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

(11) **EP 2 739 069 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
04.06.2014 Bulletin 2014/23

(51) Int Cl.:
H04R 25/00 *(2006.01)*

(21) Application number: **12195007.5**

(22) Date of filing: **30.11.2012**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME

(71) Applicant: **GN ReSound A/S**
2750 Ballerup (DK)

(72) Inventor: **Siegumfeldt, Peter**
2000 Frederiksberg (DK)

(74) Representative: **Zacco Denmark A/S**
Hans Bekkevolds Allé 7
2900 Hellerup (DK)

(54) **Hearing device with analog filtering and associated method**

(57) The present disclosure relates to a hearing device and related method. A hearing device is diclosed, