relation of an energy measure of the channel or the pair of channels and an energy measure of the multi-channel signal; and a value quantizer for deriving a quantized parameter from the input parameter, using the generated quantization rule.

[0023] According to a second aspect of the present invention this object is achieved by a parameter dequantizer for dequantizing a quantized parameter to derive a parameter, wherein the parameter is a measure for a characteristic of a single channel or a pair of channels with respect to another single channel or a pair of channels of a multi-channel signal, comprising: a dequantization rule generator for generating a de-quantization rule based on a relation of an energy measure of the channel or the pair of channels and an energy measure of the multi-channel signal; and a value dequantizer for deriving the parameter from the quantized parameter, using the generated dequantization rule.

[0024] According to a third aspect of the present invention this object is achieved by a method of quantizing an input parameter, wherein the input parameter is a measure for a characteristic of a single channel or a pair of channels with respect to another single channel or a pair of channels of a multi-channel signal, the method comprising: generating a quantization rule based on a relation of an energy measure of the channel or the pair of channels and an energy measure of the multi-channel signal; and deriving a quantized parameter from the input parameter using the generated quantization rule.

[0025] According to a fourth aspect of the present invention this object is achieved by a method of dequantizing a quantized parameter to derive a parameter, wherein the parameter is a measure for a characteristic of a single channel or a pair of channels with respect to another single channel or a pair of channels of a multi-channel signal, the method

comprising: generating a dequantization rule based on a relation of an energy measure of the channel or the pair of channels and an energy measure of the multi-channel signal; and deriving the parameter from the quantized parameter using the generated dequantization rule.

5 [0026] According to a fifth aspect of the present invention this object is achieved by a representation of a multi-channel signal having a quantized parameter being a quantized representation of a parameter being a measure for a characteristic of a single channel or a pair of channels, wherein the parameter is a measure for a characteristic of the single channel or the pair of channels with respect to another single channel or a pair of channels of a multi-channel signal, wherein the quantized parameter is derived using a quantization rule based on a relation of an energy measure of the channel or the pair of channels and an energy measure of the multi-channel signal.

10 [0027] According to a sixth aspect of the present invention this object is achieved by a machine-readable storage medium having stored thereon a representation of a multi-channel signal as described above.

15 [0028] According to a seventh aspect of the present invention this object is achieved by a transmitter or audio recorder having a parameter quantizer for quantizing an input parameter, wherein the input parameter is a measure for a characteristic of a single channel or a pair of channels with respect to another single channel or a pair of channels of a multi-channel signal, comprising: a quantization rule generator for generating a quantization rule based on a relation of an energy measure of the channel or the pair of channels and an energy measure of the multi-channel signal; and a value quantizer for deriving a quantized parameter from the input parameter, using the generated quantization rule.

20 [0029] According to an eighth aspect of the present invention this object is achieved by a receiver or audio player having a parameter dequantizer for dequantizing a quantized parameter to derive a parameter, wherein the parameter is a measure for a characteristic of a single channel or a pair of channels with respect to another single channel or a pair of channels of a multi-channel signal, comprising: a dequantization rule generator for generating a dequantization rule based on a relation of an energy measure of the channel or the pair of channels and an energy measure of the multi-channel signal; and a value dequantizer for deriving the parameter from the quantized parameter, using the generated dequantization rule.

25 [0030] According to a ninth aspect of the present invention this object is achieved by a method of transmitting or audio recording, the method comprising a method of quantizing an input parameter, wherein the input parameter is a measure for a characteristic of a single channel or a pair of channels with respect to another single channel or a pair of channels of a multi-channel signal, the method comprising: generating a quantization rule based on a relation of an energy measure of the channel or the pair of channels and an energy measure of the multi-channel signal; and deriving a quantized parameter from the input parameter using the generated quantization rule.

30 [0031] According to a tenth aspect of the present invention this object is achieved by a method of receiving or audio playing, the method having a method of dequantizing a quantized parameter to derive a parameter, wherein the parameter is a measure for a characteristic of a single channel or a pair of channels with respect to another single channel or a pair of channels of a multi-channel signal, the method comprising: generating a dequantization rule based on a relation of an energy measure of the channel or the pair of channels and an energy measure of the multi-channel signal; and deriving the parameter from the quantized parameter using the generated dequantization rule.

35 [0032] According to an eleventh aspect of the present invention this object is achieved by a transmission system having a transmitter and a receiver, the transmitter having a parameter quantizer for quantizing an input parameter; and the receiver having a parameter dequantizer for dequantizing a quantized parameter.

40 [0033] According to a twelfth aspect of the present invention this object is achieved by a method of transmitting and receiving, the method including a transmitting method having a method of quantizing an input parameter; and the method including a method of receiving including a method of dequantizing a quantized.

[0034] According to a thirteenth aspect of the present invention this object is achieved by a computer program for performing, when running on a computer, one of the above methods.

45 [0035] The present invention is based on the finding that parameters being a measure for a characteristic of a single channel or of a pair of channels with respect to another single channel or of a pair of channels of a multi-channel signal can be quantized more efficiently using a quantization rule that is generated based on a relation of an energy measure of the channel or the pair of channels and an energy measure of the multi-channel signal.

50 [0036] The inventive concept has the major advantage that a quantization rule is either generated or an appropriate quantization rule is selected from a group of available quantization rules, depending on the energy of the signal to be described. Therefore, a psycho-acoustic model can be applied to a quantizer during encoding or a dequantizer during decoding, to use a quantization rule adapted to the needs of the actual signal. Especially, when a channel contains very little energy compared to other channels within the multi-channel signal, the quantization can be much more coarse than for signals having high energies. This is due to the fact that the high energy signals mask the low energy signals during playback, i.e. a listener will hardly recognize any details of the low energy signal and thus the low energy signal can be deteriorated more through coarse quantization without the listener being able to recognize the falsification because of the high masking of the low energy signal.

55 [0037] In one embodiment of the present invention, a parameter quantizer for quantizing parameters is having a

quantization rule generator for generating a quantization rule and a value quantizer for deriving quantized parameters from input parameters using the generated quantization rule. To generate an appropriate quantization rule, the quantizer selector receives as an input the total energy of the multi-channel audio signal to be coded and the local energy of the channel or the pair of channels whose spatial parameters are to be quantized. Knowing the total energy and the local energy, the quantizer selector can decide, which quantization rule to use, i.e. select coarser quantization rules for channels or channel pairs having comparatively low local energy. Alternatively, the quantizer selector could also derive an algorithmic rule to modify an existing quantization rule or to calculate a completely new quantization rule depending on the local and the total energy. One possibility would for example be to calculate a general scale factor to be applied to a signal before a linear quantizer or a non-linear quantizer to achieve the goal of reducing the size of the side information to be transmitted.

[0038] In a further embodiment of the present invention a multi channel signal is encoded in a pairwise manner, i.e. by using a hierarchical structure that is having several 2-to-1 down-mixers ordered in a tree-like structure, each downmixer generating a mono channel out of two channels input into the downmixer. Following the inventive concept, energy dependent quantization can now be implemented not only locally, i.e. at each 2-to-1 downmixer having the information available at the input of the 2-to-1 downmixer only, but based on the global knowledge on the sum of the signal energies. This enhances the perceptual quality of a perceptual signal significantly.

[0039] It is evident that following the inventive concept, the side information size can be decreased while the quality of the encoded multi-channel audio signal is hardly affected.

[0040] In a further embodiment of the present invention, an inventive parameter quantizer is incorporated in a parameter encoder before a differential encoder and a Huffman encoder, both of which are used for further encoding the quantized parameters to derive a parameter bit stream. Such an inventive encoder has the great advantage that in addition to decreasing the size of code words needed to describe the quantized parameters, a coarser quantization will automatically increase the abundance of identical code words fed into the differential encoder and the Huffman encoder, which allows for a better compression of the quantized parameters, further reducing the size of the side information.

[0041] In a further embodiment of the present invention, an inventive parameter quantizer is having a quantizer factor function generator and a parameter multiplier. The quantizer factor function generator receives the total and the local energy as input and derives a single scaler value from the input quantities. The parameter multiplier receives the parameters and the derived quantizer factor f to divide the parameters by the quantizer factor prior to transferring the modified parameters to the quantizer that applies a fixed quantization rule to the modified parameters.

[0042] A variation of this embodiment is to have a parameter multiplier after the quantizer and hence use the derived quantizer factor f to divide the resulting index out of the quantizer. The result of this then needs to be rounded into an integer index again.

[0043] Application of a scaling factor to the parameters has the same effect as choosing different quantization rules, since for example division by a big factor compresses the input parameter space such that effectively only a smaller part of a already existing quantization rule would be effective. This solution has the advantage that on the decoder and the encoder side additional memory can be saved because there is only one quantization rule to be stored or to be processed since the scaling is done by a simple multiplication requiring only limited additional hard- or software. An additional advantage is that by applying a quantizer factor, the quantizer factor can be derived using any possible functional dependence. Therefore, a quantizer or dequantizer sensitivity can be adjusted continuously within the whole possible input parameter space rather than selecting predefined quantization rules out of a given sample.

Brief description of the drawings

[0044] Preferred embodiments of the present invention are subsequently described by referring to the enclosed drawings, wherein:

Fig. 1 shows a block diagram of an inventive parameter quantizer;

Figs. 2a to c show several possible quantization rules to be applied;

Fig. 3 shows a parameter encoder having an inventive parameter quantizer;

Figs. 4a, 4b show an alternative embodiment of a parameter encoder having an inventive parameter quantizer;

Fig. 5 shows examples of scale factor functions;

Fig. 6 shows a non-linear quantization rule;

- Fig. 7 shows an inventive parameter dequantizer;
- Fig. 8 shows a parameter decompressor having an inventive parameter dequantizer;
- 5 Fig. 9a shows an embodiment of an inventive parameter dequantizer;
- Fig. 9b shows a further embodiment of an inventive parameter dequantizer;
- Fig. 9c shows an example for implementing energy dependent dequantization;
- 10 Fig. 9d shows a further example for implementing energy dependent dequantization.
- Fig. 9e shows examples of quantization and dequantization of parameters;
- 15 Fig. 10a shows a representation of a 5-channel multi-channel audio signal; and
- Fig. 10b shows a hierarchical parametric multi-channel decoder according to prior art.

Detailed description of preferred embodiments

20 **[0045]** Fig. 1 shows an inventive parameter quantizer 199 having a quantizer 200 and a quantizer selector 202. The quantizer selector 202 receives the local energy of the channel or the pair of channels underlying the parameters to be encoded and the total energy of the multi-channel audio signal. Based on both energy informations, the quantizer selector 202 generates a quantization rule that is used by the quantizer 200 to derive a quantized parameter 204 from a parameter 206 input into the quantizer 200. Hence, in this case the quantizer selector 202 serves as a quantization rule generator.

25 **[0046]** The input parameters to the quantizer selector 202 are the total energy of the original multi-channel signal and the local energy for the channel described by the parameter to be quantized. In a preferred embodiment of the present invention the ratio between the local energy and the total energy gives a measure that can be used to decide which quantizer to use. As an example this ratio q (Relative Local energy) can be calculated in dB, using the following equation:

$$q = 10 \cdot \log_{10} \left(\frac{\text{LocalEnergy}}{\text{TotalEnergy}} \right)$$

35 **[0047]** The selected quantizer is then used to quantize the parameter 206 with the quantizer .

40 **[0048]** The present invention teaches that a coarser quantization of IID/ICLD parameters (and the like) can be used if a parametrization stage is lower in energy compared to the total energy, i.e. when the relative Local energy q is small. The present invention utilizes the psycho-acoustic relation that it is more important to parameterize the dominant/high energy signals with high accuracy than the audio signal with less significance/low energy. To make this even clearer; reference is again made to Fig. 10a. When within an audio scene in the original multi-channel signal the energy/signal is primarily present in the front image, meaning the left front channel 102, the center channel 103 and the right front channel 104, the surround channels can be quantized with less accuracy since the surround channels have much less energy. The additional quantization error introduced from the coarser quantization cannot be perceived since the front channels have much higher energy and hence the quantization error of r_4 (and the resulting energy errors for surround channels A and E) is masked by channels B, D, and/or C.

45 **[0049]** In the most extreme example, the surround channels A and E only have some faint noise and the front channels B, C, and D have full amplitude signals. In such a case, a 16 bit PCM original signal would indicate an energy difference of more than 80 dB. Therefore, parameter r_4 could be quantized arbitrarily coarse without introducing any audible differences due to (coarse) quantization.

50 **[0050]** Figs. 2a to 2c show three possible quantization rules introducing different levels of quantization errors. All figures show the original parameter on their x-axis and the integer values assigned to the parameters on their y-axis. Furthermore the Figs. 2a to 2c show dashed lines which correspond to indices for each quantization step and hence can be used for transmission or storage. The transmitted indices can then be used on the decoder side, for example in combination with a lookup-table, for de-quantization.

55 **[0051]** The finest quantization is indicated in Fig. 2a by the quantization curve 230 that maps discrete parameter intervals of the x-axis to 13 integer values. Intermediate quantization is achieved by the quantization curve 232 in Fig.

2b, whereas the coarsest quantization is achieved by the quantization curve 234 of Fig. 2c. It is obvious that the quantization error introduced is biggest in the example shown in Fig. 2c and smallest in the example shown in Fig. 2a.

[0052] These three quantization rules are examples of quantization rules that may be selected by the quantizer selector 202. In other words, Figs. 2a to c illustrate three different linear quantization rules, where the x-axis describes the input value and the y-axis gives the corresponding quantized value. Figs. 2a to 2c all have the same scale on the x-axis and y-axis and hence, Fig. 2a has the finest quantization of the three and thus the smallest quantization error. Fig. 2c has the coarsest quantization and thus the largest quantization error. It would also yield the lowest bit rate after differential coding and Huffman coding since it has the smallest amount of quantization steps.

[0053] As an example, a possible quantization rule generation could be based on the relative Local energy q between the local energy and the total energy, as introduced above. A possible range of q-values with corresponding selections of quantization rules is summarized, as an example, within the following table:

Value of q [dB]	Selected Quantizer
0 <= q <-10	Fine quantization Fig. 2A
-10 <= q <-20	Medium quantization Fig. 2B
-20 <= q	Coarse quantization Fig. 2C

[0054] Fig. 3 shows an inventive parameter compressor having an inventive parameter quantizer 199, a differential encoder 220, and a Huffman encoder 222. The inventive parameter encoder of Fig. 3 extends the parameter quantizer of Fig. 1 by using the quantized parameters as input for the differential encoder 220 that differentially encodes the quantized parameters 204 to derive differentially encoded quantized parameters that are then input into the Huffman encoder 222 that applies a Huffman coding scheme to the differentially encoded quantized parameters deriving a parameter bitstream element 224 of a final parameter bit stream as output.

[0055] The combination of an inventive parameter quantizer with a differential encoder and a Huffman encoder is particularly attractive since coarser quantization results in a higher abundance of equal symbols (quantized parameters). The combination of the differential encoder 220 and the Huffman encoder 222 will evidently provide an encoded representation of the quantized parameters (parameter bitstream element 224) that is more compact, when the maximum number of possible input symbols is decreased by a coarser quantization.

[0056] Fig. 4a shows a further embodiment of an inventive parameter encoder using an inventive parameter quantizer 250, a differential encoder 252, and a Huffman encoder 254.

[0057] The parameter quantizer 250 is having a quantizer factor generator 256, a parameter scaler 258, and a quantizer 260. In this case the quantizer factor generator 256 together with the parameter scaler 258 serve as a quantization rule generator.

[0058] The quantizer function generator 256 receives as input the total energy of the multi-channel audio signal and the local energy of the channel or the channel pair for the parameter to be quantized. The quantizer factor generator 256 generates a scale factor 262 (f) based on the local energy and the total energy. In a preferred embodiment this is done on a basis of a ratio between the local energy and the total energy resulting in a relative local energy q, as follows:

$$q = 10 \cdot \log_{10} \left(\frac{LocalEnergy}{TotalEnergy} \right)$$

[0059] This ratio q can be used within the quantizer factor generator 256 to calculate the quantizer factor f (262) that is used as input for the parameter scaler 258 that additionally receives the parameter to be quantized.

[0060] The parameter scaler 258 applies a scaling to the input parameter that could for example be a division of the parameter by the quantizer factor 262. The scaling of the parameter is equivalent to selecting different quantization rules. The scaled parameter is then input into a quantizer 260 that applies a fixed quantization rule within this embodiment of the present invention. The further processing of the quantized parameter is equal to the processing of Fig. 3, the parameter is differentially encoded and afterwards Huffman encoded to finally yield a parameter bit stream element.

[0061] Applying a scaling factor to the parameters has the advantage that the quantization rule could be adapted to the needs in a continuous way, since an analytical function deriving the quantization factor 262 can basically have any form.

[0062] Fig. 4b shows a further embodiment of an inventive parameter encoder 270 which is similar to the inventive

parameter encoder 250 shown in Fig. 4a. Therefore, only the differences to parameter encoder 250 shall be explained shortly within the following paragraph.

[0063] The inventive parameter encoder 270 is not having a parameter scaler (parameter scaler 258 of parameter encoder 250). To achieve an energy dependency of quantization, the parameter quantizer 270 is having a compression device 272 instead. That means the quantizer factor generator 256 together with the compression device 258 serve as a quantization rule generator in this case. The compression device 272 is connected to the quantizer 260 and to the quantizer factor generator 256. The compression unit 272 receives as an input a quantized parameter that is quantized by the quantizer 260 according using a fixed quantization scheme. To implement the energy dependence, the compression unit uses the quantized parameter as input and scales the quantized parameter using the scale factor 262. This saves bit rate by decreasing the possible number of quantized parameters to be transmitted to the delta coder 252. This compression can for example be achieved by a division of the quantized parameter index by the scaling factor 262.

[0064] Possible functions to derive the scale factor 262 from the relative Local energy ratio q are shown in Fig. 5. Fig. 5 shows as an example four different possible functions 300, 302, 303, and 304 that can be used to derive the scale factor f . The first factor function 300 is a constant function and thus has no energy dependency.

[0065] The factor functions 302, and 304 show two possibilities to implement factor functions, wherein the factor function 302 is the less aggressive one and would therefore increase the introduced quantization error less than using factor function 304. On the other hand, factor function 302 would save less bit rate than factor function 304. Factor function 303 shows a fourth possibility to derive the quantizer factor from the energy quota q , whereas the factor function 303 is step-like in form and therefore assigns intervals of the energy quota q to the same quantizer factor.

[0066] Fig. 6 exemplifies a non-uniform quantizer where the input on the x-axis in dB is quantized according to the function 310 to result in the output y in dB that is drawn on the y-axis. Such a non-uniform quantizer function can be used to quantize spatial parameters as well. This is of special interest when the reference channel within a BCC-coding scheme is chosen to be the strongest channel within a multi-channel signal. The non-uniform quantizer as shown in Fig. 6 exemplifies a quantizer function 310 that would suit the needs then, since the quantization steps increase as the energy level becomes smaller compared to the referenced channel. This is a particularly attractive property since the energy level quantizing errors can be larger for channels with less energy than for the strongest channels.

[0067] Fig. 7 shows an inventive parameter dequantizer 500 having a dequantizer 502 and a dequantizer selector 504. The dequantizer selector 504 receives the total energy of the multi-channel audio signal and the local energy of the channel or channel pairs together with a quantized parameter 505 that is to be dequantized. Based on the received energy information, the dequantizer selector 504 derives a dequantization rule that is used by the dequantizer 502 to dequantize the quantized parameter 505. Hence, in this case the dequantizer selector 504 serves as a dequantization rule generator.

[0068] It may be noted that the dequantizer selector 504 may operate in different ways. A first possibility is that the dequantizer selector 504 derives the quantization rule directly and transfers the derived quantization rule to the dequantizer 502. Another possibility is that the dequantizer selector 504 meets a dequantization rule decision, which is transferred to the dequantizer 502 that can use the dequantization rule decision to select the appropriate dequantization rule from a number of quantization rules that are for example stored in the dequantizer 502.

[0069] Fig. 8 shows an inventive parameter decoder having a parameter dequantizer 500, a differential decoder 510, and a Huffman decoder 512.

[0070] The Huffman decoder 512 receives a parameter bit stream element 513 and in association therewith, the dequantizer selector 504 receives the local energy of a channel or a pair of channels described by the parameter bit stream element 513 and the total energy of the multi-channel audio signal. The parameter bit stream element 513 is produced by an inventive parameter encoder, as shown in Fig. 3. Therefore, the parameter bit stream element 513 is Huffman decoded by the Huffman decoder 512 and differentially decoded by a differential decoder 510 before being supplied to the dequantizer 502. After the decoding by the Huffman decoder 512 and the differential decoder 510, the dequantization is performed by the inventive parameter dequantizer 500, as already described in the description of the inventive parameter of Fig. 7.

[0071] In other words, Fig. 8 illustrates a decoder using an energy dependent dequantizer 500, the decoder corresponding to an inventive encoder. The parameter bit stream element is Huffman decoded and differentially decoded into indices. The correct dequantizer is chosen in the dequantizer selector 504 using the same rule and function as was used in the encoder with the total energy and local energy as input. The selected dequantizer is then used to dequantize (using the dequantizer 502) the indices into dequantized parameters.

[0072] Fig. 9a shows a further embodiment of an inventive parameter decoder, having an inventive energy dependent dequantizer 520, a Huffman decoder 512, and a differential decoder 510. The parameter dequantizer 520 comprises a quantizer factor generator 522, a dequantizer 524, and a parameter scaler 526. In this case the dequantizer factor generator 522 together with the parameter scaler 526 serve as a de-quantization rule generator.

[0073] After decoding the parameter bit stream element 513 by the Huffman decoder and the differential decoder, the quantized parameter is dequantized by the dequantizer 524, wherein the dequantizer 524 is using a dequantization rule

matching a quantization rule used to generate the quantized parameter. The quantizer factor generator 522 derives a scale factor 528 (f) from a ratio of the local energy and the total energy of the multi-channel audio signal. The parameter scaler 526 then applies the scale factor 528 to the dequantized parameter by a multiplication of the scale factor with the dequantized parameter.

5 **[0074]** After the scaling by the parameter scaler 526, the decompressed dequantized parameters are available at an output of the inventive parameter decoder.

[0075] Fig. 9b shows a further embodiment of an inventive parameter decoder 530, similar to the inventive parameter decoder 520. Therefore, only the differences to the parameter decoder 520 shall be elaborated on in the following paragraph.

10 **[0076]** The inventive parameter decoder 530 is having a decompressor 532, the decompressor 532 achieving the same functional result as the parameter scaler 526 in the inventive parameter decoder 520. The decompressor 532 receives as an input the quantized parameters and as further input the scale factor 528 from the factor generator 522. That means the factor generator 522 together with the decompressor 532 serve as a dequantization rule generator in this case. To implement the energy weighted dequantizing functionality, the quantized parameter is scaled by the de-
15 compressor 532 before the so derived scaled quantized parameter is input into the dequantizer 524. The dequantizer 524 then dequantizes the scaled quantized parameter to derive the dequantized parameter using a fixed dequantization rule. This decompression can for example be achieved by a multiplication of the quantized parameter index by the scale factor 528.

20 **[0077]** Although the scaling by the parameter scaler 258 and the parameter scaler 526 during the encoding and decoding is described to be a division during the encoding and a multiplication during the decoding, any other type of scaling that has the same effect as using a different quantization rule can be applied to the parameters during the encoding or decoding.

25 **[0078]** In the case of a stacked parameterization (hierarchical de- or encoding) as exemplified for example in Fig. 10b, it should be noted that since the decoder can decode the energy distribution from the roots (the down-mix channel) out to the leafs, there is a well-defined local energy in each parametrization r_1 to r_4 (two channel decoders 122, 124, 126, and 128), which can be used as the local energy on the decoder side. Additionally, if an encoder also quantizes from root to leaf, exactly the same local energy can be used on the encoder as local energy for the quantizer selector and the quantizer factor function.

30 **[0079]** In other words, a decoder may either decide autonomously which dequantization rule to use using the total energy and the local energy. Alternatively, it could be signalled by some additional side information to the decoder, which de-quantization rule is the appropriate one to dequantize the parameters.

[0080] Although described within different embodiments of the present invention, the application of a scale factor and the selection of an appropriate dequantization rule can also be combined within one embodiment of an inventive encoder or decoder.

35 **[0081]** To give a more detailed example, two possible ways of implementing energy dependent dequantization for the reconstruction of a multi-channel signal from a transferred monophonic signal M using additionally transmitted spatial parameters (CLD, ICC) are shown in Figs. 9c and 9d. Before discussing the Figs., it may be noted that the tree-like structure shown in the Figs. is only important for the reconstruction of the spatial parameters, wherein the actual ab-mix for generation of the individual channels of a multi-channel signal is normally performed within a single step.

40 **[0082]** Fig. 9c shows the situation where the parameters CLD are derived such that it is assumed that a parameter CLD° describes the energy distribution between channels that are combined using a number of channels of the original signal.

45 **[0083]** In the first hierarchic up-mix position 1000, CLD° describes the energy relation between two channels, wherein a first channel is a combination 1002 of a front-left, a front-right, a center and a low-frequency-enhancement channel. The second channel is a combination of a back-left and a back-right channel. In other words, the parameter CLD° describes the energy distribution between all rear channels and all front channels.

50 **[0084]** It is therefore evident when CLD° indicates that only little energies contained in the rear channels, the parameters describing the spatial properties between the back-left and the back-right channel may be quantized stronger, since the additionally-introduced distortion by the coarse quantization is hardly audible when all channels are played back simultaneously.

[0085] An inventive parameter dequantizer, as shown in Fig. 9b is, for example, calculating a scale factor 528 to implement the dequantization by multiplying a parameter to be dequantized with a parameter index before the actual dequantization is performed. Therefore, if a parameter CLD° is transmitted, one may, when using the decoder of Fig. 9b for example, calculate the finally-used CLD parameters of other hierarchical steps according to the following formula.

55 **[0086]** In the following, the term "DEQ" describes the application of a fixed dequantization table to a parameter given to the procedure DEQ. That means, a transmitted parameter $IDX\ CLD(0,L)$ can be dequantized directly, indicated by the following expression:

$$D_{CLD}^0(0,l,m) = deq(\text{idxCLD}(0,l,m), CLD)$$

5 [0087] Since the CLD parameter describes an energy distribution between two channels and the channels are combinations of channels as indicated in Fig. 9c, one may now derive the relative local energy FC according to:

$$10 \quad \text{RelativeLocalEnergyFC}_{S_{151}}(l,m) = 10 \cdot \log_{10} \left(\frac{10^{\left(\frac{D_{CLD}^0(0,l,m)}{10}\right)}}{1 + 10^{\left(\frac{D_{CLD}^0(0,l,m)}{10}\right)}} \right)$$

15 [0088] The relative local energy of the back channels is accordingly:

$$20 \quad \text{RelativeLocalEnergyS}_{S_{151}}(l,m) = 10 \cdot \log_{10} \left(\frac{1}{1 + 10^{\left(\frac{D_{CLD}^0(0,l,m)}{10}\right)}} \right)$$

25 [0089] Given the above and the inventive concept, CLD¹ can now be computed, taking into account the overall energy contained in the combination signal 1002:

$$30 \quad \text{idxCLDEdQ}(1,l,m) = \max\left(-15, \min\left(15, \text{round}\left(\text{idxCLD}(1,l,m) \cdot \text{facFunc}\left(\text{RelativeLocalEnergyFC}_{S_{151}}(l,m)\right)\right)\right)\right)$$

35 [0090] In the formula given above, the term "facFunc" describes a function giving a real value independency of the relative local energy FC. In other words, formula 4 describes that before dequantization, the transmitted parameter index IDX CLD (1,1,m) is multiplied with a scale factor (facFunc) to derive an intermediate quantized parameter. Since the intermediate quantized parameter is not necessarily integer-valued, the intermediate quantized parameter must be rounded to derive IdxCLDEdQ, which is then dequantized into the final parameter used by the following operation:

$$40 \quad D_{CLD}^0(1,l,m) = deq(\text{idxCLDEdQ}(1,l,m), CLD)$$

45 [0091] Dequantization is performed by a standard dequantization table, such as, for example, the following:

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Idx	-15	-	-	-	-	-	-9	-8	-7	-6	-5
CLD EdQ		14	13	12	11	10					
CLD EdQ	-	-	-	-	-	-	-	-	-16	-	-
CLD EdQ	150	45	40	35	30	25	22	19		13	10
Idx	-4	-3	-2	-1	0	1	2	3	4	5	6
Cymb EdQ	-8	-6	-4	-2	0	2	4	6	8	10	13
CLD EdQ	7	8	9	10	11	12	13	14	15		
CLD EdQ	16	19	22	25	30	35	40	45	150		

[0092] The derived parameter CLD¹ describes an energy relation between a channel being a combination of a front-left and a front-right channel and a channel being a combination of a center and a low-frequency-enhancement channel, as can be seen from the channel decomposition in the second hierarchical step 1004. Such a relative local energy F, describing an energy contained in the front channels, front-left and front-right, can be computed according to the following formula:

$$RelativeLocalEnergyF_{5151}(l,m) = 10 \cdot \log_{10} \left(\frac{10^{\left(\frac{D_{CLD}^0(l,l,m)}{10}\right)} \cdot 10^{\frac{RelativeLocalEnergyFC_{5151}(l,m)}{10}}}{1 + 10^{\left(\frac{D_{CLD}^0(l,l,m)}{10}\right)}} \right)$$

[0093] Previously, a relative local energy S describing the energy of the back channels has been derived such that an intermediate quantized parameter IDX CLD EDQ can be calculated for the hierarchical box 1006 according to the following formulas:

$$idxCLDEdQ(2,l,m) = \max\left(-15, \min\left(15, \text{round}\left(idxCLD(2,l,m) \cdot \text{facFunc}\left(RelativeLocalEnergyS_{5151}(l,m)\right)\right)\right)\right)$$

$$D_{CLD}^0(2,l,m) = \text{deg}\left(idxCLDEdQ(2,l,m), CLD\right)$$

[0094] Since, as previously described, a relative local energy describing the energy of the front-channels only (F⁵¹⁵¹) is now available, parameter CLD³ describing an energy relation between the front-left and the front-right channel can now be derived in an energy-dependent way according to the following formulas:

$$idxCLDEdQ(3,l,m) = \max\left(-15, \min\left(15, \text{round}\left(idxCLD(3,l,m) \cdot \text{facFunc}\left(RelativeLocalEnergyF_{5151}(l,m)\right)\right)\right)\right)$$

$$D_{CLD}^0(3,l,m) = \text{deg}\left(idxCLDEdQ(3,l,m), CLD\right)$$

[0095] In one possible implementation, parameter CAD⁴ describing an energy relation between the center and the low-frequency-enhancement channel can now be derived using no factor function:

$$D_{CLD}^0(4,l,m) = deq(\text{idxCLD}(4,l,m), CLD)$$

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[0096] In alternative embodiments, it is, of course, also feasible to implement energy-dependency also in the derivation of the parameter CLD⁴.

[0097] Fig. 9d shows another possibility of defining a hierarchic for the derivation of the spatial parameters.

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[0098] In analogy to the description of Fig. 9c, the individual CLD-parameters may be derived according to the following formulas:

$$D_{CLD}^0(0,l,m) = deq(\text{idxCLD}(0,l,m), CLD)$$

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$$RelativeLocalEnergyLR_{5152}(l,m) = 10 \cdot \log_{10} \left(\frac{10^{\left(\frac{D_{CLD}^0(0,l,m)}{10}\right)}}{1 + 10^{\left(\frac{D_{CLD}^0(0,l,m)}{10}\right)}} \right)$$

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$$\text{idxCLDEdQ}(1,l,m) = \max\left(-15, \min\left(15, \text{round}\left(\text{idxCLD}(1,l,m) \cdot \text{facFunc}\left(\text{RelativeLocalEnergyLR}_{5152}(l,m)\right)\right)\right)\right)$$

30

$$D_{CLD}^0(1,l,m) = deq(\text{idxCLDEdQ}(1,l,m), CLD)$$

35

$$RelativeLocalEnergyL_{5152}(l,m) = 10 \cdot \log_{10} \left(\frac{10^{\left(\frac{D_{CLD}^0(1,l,m)}{10}\right)}}{1 + 10^{\left(\frac{D_{CLD}^0(1,l,m)}{10}\right)}} \cdot 10^{\frac{RelativeLocalEnergyLR_{5152}(l,m)}{10}} \right)$$

40

$$RelativeLocalEnergyR_{5152}(l,m) = 10 \cdot \log_{10} \left(\frac{1}{1 + 10^{\left(\frac{D_{CLD}^0(1,l,m)}{10}\right)}} \cdot 10^{\frac{RelativeLocalEnergyLR_{5152}(l,m)}{10}} \right)$$

45

$$D_{CLD}^0(2,l,m) = deq(\text{idxCLD}(2,l,m), CLD)$$

50

$$\text{idxCLDEdQ}(3,l,m) = \max\left(-15, \min\left(15, \text{round}\left(\text{idxCLD}(3,l,m) \cdot \text{facFunc}\left(\text{RelativeLocalEnergyL}_{5152}(l,m)\right)\right)\right)\right)$$

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$$D_{CLD}^0(3,l,m) = deq(\text{idxCLDEdQ}(3,l,m), CLD)$$

$$\text{idxCLDEdQ}(4, l, m) = \max\left(-15, \min\left(15, \text{round}\left(\text{idxCLD}(4, l, m) \cdot \text{facFunc}\left(\text{RelativeLocalEnergy}R_{s1s2}(l, m)\right)\right)\right)\right)$$

5

$$D_{\text{CLD}}^q(4, l, m) = \text{deq}\left(\text{idxCLDEdQ}(4, l, m), \text{CLD}\right)$$

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[0099] It may be noted that different factor functions may be used to implement the inventive concept as, for example, one of the functions shown in Fig. 5.

[0100] Generally, as already mentioned above, it is the inventive concept to apply an energy-dependent quantization in the sense that parameters (CLD) of parts of the signal that contain relatively low energy compared to other signal parts, are quantized in a coarser way. That is, the factor function has to be such that for low energy components, the factor applied is large.

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[0101] To illustrate this in more detail, one example is given in Fig. 9e, which shows the manipulations during encoding and decoding, further pointing out the concept of the invention. Reference is further made to the previously-introduced quantization table to calculate the examples shown.

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[0102] Table 9d shows the manipulation of the quantization index on the quantizer side in a left column 1100, and the reconstruction of the transmitted parameter on the quantizer side in a column 1102. The transmitted parameter is given in column 1104. Two examples for a combination of channels having relatively low energy are shown. This is indicated by the common scale factor 4.5, which is significantly bigger than 1 (see Fig. 4). According to the inventive concept, the quantization index IDX is divided by the scale factor after the quantization at the quantizer size. Afterwards, the result has to be rounded to an integer value to be differentially and Huffman encoded (see Fig. 4a). Therefore, both example indexes 10 and 9 result in a transmitted index IDXtransm of 2.

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[0103] The dequantizer multiplies the transmitted index by the scale factor to derive a reconstructed index IDXrek used for de-quantization. As can be seen in the first example of an index 10 on the quantizer size, an additional error of 1 arises due to the rounding of the divided index on the quantizer size. On the other hand, when, by chance, the division of the scale factor at the quantizer side yields an integer valued index IDXtransm to be transmitted, no additional error is introduced.

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[0104] Evidently, the danger of introducing additional errors rises with rising scale factor f . This means that the probability of adding additional errors to low energy signals is rather high. When signals described by the CLD parameter in question have comparatively equal energy, the CLD value will be close to unity and such will be the scale factor (see, for example Fig. 5). This means, when the channels for which the parameters are encoded in an energy-dependent manner share roughly the same energy, no additional errors are normally introduced in the quantization. This is, of course, most appropriate, since when every channel has about the same energy within a multi-channel signal, every single channel is audible during simultaneous playback and, therefore, an error introduced would be clearly audible to the audience.

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[0105] It is evidently an enormous advantage of the present invention that errors are only accepted for channels having comparatively low energy. For those channels, on the other hand, by dividing the indices of the associated parameters by some large numbers brings the index values of those channels closer to zero, on the average. This can be exploited perfectly by the following differential encoding and Huffman encoding procedure to efficiently decrease the bit rate consumed for the transmitted parameters of a multi-channel signal.

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[0106] The relation of the local and the total energy upon which the decision which de-/quantization rule to use is based, is described to be a logarithmic measure within the previous paragraphs. This of course not the only possible measure that can be used to realize the inventive concept. Any other measure describing an energy difference between the local energy or the total energy, as for example the plain difference, can be used to make the decision.

45

[0107] Another important feature with the present invention is that in combination with a two channel decoder (PS) design that distributes the incoming energy into the two output channels typically controlled by e.g. CLD like parameter (meaning that the incoming energy equals the sum of the energies for the two output channels), is that the difference in energy, Relative Local Energy between the total energy and the local energy for each two channel decoders (122, 124, 126, and 128) is defined by the CLD parameters. This means that there is no need to actually measure the total energy and the local energy since the difference in energy in dB that is typically used to calculate the scale factor is defined by the CLD parameters.

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[0108] Depending on certain implementation requirements of the inventive methods, the inventive methods can be implemented in hardware or in software. The implementation can be performed using a digital storage medium, in particular a disk, DVD or a CD having electronically readable control signals stored thereon, which cooperate with a programmable computer system such that the inventive methods are performed. Generally, the present invention is, therefore, a computer program product with a program code stored on a machine-readable carrier, the program code

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being operative for performing the inventive methods when the computer program product runs on a computer. In other words, the inventive methods are, therefore, a computer program having a program code for performing at least one of the inventive methods when the computer program runs on a computer.

[0109] While the foregoing has been particularly shown and described with reference to particular embodiments thereof, it will be understood by those skilled in the art that various other changes in the form and details may be made without departing from the scope of the invention as defined by the appended claims.

Claims

1. Parameter quantizer for quantizing an input parameter, wherein the input parameter is a measure for a characteristic of a single channel or a pair of channels with respect to another single channel or a pair of channels of a multi-channel signal, comprising:

a quantization rule generator for generating a quantization rule based on a relation of an energy measure of the channel or the pair of channels and an energy measure of the multi-channel signal; and
a value quantizer for deriving a quantized parameter from the input parameter, using the generated quantization rule.

2. Parameter quantizer according to claim 1, in which the quantization rule generator is operative to generate the quantization rule such that a quantization is coarser for a channel or a channel pair having a low energy measure than for a channel or a channel pair having a high energy measure.

3. Parameter quantizer according to claim 1, in which the quantization rule generator is operative to choose one quantization rule from two or more predetermined quantization rules.

4. Parameter quantizer according to claim 1, in which the quantization rule generator is operative to calculate a new quantization rule based on a relation of the energy measure of the channel or the pair of channels and the energy measure of the multi-channel signal.

5. Parameter quantizer according to claim 4, in which the quantization rule generator is operative such that the calculation of the quantization rule comprises a calculation of a scale factor.

6. Parameter quantizer according to claim 5, further comprising a parameter scaler for modifying the input parameter using the scale factor.

7. Parameter quantizer according to claim 6, in which the parameter scaler is operative to modify the input parameter such that the modification includes a division of the input parameter by the scale factor.

8. Parameter quantizer in accordance with claim 5, further comprising a compression device, in which the parameter quantizer is operative to derive an intermediate quantized parameter using a predetermined quantization rule; and
in which the compression device is operative to derive the quantized parameter using the intermediate quantized parameter and the scale factor.

9. Parameter quantizer according to claim 1, in which the quantization rule generator is operative to generate a quantization rule such that an application of the quantization rule to the input parameter comprises an assignment of the same quantized parameter to all input parameters within a given input parameter range.

10. Parameter quantizer according to claim 1, in which the input parameter is a spatial parameter, describing a spatial perception of the multi-channel audio signal, and in which the input parameter is chosen from the following list of parameters:

inter-channel correlation/coherence (ICC),
inter-channel level/intensity difference (ICLD or IID),
inter-channel phase difference (IPD), and
inter-channel time difference (ICTD).

- 5 11. Parameter quantizer according to claim 1, further comprising a differential encoder and a Huffman encoder, wherein the differential encoder is operative to derive a differentially encoded representation of the quantized parameter; and wherein the Huffman encoder is operative to derive a Huffman encoded representation of the differentially encoded representation.
- 10 12. Parameter dequantizer for dequantizing a quantized parameter to derive a parameter, wherein the parameter is a measure for a characteristic of a single channel or a pair of channels with respect to another single channel or a pair of channels of a multi-channel signal, comprising:
a dequantization rule generator for generating a dequantization rule based on a relation of an energy measure of the single channel or the pair of channels and an energy measure derived from channels of the multi-channel signal; and
15 a value dequantizer for deriving the parameter from the quantized parameter, using the generated dequantization rule.
- 20 13. Parameter dequantizer according to claim 12, in which the dequantization rule generator is operative to use an energy measure derived from channels of the multi-channel signal which is derived from a combination of channels not having the channel or the pair of channels.
- 25 14. Parameter dequantizer according to claim 12, in which the dequantization rule generator is operative to generate the dequantization rule such that a dequantization is coarser for a channel or a pair of channels having a low energy measure than for a channel or a pair of channels having a high energy measure.
- 30 15. Parameter dequantizer according to claim 12, in which the dequantization rule generator is operative to choose one dequantization rule from two or more fixed dequantization rules stored in a memory.
- 35 16. Parameter dequantizer according to claim 12, in which the dequantization rule generator is operative to calculate the new dequantization rule based on a relation of the energy measure of the channel or the pair of channels and the energy measure derived from channels of the multi-channel signal.
- 40 17. Parameter dequantizer according to claim 12, in which the dequantization rule generator is operative such that the calculation of the dequantization rule comprises a calculation of a scale factor.
- 45 18. Parameter dequantizer according to claim 17, in which the dequantization rule generator further comprises a parameter scaler for modifying the parameter using the scale factor.
- 50 19. Parameter dequantizer according to claim 17, in which the parameter scaler is operative to modify the parameter such that the modification includes a multiplication of the parameter by the scale factor.
- 55 20. Parameter dequantizer according to claim 17, in which the dequantization rule generator further comprises a decompressor for deriving an intermediate quantized parameter from the quantized parameter using the scale factor; and in which the value dequantizer is operative to derive the parameter from the intermediate quantized parameter using a fixed dequantization rule.
21. Parameter dequantizer according to claim 20, in which the decompressor is operative to derive the intermediate quantized parameter by multiplication of the scale factor and the quantized parameter.
22. Parameter dequantizer according to claim 20, in which the dequantization rule generator further comprises a rounder to derive an integer valued intermediate quantized parameter from the intermediate quantized parameter; and in which the value dequantizer is operative to derive the parameter from the integer valued intermediate quantized parameter using a fixed dequantization rule.
23. Parameter dequantizer according to claim 12, in which the quantized parameter is a measure for an energy relation between a combination of a left-front channel and a right-front channel and a combination of a center-channel and a low-frequency-enhancement-channel; wherein the energy measure is an energy measure for a pair of channels having a first channel combined from the

front-left and the front-right channel and having a second channel combined from the center-channel and the low-frequency-enhancement-channel; and
 wherein the energy measure derived from channels of the multi-channel signal is an energy measure derived from a combination of a back-left and a back-right channel.

5
24. Parameter dequantizer according to claim 12, in which the quantized parameter is a measure for an energy relation between a back-left and a back-right channel;
 wherein the energy measure is an energy measure for a pair of channels having the back-left and the back-right channel; and
 10 wherein the energy measure derived from channels of the multi-channel signal is an energy measure derived from a combination of a left-front, a right-front, a center and a low-frequency-enhancement channel.

25. Parameter dequantizer according to claim 12, in which the quantized parameter is a measure for an energy relation between a front-left and a front-right channel;
 15 wherein the energy measure is a measure for a pair of channels having the front-left and the front-right channel; and wherein the energy measure derived from channels of the multi-channel signal is an energy measure derived from a combination of a center and a low-frequency-enhancement channel.

26. Parameter dequantizer according to claim 12, in which the quantized parameter is a measure for an energy relation between a combination of left-front and a left-back channel and a combination of a right-front and a right-back channel; wherein
 20 the energy measure is an energy measure for a pair of channels having a first channel combined from the left-front and the left-back channel and having a second channel combined from the right-front and the right-back channel; and wherein the energy measure derived from channels of the multi-channel signal is an energy measure derived from
 25 a combination of a center and a low-frequency-enhancement channel.

27. Parameter dequantizer according to claim 12, in which the quantized parameter is a measure for an energy relation between a left-front and a left-back channel; wherein
 30 the energy measure is an energy measure for a pair of channels having the left-front and the left-back channel; and wherein the energy measure derived from channels of the multi-channel signal is an energy measure derived from a combination of a right-front and a right-back channel.

28. Parameter dequantizer according to claim 12, in which the quantized parameter is a measure for an energy relation between a right-front and a right-back channel; wherein
 35 the energy measure is an energy measure for a pair of channels having the right-front and the right-back channel; and wherein the energy measure derived from channels of the multi-channel signal is an energy measure derived from a combination of a left-front and a left-back channel.

29. Parameter dequantizer according to claim 12, in which the dequantization rule generator is operative to generate a dequantization rule such that an application of the dequantization rule to the quantized parameter comprises an assignment of the quantized parameter to a parameter.

30. Parameter dequantizer according to claim 12, further comprising a differential decoder and a Huffman decoder, wherein the Huffman decoder is operative to derive a Huffman decoded representation of a received Huffman encoded representation; and
 45 wherein the differential decoder is operative to derive the quantized parameter from the Huffman decoded representation.

31. Parameter dequantizer according to claim 12, in which the parameter is a spatial parameter, describing a spatial perception of the multi-channel audio signal, and in which the input parameter is chosen from the following list of parameters:

- inter-channel correlation/coherence (ICC),
- inter-channel level/intensity difference (ICLD or IID),
- inter-channel phase difference (IPD), and
- inter-channel time difference (ICTD).

32. Method of quantizing an input parameter, wherein the input parameter is a measure for a characteristic of a single

channel or a pair of channels with respect to another single channel or a pair of channels of a multi-channel signal, the method comprising:

5 generating a quantization rule based on a relation of an energy measure of the channel or the pair of channels and an energy measure of the multi-channel signal; and
 deriving a quantized parameter from the input parameter using the generated quantization rule.

10 **33.** Method of dequantizing a quantized parameter to derive a parameter, wherein the parameter is a measure for a characteristic of a single channel or a pair of channels with respect to another single channel or a pair of channels of a multi-channel signal, the method comprising:

 generating a dequantization rule based on a relation of an energy measure of the channel or the pair of channels and an energy measure of the multi-channel signal; and
 deriving the parameter from the quantized parameter using the generated dequantization rule.

15 **34.** Representation of a multi-channel signal having a quantized parameter being a quantized representation of a parameter being a measure for a characteristic of a single channel or a pair of channels, wherein the parameter is a measure for a characteristic of the single channel or the pair of channels with respect to another single channel or a pair of channels of a multi-channel signal, wherein the quantized parameter is derived using a quantization rule based on a relation of an energy measure of the channel or the pair of channels and an energy measure of the multi-channel signal.

20 **35.** Machine-readable storage medium having stored thereon a representation of a multi-channel signal of claim 34.

25 **36.** Transmitter or audio recorder, having a parameter quantizer of claim 1.

37. Receiver or audio player, having a parameter dequantizer of claim 12.

30 **38.** Method of transmitting or audio recording, the method comprising a method of quantizing of claim 32.

39. Method of receiving or audio playing, the method having a method of dequantizing of claim 33.

35 **40.** Transmission system having a transmitter and a receiver, the transmitter having a parameter quantizer of claim 1 and the receiver having a parameter dequantizer of claim 12.

41. Method of transmitting and receiving, the method including a transmitting method having a method of quantizing of claim 32 and a receiving method having a method of dequantizing of claim 33.

40 **42.** Computer program adapted to perform, when running on a computer, a method in accordance with any one of method claims 32, 33, 38, 39, or 41.

43. Multi-channel decoder for generating a reconstruction of a multi-channel signal:

45 a parameter dequantizer according to claim 12; and
 an up-mixer for up-mixing the reconstruction of the multi-channel signal from a transmitted downmixed signal using parameters dequantized by the parameter dequantizer.

44. Multi-channel encoder for generating an encoded representation of a multi-channel signal, comprising:

50 a parameter quantizer according to claim 1; and
 a down-mixer for generating a down-mix signal from the multi-channel signal using parameters quantized by the quantizer, wherein this down-mix signal has fewer channels than the multi-channel signal.

55 **Patentansprüche**

1. Parameterquantisierer zum Quantisieren eines Eingangsparameters, bei dem der Eingangsparameter ein Maß einer Charakteristik eines Einzelkanals oder eines Paares von Kanälen bezüglich eines anderen Einzelkanals oder

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eines Paares von Kanälen eines Mehrkanalsignals ist, mit folgenden Merkmalen:

5 einem Quantisierungsregelgenerator zum Erzeugen einer Quantisierungsregel auf der Basis einer Beziehung eines Energiemaßes des Kanals oder des Paares von Kanälen und eines Energiemaßes des Mehrkanalsignals; und
einem Wertquantisierer zum Ableiten eines quantisierten Parameters von dem Eingangsparameter unter Verwendung der erzeugten Quantisierungsregel.

10 2. Parameterquantisierer gemäß Anspruch 1, bei dem der Quantisierungsregelgenerator dahin gehend wirksam ist, die Quantisierungsregel zu erzeugen, so dass eine Quantisierung für einen Kanal oder ein Kanalpaar, der beziehungsweise das ein niedriges Energiemaß aufweist, gröber ist als für einen Kanal oder ein Kanalpaar, der beziehungsweise das ein hohes Energiemaß aufweist.

15 3. Parameterquantisierer gemäß Anspruch 1, bei dem der Quantisierungsregelgenerator dahin gehend wirksam ist, eine Quantisierungsregel aus zwei oder mehr vorbestimmten Quantisierungsregeln auszuwählen.

20 4. Parameterquantisierer gemäß Anspruch 1, bei dem der Quantisierungsregelgenerator dahin gehend wirksam ist, eine neue Quantisierungsregel auf der Basis einer Beziehung des Energiemaßes des Kanals oder des Paares von Kanälen und des Energiemaßes des Mehrkanalsignals zu berechnen.

25 5. Parameterquantisierer gemäß Anspruch 4, bei dem der Quantisierungsregelgenerator dahin gehend wirksam ist, dass die Berechnung der Quantisierungsregel eine Berechnung eines Skalenfaktors umfasst.

6. Parameterquantisierer gemäß Anspruch 5, der ferner einen Parameterskalierer zum Modifizieren des Eingangsparameters unter Verwendung des Skalenfaktors umfasst.

30 7. Parameterquantisierer gemäß Anspruch 6, bei dem der Parameterskalierer dahin gehend wirksam ist, den Eingangsparameter so zu modifizieren, dass die Modifizierung eine Teilung des Eingangsparameters durch den Skalenfaktor umfasst.

35 8. Parameterquantisierer gemäß Anspruch 5, der ferner eine Komprimierungsvorrichtung umfasst, wobei der Parameterquantisierer dahin gehend wirksam ist, einen quantisierten Zwischenparameter unter Verwendung einer vorbestimmten Quantisierungsregel abzuleiten; und wobei die Komprimierungsvorrichtung dahin gehend wirksam ist, den quantisierten Parameter unter Verwendung des quantisierten Zwischenparameters und des Skalenfaktors abzuleiten.

40 9. Parameterquantisierer gemäß Anspruch 1, bei dem der Quantisierungsregelgenerator dahin gehend wirksam ist, eine Quantisierungsregel zu erzeugen, so dass eine Anwendung der Quantisierungsregel auf den Eingangsparameter eine Zuweisung desselben quantisierten Parameters zu allen Eingangsparametern innerhalb eines gegebenen Eingangsparameterbereichs umfasst.

45 10. Parameterquantisierer gemäß Anspruch 1, bei dem der Eingangsparameter ein räumlicher Parameter ist, der eine räumliche Wahrnehmung des Mehrkanalaudiosignals beschreibt, und bei dem der Eingangsparameter aus der folgenden Liste von Parametern ausgewählt ist:

Korrelation/Kohärenz zwischen Kanälen (ICC - inter-channel correlation/coherence),
Pegel-/Intensitätsdifferenz zwischen den Kanälen (ICLD oder IID - inter-channel level/intensity difference),
Phasendifferenz zwischen den Kanälen (IPD - inter-channel phase difference) und
Zeitdifferenz zwischen den Kanälen (ICTD - inter-channel time difference).

50 11. Parameterquantisierer gemäß Anspruch 1, der ferner einen Differenzcodierer und einen Huffman-Codierer umfasst, wobei der Differenzcodierer dahin gehend wirksam ist, eine unterschiedlich codierte Darstellung des quantisierten Parameters abzuleiten; und wobei der Huffman-Codierer dahin gehend wirksam ist, eine Huffman-codierte Darstellung der unterschiedlich codierten Darstellung abzuleiten.

55 12. Parameterdequantisierer zum Dequantisieren eines quantisierten Parameters, um einen Parameter abzuleiten, bei dem der Parameter ein Maß einer Charakteristik eines Einzelkanals oder eines Paares von Kanälen bezüglich eines

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anderen Einzelkanals oder eines Paares von Kanälen eines Mehrkanalsignals ist, mit folgenden Merkmalen:

5 einem Dequantisierungsregelgenerator zum Erzeugen einer Dequantisierungsregel auf der Basis einer Beziehung eines Energiemaßes des Einzelkanals oder des Paares von Kanälen und eines Energiemaßes, das von Kanälen des Mehrkanalsignals abgeleitet ist; und
einem Wertdequantisierer zum Ableiten des Parameters von dem quantisierten Eingangsparameter unter Verwendung der erzeugten Dequantisierungsregel.

10 **13.** Parameterdequantisierer gemäß Anspruch 12, bei dem der Dequantisierungsregelgenerator dahin gehend wirksam ist, ein Energiemaß zu verwenden, das von Kanälen des Mehrkanalsignals abgeleitet ist, das von einer Kombination von Kanälen abgeleitet ist, die nicht den Kanal oder das Paar von Kanälen aufweist.

15 **14.** Parameterdequantisierer gemäß Anspruch 12, bei dem der Dequantisierungsregelgenerator dahin gehend wirksam ist, die Dequantisierungsregel zu erzeugen, so dass eine Dequantisierung für einen Kanal oder ein Kanalpaar, der beziehungsweise das ein niedriges Energiemaß aufweist, gröber ist als für einen Kanal oder ein Kanalpaar, der beziehungsweise das ein hohes Energiemaß aufweist.

20 **15.** Parameterentquantisierer gemäß Anspruch 12, bei dem der Dequantisierungsregelgenerator dahin gehend wirksam ist, eine Dequantisierungsregel aus zwei oder mehr feststehenden Dequantisierungsregeln, die in einem Speicher gespeichert sind, auszuwählen.

25 **16.** Parameterentquantisierer gemäß Anspruch 12, bei dem der Dequantisierungsregelgenerator dahin gehend wirksam ist, die neue Dequantisierungsregel auf der Basis einer Beziehung des Energiemaßes des Kanals oder des Paares von Kanälen und des Energiemaßes, das von Kanälen des Mehrkanalsignals abgeleitet ist, zu berechnen.

17. Parameterentquantisierer gemäß Anspruch 12, bei dem der Dequantisierungsregelgenerator dahin gehend wirksam ist, dass die Berechnung der Dequantisierungsregel eine Berechnung eines Skalenfaktors umfasst.

30 **18.** Parameterentquantisierer gemäß Anspruch 17, bei dem der Dequantisierungsregelgenerator ferner einen Parameterskalierer zum Modifizieren des Parameters unter Verwendung des Skalenfaktors umfasst.

35 **19.** Parameterentquantisierer gemäß Anspruch 17, bei dem der Parameterskalierer dahin gehend wirksam ist, den Parameter derart zu modifizieren, dass die Modifizierung eine Multiplikation des Parameters mit dem Skalenfaktor umfasst.

40 **20.** Parameterentquantisierer gemäß Anspruch 17, bei dem der Dequantisierungsregelgenerator ferner einen Dekomprimierer zum Ableiten eines quantisierten Zwischenparameters von dem quantisierten Parameter unter Verwendung des Skalenfaktors umfasst; und
bei dem der Wertdequantisierer dahin gehend wirksam ist, den Parameter unter Verwendung einer feststehenden Dequantisierungsregel von dem quantisierten Zwischenparameter abzuleiten.

21. Parameterentquantisierer gemäß Anspruch 20, bei dem der Dekomprimierer dahin gehend wirksam ist, den quantisierten Zwischenparameter durch Multiplikation des Skalenfaktors und des quantisierten Parameters abzuleiten.

45 **22.** Parameterentquantisierer gemäß Anspruch 20, bei dem der Dequantisierungsregelgenerator ferner einen Runder umfasst, um einen ganzzahlwertigen quantisierten Zwischenparameter von dem quantisierten Zwischenparameter abzuleiten; und
bei dem der Wertdequantisierer dahin gehend wirksam ist, den Parameter unter Verwendung einer feststehenden Dequantisierungsregel von dem ganzzahlwertigen quantisierten Zwischenparameter abzuleiten.

50 **23.** Parameterentquantisierer gemäß Anspruch 12, bei dem der quantisierte Parameter ein Maß einer Energiebeziehung zwischen einer Kombination eines Links-Vorne-Kanals und eines Rechts-Vorne-Kanals und einer Kombination eines Mitte-Kanals und eines Niederfrequenzverbesserungskanals ist;
wobei das Energiemaß ein Energiemaß eines Paares von Kanälen ist, das einen ersten Kanal, der aus dem Vorne-Links- und dem Vorne-Rechts-Kanal kombiniert ist, und einen zweiten Kanal, der aus dem Mitte-Kanal und dem Niederfrequenzverbesserungskanal kombiniert ist, aufweist; und
55 wobei das Energiemaß, das von Kanälen des Mehrkanalsignals abgeleitet ist, ein Energiemaß ist, das von einer Kombination eines Hinten-Links- und eines Hinten-Rechts-Kanals abgeleitet ist.

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24. Parameterentquantisierer gemäß Anspruch 12, bei dem der quantisierte Parameter ein Maß einer Energiebeziehung zwischen einem Hinten-Links- und einem Hinten-Rechts-Kanal ist; wobei das Energiemaß ein Energiemaß eines Paares von Kanälen ist, das den Hinten-Links- und den Hinten-Rechts-Kanal aufweist; und
5 wobei das von Kanälen des Mehrkanalsignals abgeleitete Energiemaß ein Energiemaß ist, das von einer Kombination eines Links-Vorne-, eines Rechts-Vorne-, eines Mitte- und eines Niederfrequenzverbesserungskanals abgeleitet ist.
25. Parameterentquantisierer gemäß Anspruch 12, bei dem der quantisierte Parameter ein Maß einer Energiebeziehung zwischen einem Vorne-Links- und einem Vorne-Rechts-Kanal ist; wobei das Energiemaß ein Maß eines Paares von Kanälen ist, das den Vorne-Links- und den Vorne-Rechts-Kanal aufweist; und
10 wobei das von Kanälen des Mehrkanalsignals abgeleitete Energiemaß ein Energiemaß ist, das von einer Kombination eines Mitte- und eines Niederfrequenzverbesserungskanals abgeleitet ist.
26. Parameterentquantisierer gemäß Anspruch 12, bei dem der quantisierte Parameter ein Maß einer Energiebeziehung zwischen einer Kombination eines Links-Vorne- und eines Links-Hinten-Kanals und einer Kombination eines Rechts-Vorne- und eines Rechts-Hinten-Kanals ist; wobei
20 das Energiemaß ein Energiemaß eines Paares von Kanälen ist, das einen aus dem Links-Vorne- und dem Links-Hinten-Kanal kombinierten ersten Kanal aufweisen und einen aus dem Rechts-Vorne- und dem Rechts-Hinten-Kanal kombinierten zweiten Kanal aufweist; und
wobei das von Kanälen des Mehrkanalsignals abgeleitete Energiemaß ein Energiemaß ist, das von einer Kombination eines Mitte- und eines Niederfrequenzverbesserungskanals abgeleitet ist.
27. Parameterentquantisierer gemäß Anspruch 12, bei dem der quantisierte Parameter ein Maß einer Energiebeziehung zwischen einem Links-Vorne- und einem Links-Hinten-Kanal ist; wobei
25 das Energiemaß ein Energiemaß eines Paares von Kanälen ist, das den Links-Vorne- und den Links-Hinten-Kanal aufweist; und
wobei das von Kanälen des Mehrkanalsignals abgeleitete Energiemaß ein Energiemaß ist, das von einer Kombination eines Rechts-Vorne- und eines Rechts-Hinten-Kanals abgeleitet ist.
30
28. Parameterentquantisierer gemäß Anspruch 12, bei dem der quantisierte Parameter ein Maß einer Energiebeziehung zwischen einem Rechts-Vorne- und einem Rechts-Hinten-Kanal ist; wobei
35 das Energiemaß ein Energiemaß eines Paares von Kanälen ist, das den Rechts-Vorne- und den Rechts-Hinten-Kanal aufweist; und
wobei das von Kanälen des Mehrkanalsignals abgeleitete Energiemaß ein Energiemaß ist, das von einer Kombination eines Links-Vorne- und eines Links-Hinten-Kanals abgeleitet ist.
29. Parameterentquantisierer gemäß Anspruch 12, bei dem der Dequantisierungsregelgenerator dahin gehend wirksam
40 ist, eine Dequantisierungsregel zu erzeugen, derart, dass eine Anwendung der Dequantisierungsregel auf die quantisierten Parameter eine Zuweisung der quantisierten Parameter zu einem Parameter umfasst.
30. Parameterentquantisierer gemäß Anspruch 12, der ferner einen Differenzdecodierer und einen Huffman-Decodierer umfasst,
45 wobei der Huffman-Decodierer dahin gehend wirksam ist, eine Huffman-decodierte Darstellung einer empfangenen Huffman-codierten Darstellung abzuleiten; und
wobei der Differenzdecodierer dahin gehend wirksam ist, den quantisierten Parameter von der Huffmandecodierten Darstellung abzuleiten.
31. Parameterentquantisierer gemäß Anspruch 12, bei dem der Parameter ein räumlicher Parameter ist, der eine räumliche Wahrnehmung des Mehrkanalaudiosignals beschreibt, und bei dem der Eingangsparameter aus der folgenden
50 Liste von Parametern ausgewählt ist:
- Korrelation/Kohärenz zwischen Kanälen (ICC - inter-channel correlation/coherence),
55 Pegel-/Intensitätsdifferenz zwischen den Kanälen (ICLD oder IID - inter-channel level/intensity difference),
Phasendifferenz zwischen den Kanälen (IPD - inter-channel phase difference) und
Zeitdifferenz zwischen den Kanälen (ICTD - inter-channel time difference).

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- 32.** Verfahren zum Quantisieren eines Eingangsparameters, bei dem der Eingangsparameter ein Maß einer Charakteristik eines Einzelkanals oder eines Paares von Kanälen bezüglich eines anderen Einzelkanals oder eines Paares von Kanälen eines Mehrkanalsignals ist, wobei das Verfahren folgende Schritte umfasst:
- 5 Erzeugen einer Quantisierungsregel auf der Basis einer Beziehung eines Energiemaßes des Kanals oder des Paares von Kanälen und eines Energiemaßes des Mehrkanalsignals; und
Ableiten eines quantisierten Parameters von dem Eingangsparameter unter Verwendung der erzeugten Quantisierungsregel.
- 33.** Verfahren zum Dequantisieren eines quantisierten Parameters, um einen Parameter abzuleiten, bei dem der Parameter ein Maß einer Charakteristik eines Einzelkanals oder eines Paares von Kanälen bezüglich eines anderen Einzelkanals oder eines Paares von Kanälen eines Mehrkanalsignals ist, wobei das Verfahren folgende Schritte umfasst:
- 15 Erzeugen einer Dequantisierungsregel auf der Basis einer Beziehung eines Energiemaßes des Kanals oder des Paares von Kanälen und eines Energiemaßes des Mehrkanalsignals; und
Ableiten des Parameters von dem quantisierten Eingangsparameter unter Verwendung der erzeugten Dequantisierungsregel.
- 34.** Darstellung eines Mehrkanalsignals, das einen quantisierten Parameter aufweist, der eine quantisierte Darstellung eines Parameters ist, der ein Maß einer Charakteristik eines Einzelkanals oder eines Paares von Kanälen ist, wobei der Parameter ein Maß einer Charakteristik des Einzelkanals oder des Paares von Kanälen bezüglich eines anderen Einzelkanals oder eines Paares von Kanälen eines Mehrkanalsignals ist, wobei der quantisierte Parameter unter Verwendung einer Quantisierungsregel auf der Basis einer Beziehung eines Energiemaßes des Kanals oder des Paares von Kanälen und eines Energiemaßes des Mehrkanalsignals abgeleitet wird.
- 35.** Maschinenlesbares Speichermedium, auf dem eine Darstellung eines Mehrkanalsignals gemäß Anspruch 34 gespeichert ist.
- 36.** Sender oder Audioaufzeichnungsvorrichtung, der beziehungsweise die einen Parameterquantisierer gemäß Anspruch 1 aufweist.
- 37.** Empfänger oder Audiowiedergabevorrichtung, der beziehungsweise die einen Parameterdequantisierer gemäß Anspruch 12 aufweist.
- 38.** Verfahren zum Senden oder Audio-Aufzeichnen, wobei das Verfahren ein Verfahren zum Quantisieren gemäß Anspruch 32 umfasst.
- 39.** Verfahren zum Empfangen oder Audio-Wiedergeben, wobei das Verfahren ein Verfahren zum Dequantisieren gemäß Anspruch 33 aufweist.
- 40.** Übertragungssystem, das einen Sender und einen Empfänger aufweist, wobei der Sender einen Parameterquantisierer gemäß Anspruch 1 aufweist und der Empfänger einen Parameterdequantisierer gemäß Anspruch 12 aufweist.
- 41.** Verfahren zum Senden und Empfangen, wobei das Verfahren ein Sendeverfahren, das ein Verfahren zum Quantisieren gemäß Anspruch 32 aufweist, und ein Empfangsverfahren, das ein Verfahren zum Dequantisieren gemäß Anspruch 33 aufweist, umfasst.
- 42.** Computerprogramm, das dahin gehend angepasst ist, ein Verfahren gemäß einem der Verfahrensansprüche 32, 33, 38, 39 oder 41 auszuführen, wenn es auf einem Computer läuft.
- 43.** Mehrkanaldecodierer zum Erzeugen einer Rekonstruktion eines Mehrkanalsignals:
- 55 ein Parameterdequantisierer gemäß Anspruch 12; und
ein Aufwärtsmischer zum Aufwärtsmischen der Rekonstruktion des Mehrkanalsignals aus einem gesendeten abwärtsgemischten Signal unter Verwendung von Parametern, die durch den Parameterdequantisierer dequantisiert werden.

44. Mehrkanalcodierer zum Erzeugen einer codierten Darstellung eines Mehrkanalsignals, der folgende Merkmale aufweist:

einen Parameterquantisierer gemäß Anspruch 1; und
 einen Abwärtsmischer zum Erzeugen eines Abwärtsmischsignals aus dem Mehrkanalsignal unter Verwendung von Parametern, die durch den Quantisierer quantisiert werden, wobei dieses Abwärtsmischsignal weniger Kanäle aufweist als das Mehrkanalsignal.

Revendications

1. Quantificateur de paramètre pour quantifier un paramètre d'entrée, dans lequel le paramètre d'entrée est une mesure d'une caractéristique d'un canal unique ou d'une paire de canaux par rapport à un autre canal unique ou une autre paire de canaux d'un signal multicanal, comprenant:

un générateur de règle de quantification destiné à générer une règle de quantification sur base d'un rapport entre une mesure d'énergie du canal ou de la paire de canaux et une mesure d'énergie du signal multicanal ; et un quantificateur de valeur destiné à dériver un paramètre quantifié du paramètre d'entrée, à l'aide de la règle de quantification générée.

2. Quantificateur de paramètre selon la revendication 1, dans lequel le générateur de règle de quantification est opérationnel pour générer la règle de quantification de sorte qu'une quantification soit plus approximative pour un canal ou une paire de canaux ayant une faible mesure d'énergie que pour un canal ou une paire de canaux ayant une haute mesure d'énergie.

3. Quantificateur de paramètre selon la revendication 1, dans lequel le générateur de règle de quantification est opérationnel pour sélectionner une règle de quantification parmi deux ou plusieurs règles de quantification prédéterminées.

4. Quantificateur de paramètre selon la revendication 1, dans lequel le générateur de règle de quantification est opérationnel pour calculer une nouvelle règle de quantification sur base d'un rapport entre la mesure d'énergie du canal ou de la paire de canaux et la mesure d'énergie du signal multicanal.

5. Quantificateur de paramètre selon la revendication 4, dans lequel le générateur de règle de quantification est opérationnel de sorte que le calcul de la règle de quantification comprenne un calcul d'un facteur d'échelle.

6. Quantificateur de paramètre selon la revendication 5, comprenant par ailleurs un moyen de modulation de paramètre destiné à modifier le paramètre d'entrée à l'aide du facteur d'échelle.

7. Quantificateur de paramètre selon la revendication 6, dans lequel le moyen de modulation de paramètre est opérationnel pour modifier le paramètre d'entrée de sorte que la modification comporte une division du paramètre d'entrée par le facteur d'échelle.

8. Quantificateur de paramètre selon la revendication 5, comprenant par ailleurs un dispositif de compression, dans lequel le quantificateur de paramètre est opérationnel pour dériver un paramètre quantifié intermédiaire à l'aide d'une règle de quantification prédéterminée; et dans lequel le dispositif de compression est opérationnel pour dériver le paramètre quantifié à l'aide du paramètre quantifié intermédiaire et du facteur d'échelle.

9. Quantificateur de paramètre selon la revendication 1, dans lequel le générateur de règle de quantification est opérationnel pour générer une règle de quantification de sorte qu'une application de la règle de quantification au paramètre d'entrée comprenne une attribution du même paramètre quantifié à tous les paramètres d'entrée dans une plage de paramètres d'entrée donnée.

10. Quantificateur de paramètre selon la revendication 1, dans lequel le paramètre d'entrée est un paramètre tridimensionnel décrivant une perception tridimensionnelle du signal audio multicanal, et dans lequel le paramètre d'entrée est sélectionné parmi la liste de paramètres suivante:

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corrélation/cohérence entre canaux (ICC),
différence de niveau/d'intensité entre canaux (ICLD ou IID),
différence de phase entre canaux (IPD), et
différence de temps entre canaux (ICTD).

- 5
11. Quantificateur de paramètre selon la revendication 1, comprenant par ailleurs un codeur différentiel et un codeur de Huffman,
dans lequel le codeur différentiel est opérationnel pour dériver une représentation codée différentielle du paramètre quantifié; et
10 dans lequel le codeur de Huffman est opérationnel pour dériver une représentation codée de Huffman de la représentation codée différentielle.
12. Déquantificateur de paramètre pour déquantifier un paramètre quantifié, pour dériver un paramètre, dans lequel le paramètre est une mesure d'une caractéristique d'un canal unique ou d'une paire de canaux par rapport à un autre canal unique ou une autre paire de canaux d'un signal multicanal, comprenant:
- 15 un générateur de règle de déquantification destiné à générer une règle de déquantification sur base d'un rapport entre une mesure d'énergie du canal unique ou de la paire de canaux et une mesure d'énergie dérivée des canaux du signal multicanal; et
20 un déquantificateur de valeur destiné à dériver le paramètre du paramètre quantifié, à l'aide de la règle de déquantification générée.
13. Déquantificateur de paramètre selon la revendication 12, dans lequel le générateur de règle de déquantification est opérationnel pour utiliser une mesure d'énergie dérivée des canaux du signal multicanal qui est dérivé d'une combinaison de canaux ne présentant pas le canal ou la paire de canaux.
- 25
14. Déquantificateur de paramètre selon la revendication 12, dans lequel le générateur de règle de déquantification est opérationnel pour générer la règle de déquantification de sorte qu'une déquantification soit plus approximative pour un canal ou une paire de canaux ayant une faible mesure d'énergie que pour un canal ou une paire de canaux ayant une haute mesure d'énergie.
- 30
15. Déquantificateur de paramètre selon la revendication 12, dans lequel le générateur de règle de déquantification est opérationnel pour sélectionner une règle de déquantification parmi deux ou plusieurs règles de déquantification fixes mémorisées dans une mémoire.
- 35
16. Déquantificateur de paramètre selon la revendication 12, dans lequel le générateur de règle de déquantification est opérationnel pour calculer la nouvelle règle de déquantification sur base d'un rapport entre la mesure d'énergie du canal ou de la paire de canaux et la mesure d'énergie dérivée des canaux du signal multicanal.
- 40
17. Déquantificateur de paramètre selon la revendication 12, dans lequel le générateur de règle de déquantification est opérationnel de sorte que le calcul de la règle de déquantification comprenne un calcul d'un facteur d'échelle.
18. Déquantificateur de paramètre selon la revendication 17, dans lequel le générateur de règle de déquantification comprend par ailleurs un moyen de modulation de paramètre destiné à modifier le paramètre à l'aide du facteur d'échelle.
- 45
19. Déquantificateur de paramètre selon la revendication 17, dans lequel le moyen de modulation de paramètre est opérationnel pour modifier le paramètre de sorte que la modification comprenne une multiplication du paramètre par le facteur d'échelle.
- 50
20. Déquantificateur de paramètre selon la revendication 17, dans lequel le générateur de règle de déquantification comprend par ailleurs un décompresseur destiné à dériver un paramètre quantifié intermédiaire du paramètre quantifié à l'aide du facteur d'échelle ; et dans lequel le déquantificateur de valeur est opérationnel pour dériver le paramètre du paramètre quantifié intermédiaire à l'aide d'une règle de déquantification fixe.
- 55
21. Déquantificateur de paramètre selon la revendication 20, dans lequel le décompresseur est opérationnel pour dériver le paramètre quantifié intermédiaire par multiplication du facteur d'échelle et du paramètre quantifié.

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- 5 22. Déquantificateur de paramètre selon la revendication 20, dans lequel le générateur de règle de déquantification comprend par ailleurs un moyen d'arrondi destiné à dériver un paramètre quantifié intermédiaire à valeur de nombre entier du paramètre quantifié intermédiaire; et dans lequel le déquantificateur de valeur est opérationnel pour dériver le paramètre du paramètre quantifié intermédiaire à valeur de nombre entier à l'aide d'une règle de déquantification fixe.
- 10 23. Déquantificateur de paramètre selon la revendication 12, dans lequel le paramètre quantifié est une mesure d'un rapport d'énergie entre une combinaison d'un canal gauche-avant et d'un canal droit-avant et une combinaison d'un canal central et d'un canal d'amélioration de basses fréquences; dans lequel la mesure d'énergie est une mesure d'énergie pour une paire de canaux présentant un premier canal combiné du canal avant-gauche et avant-droit et présentant un deuxième canal combiné du canal central et du canal d'amélioration de basses fréquences; et dans lequel la mesure d'énergie dérivée de canaux du signal multicanal est une mesure d'énergie dérivée d'une combinaison d'un canal arrière-gauche et d'un canal arrière-droit.
- 15 24. Déquantificateur de paramètre selon la revendication 12, dans lequel le paramètre quantifié est une mesure d'un rapport d'énergie entre un canal arrière-gauche et un canal arrière-droit; dans lequel la mesure d'énergie est une mesure d'énergie pour une paire de canaux présentant le canal arrière-gauche et le canal arrière-droit; et dans laquelle la mesure d'énergie dérivée de canaux du signal multicanal est une mesure d'énergie dérivée d'une combinaison d'un canal avant-gauche, d'un canal avant-droit, d'un canal central et d'un canal d'amélioration de basses fréquences.
- 20 25. Déquantificateur de paramètre selon la revendication 12, dans lequel le paramètre quantifié est une mesure d'un rapport d'énergie entre un canal avant-gauche et un canal avant-droit ; dans lequel la mesure d'énergie est une mesure pour une paire de canaux présentant le canal avant-gauche et le canal avant-droit; et dans lequel la mesure d'énergie dérivée de canaux du signal multicanal est une mesure d'énergie dérivée d'une combinaison d'un canal central et d'un canal d'amélioration de basses fréquences.
- 25 30 26. Déquantificateur de paramètre selon la revendication 12, dans lequel le paramètre quantifié est une mesure d'un rapport d'énergie entre une combinaison d'un canal avant-gauche et d'un canal arrière-gauche et une combinaison d'un canal avant-droit et d'un canal arrière -droit; dans lequel la mesure d'énergie est une mesure d'énergie pour une paire de canaux présentant un premier canal combiné du canal avant-gauche et du canal arrière-gauche et présentant un deuxième canal combiné du canal avant-droit et du canal arrière-droit; et dans lequel la mesure d'énergie dérivée de canaux du signal multicanal est une mesure d'énergie dérivée d'une combinaison d'un canal central et d'un canal d'amélioration de basses fréquences.
- 35 40 27. Déquantificateur de paramètre selon la revendication 12, dans lequel le paramètre quantifié est une mesure d'un rapport d'énergie entre un canal avant-gauche et un canal arrière -gauche; dans lequel la mesure d'énergie est une mesure d'énergie pour une paire de canaux présentant le canal avant-gauche et le canal arrière-gauche; et dans lequel la mesure d'énergie dérivée de canaux du signal multicanal est une mesure d'énergie dérivée d'une combinaison d'un canal avant-droit et d'un canal arrière-droit.
- 45 28. Déquantificateur de paramètre selon la revendication 12, dans lequel le paramètre quantifié est une mesure d'un rapport d'énergie entre un canal avant-droit et un canal arrière-droit; dans lequel la mesure d'énergie est une mesure d'énergie pour une paire de canaux présentant le canal avant-droit et le canal arrière-droit; et dans lequel la mesure d'énergie dérivée de canaux du signal multicanal est une mesure d'énergie dérivée d'une combinaison d'un canal avant-gauche et d'un canal arrière-gauche.
- 50 55 29. Déquantificateur de paramètre selon la revendication 12, dans lequel le générateur de règle de déquantification est opérationnel pour générer une règle de déquantification de sorte qu'une application de la règle de déquantification au paramètre quantifié comprenne une attribution du paramètre quantifié à un paramètre.
30. Déquantificateur de paramètre selon la revendication 12, comprenant par ailleurs un décodeur différentiel et un

décodeur de Huffman,
 dans lequel le décodeur de Huffman est opérationnel pour dériver une représentation décodée de Huffman d'une
 représentation codée de Huffman reçue; et
 dans lequel le décodeur différentiel est opérationnel pour dériver le paramètre quantifié de la représentation décodée
 de Huffman.

5
 31. Déquantificateur de paramètre selon la revendication 12, dans lequel le paramètre est un paramètre tridimensionnel
 décrivant une perception tridimensionnelle du signal audio multicanal, et dans lequel le paramètre d'entrée est
 sélectionné parmi la liste de paramètres suivante:

10
 corrélation/cohérence entre canaux (ICC),
 différence de niveau/d'intensité entre canaux (ICLD ou IID),
 différence de phase entre canaux (IPD), et
 différence de temps entre canaux (ICTD).

15
 32. Procédé de quantification d'un paramètre d'entrée, dans lequel le paramètre d'entrée est une mesure d'une caracté-
 ristique d'un canal unique ou d'une paire de canaux par rapport à un autre canal unique ou une autre paire de
 canaux d'un signal multicanal, le procédé comprenant:

20
 générer une règle de quantification sur base d'un rapport entre une mesure d'énergie du canal ou de la paire
 de canaux et une mesure d'énergie du signal multicanal; et
 dériver un paramètre quantifié du paramètre d'entrée à l'aide de la règle de quantification générée.

25
 33. Procédé de déquantification d'un paramètre quantifié, pour dériver un paramètre, dans lequel le paramètre est une
 mesure d'une caractéristique d'un canal unique ou d'une paire de canaux par rapport à un autre canal unique ou
 une autre paire de canaux d'un signal multicanal, le procédé comprenant:

30
 générer une règle de déquantification sur base d'un rapport entre une mesure d'énergie du canal ou de la paire
 de canaux et une mesure d'énergie du signal multicanal; et
 dériver le paramètre du paramètre quantifié à l'aide de la règle de déquantification générée.

35
 34. Représentation d'un signal multicanal présentant un paramètre quantifié qui est une représentation quantifiée d'un
 paramètre qui est une mesure d'une caractéristique d'un canal unique ou d'une paire de canaux, dans laquelle le
 paramètre est une mesure d'une caractéristique du canal unique ou de la paire de canaux par rapport à un autre
 canal unique ou une autre paire de canaux d'un signal multicanal, dans laquelle le paramètre quantifié est dérivé
 à l'aide d'une règle de quantification sur base d'un rapport entre une mesure d'énergie du canal ou de la paire de
 canaux et une mesure d'énergie du signal multicanal.

40
 35. Support de mémorisation pouvant être lu dans un ordinateur et présentant, y mémorisée, une représentation d'un
 signal multicanal selon la revendication 34.

36. Émetteur ou enregistreur audio, présentant un quantificateur de paramètre selon la revendication 1.

45
 37. Récepteur ou reproducteur audio, présentant un déquantificateur de paramètre selon la revendication 12.

38. Procédé de transmission ou d'enregistrement audio, le procédé comprenant un procédé de quantification selon la
 revendication 32.

50
 39. Procédé de réception ou de reproduction audio, le procédé présentant un procédé de déquantification selon la
 revendication 33.

40. Système de transmission présentant un émetteur et un récepteur, l'émetteur présentant un quantificateur de para-
 mètre selon la revendication 1 et le récepteur présentant un déquantificateur de paramètre selon la revendication 12.

55
 41. Procédé de transmission et de réception, le procédé comportant un procédé de transmission présentant un procédé
 de quantification selon la revendication 32 et un procédé de réception présentant un procédé de déquantification
 selon la revendication 33.

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42. Programme d'ordinateur adapté pour réaliser, lorsqu'il est exécuté sur un ordinateur, un procédé selon l'une quelconque des revendications de procédé 32, 33, 38, 39 ou 41.

43. Décodeur multicanal pour générer une reconstruction d'un signal multicanal:

5 un déquantificateur de paramètre selon la revendication 12; et
un mélangeur ascendant destiné à effectuer un mélange ascendant de la reconstruction du signal multicanal à partir du signal soumis à un mélange descendant transmis à l'aide des paramètres déquantifiés par le déquantificateur de paramètre.

10

44. Codeur multicanal pour générer une représentation codée d'un signal multicanal, comprenant:

un quantificateur de paramètre selon la revendication 1; et
15 un mélangeur descendant destiné à générer un signal soumis à un mélange descendant à partir du signal multicanal à l'aide des paramètres quantifiés par le quantificateur, dans lequel ce signal soumis à un mélange descendant présente moins de canaux que le signal multicanal.

20

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FIG 1

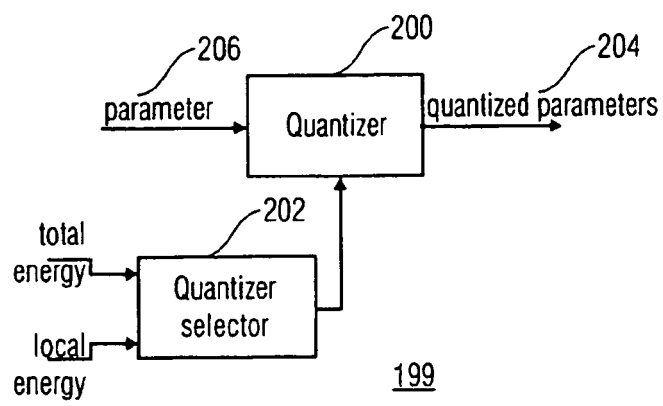


FIG 2a

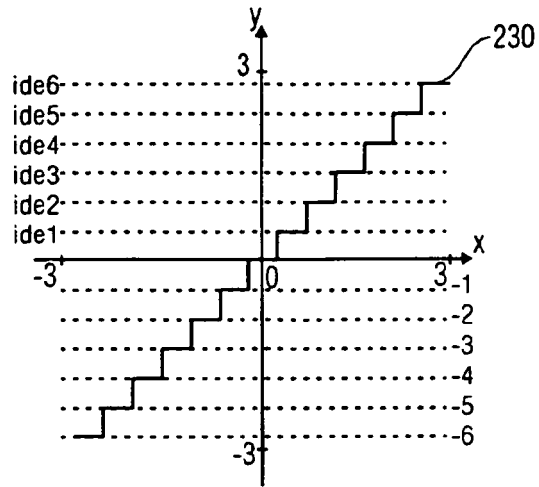


FIG 2b

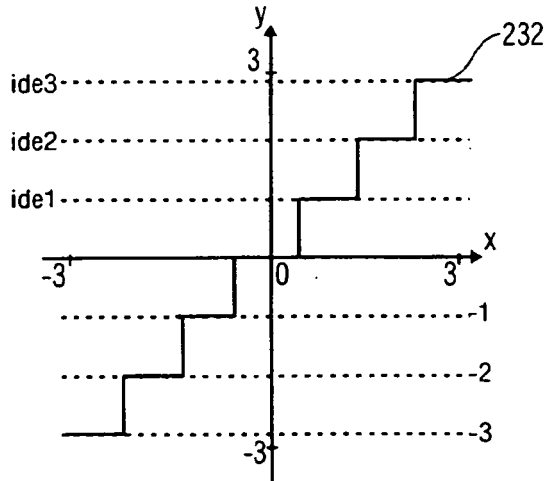


FIG 2c

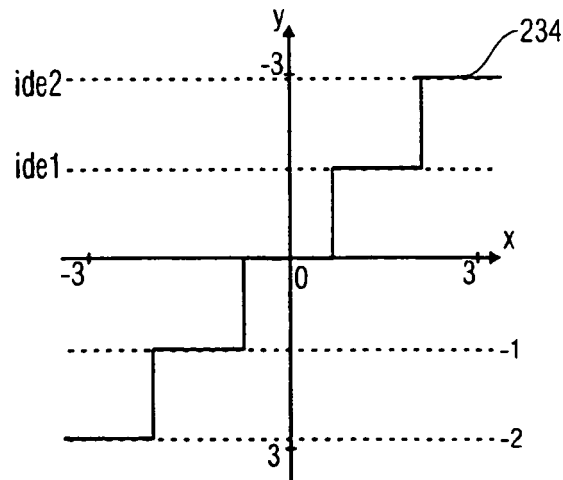


FIG 3

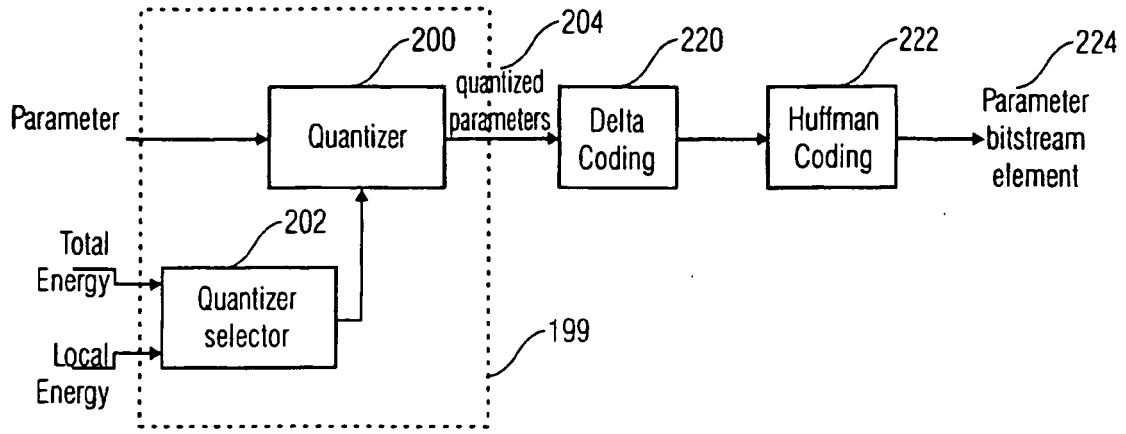


FIG 4a

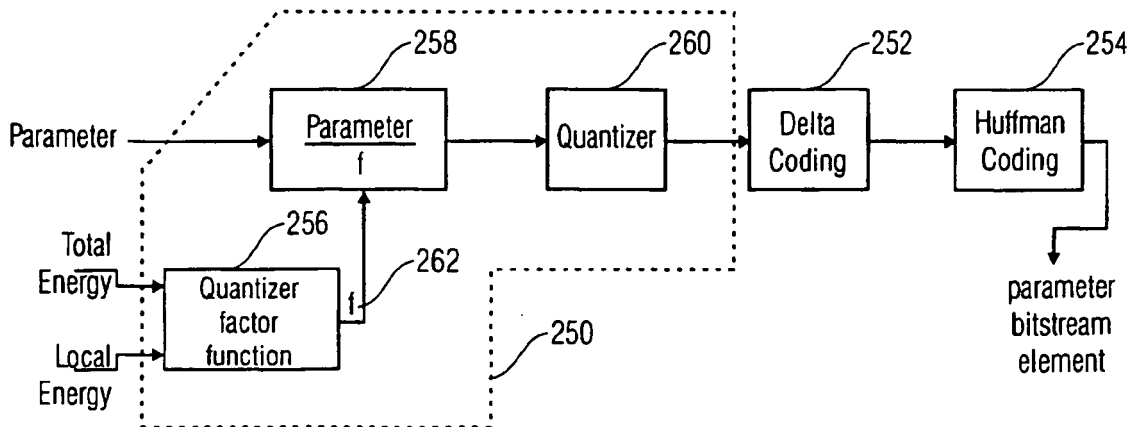


FIG 4b

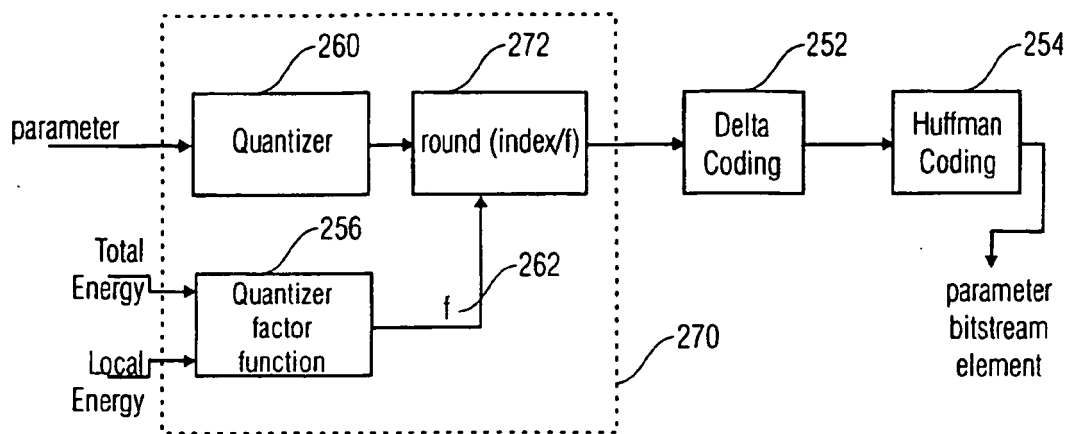


FIG 5

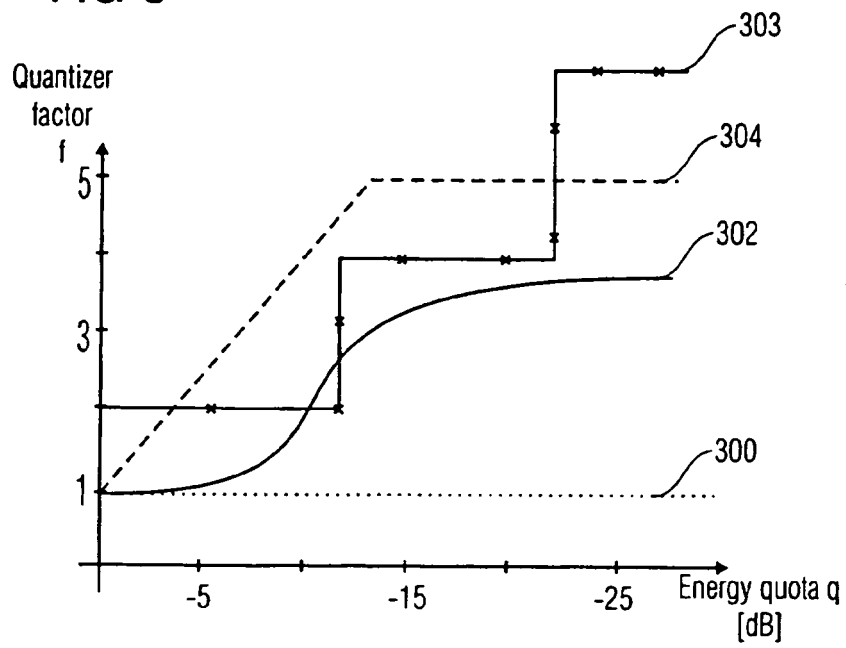


FIG 6

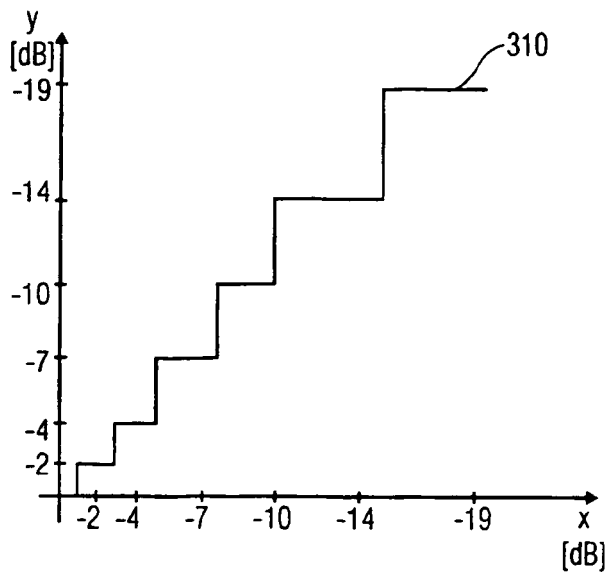


FIG 7

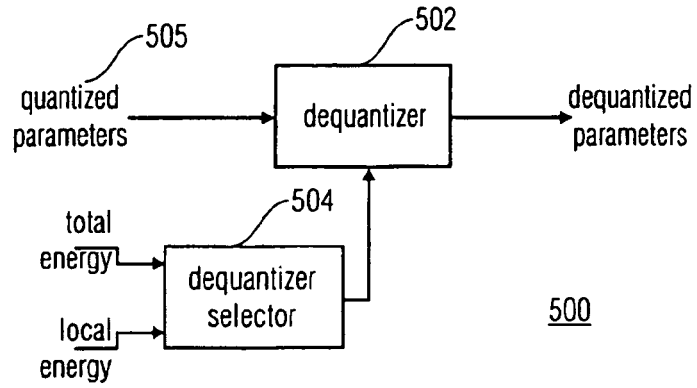


FIG 8

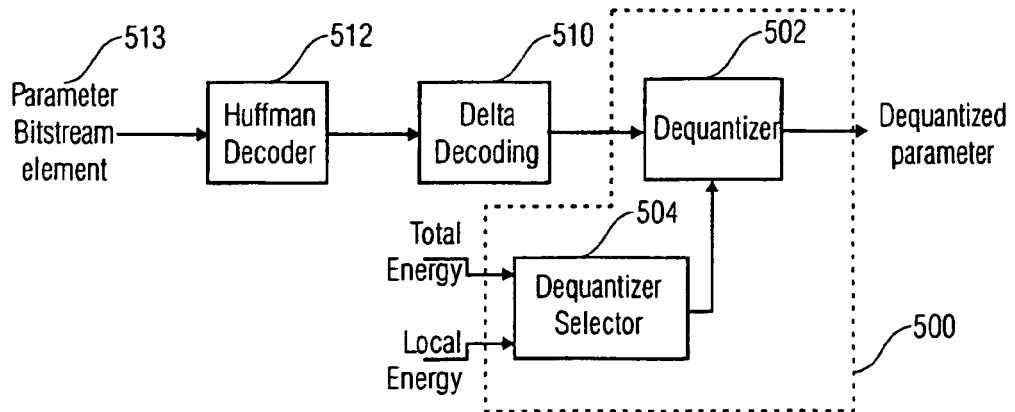


FIG 9a

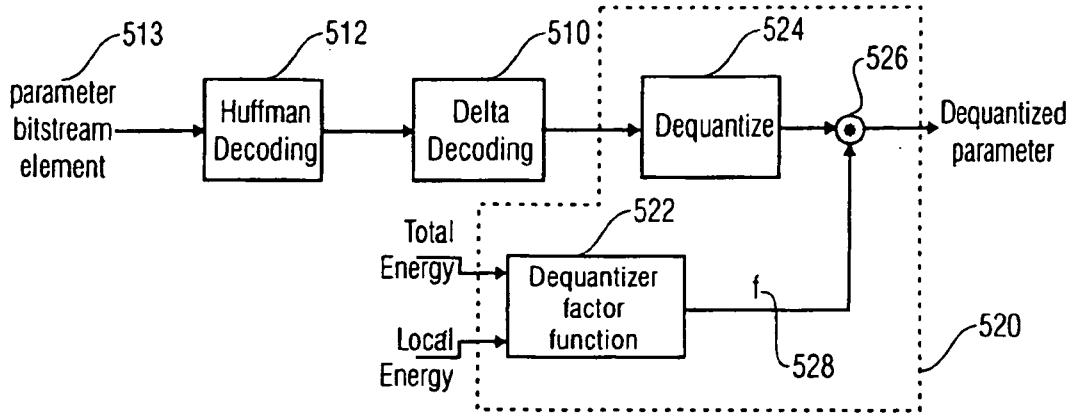


FIG 9b

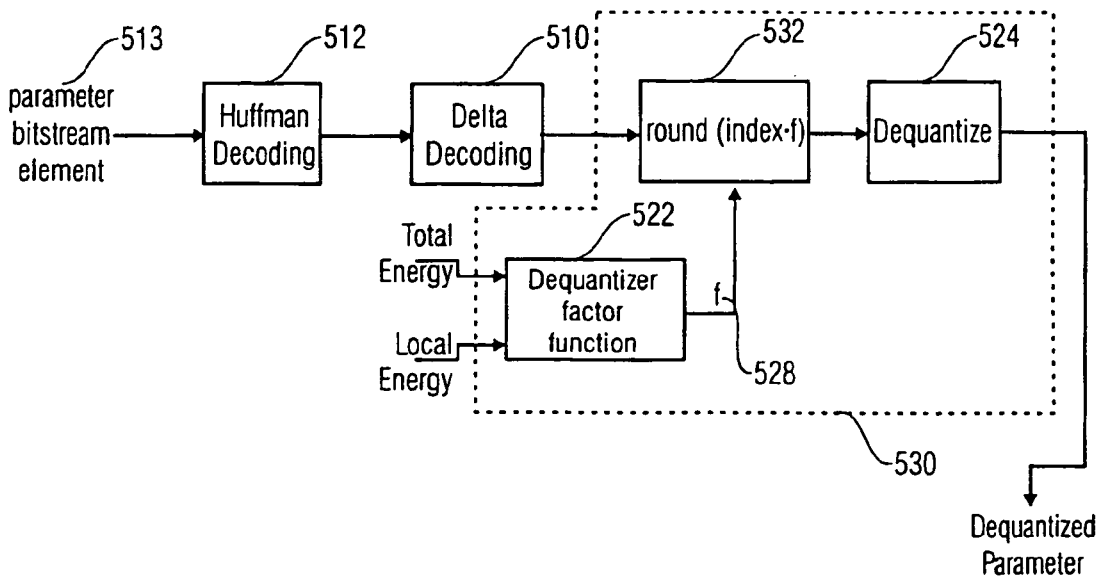


FIG 9c

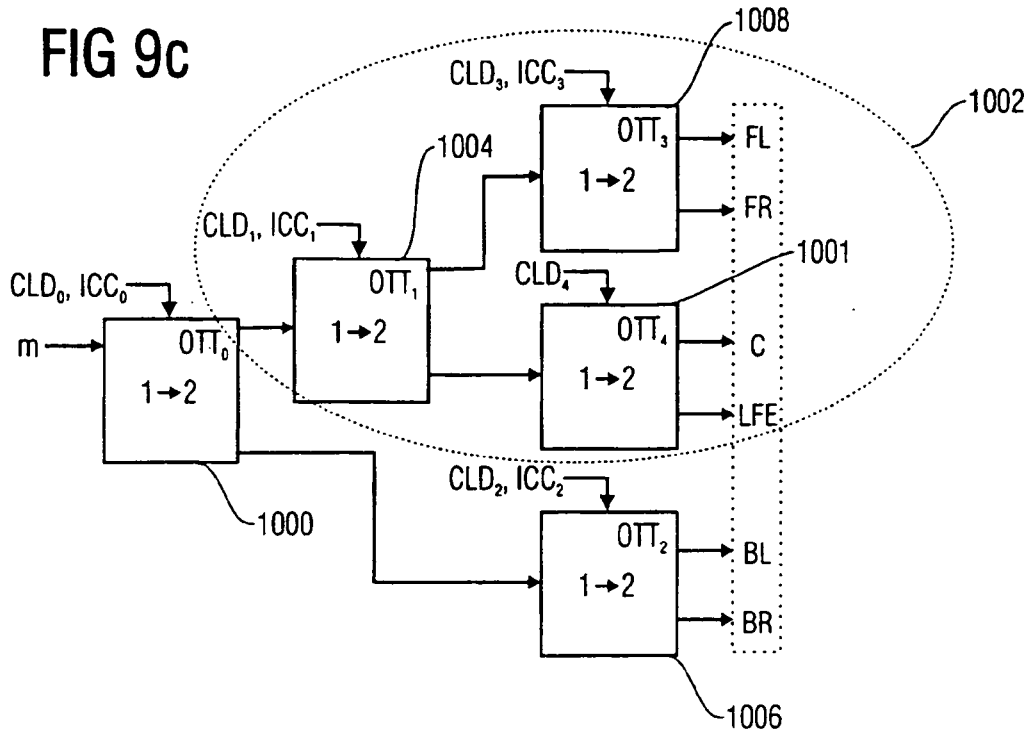


FIG 9d

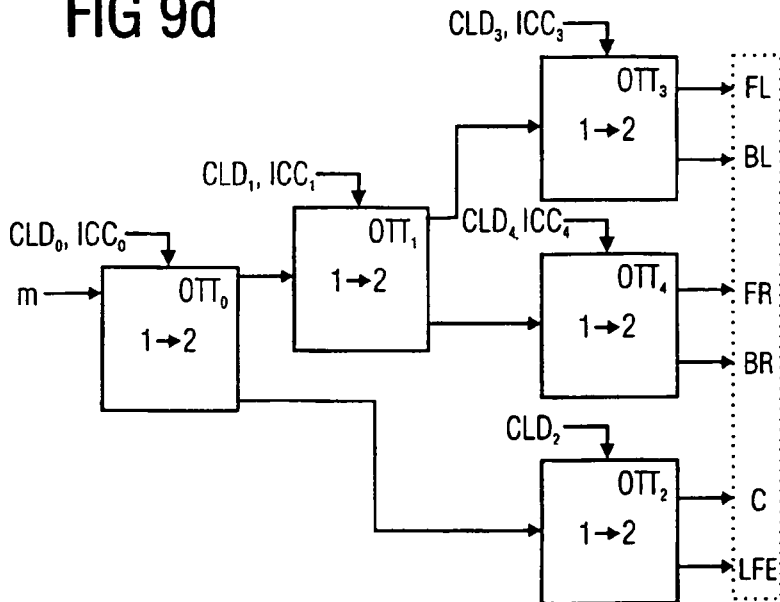


FIG 9e

Quantizer		Idxtransm.	Dequ.		Error
Idx	f		f	Idxreh.	
10	4,5	2	4,5	9	1
9	4,5	2	4,5	9	0

1100

1104

1102

6

FIG 10a

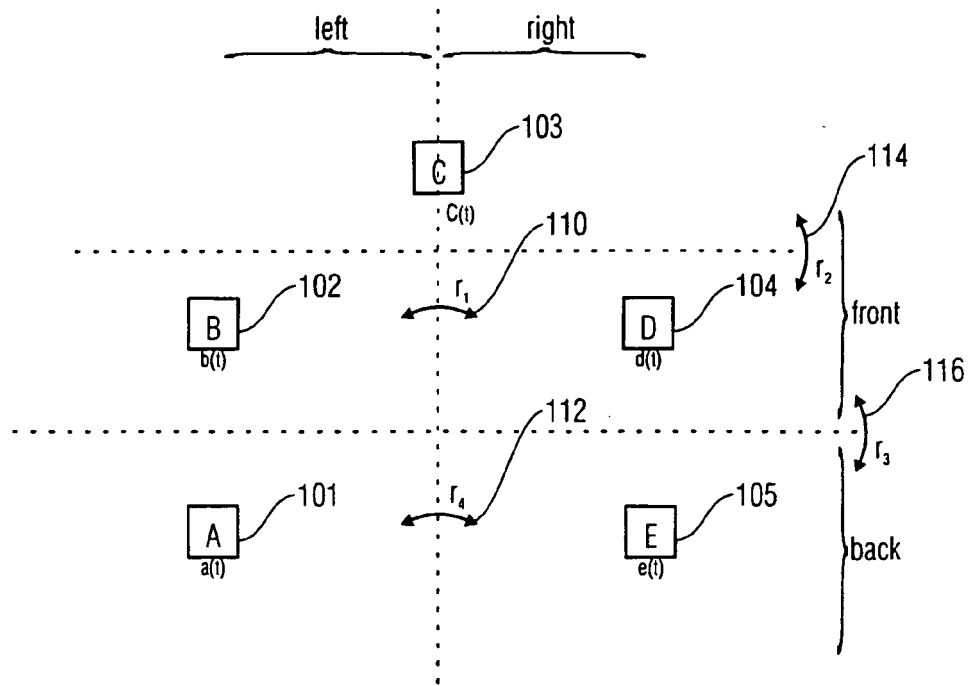
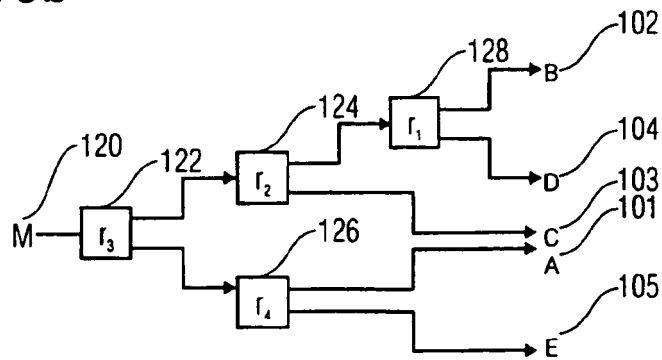


FIG 10b



REFERENCES CITED IN THE DESCRIPTION

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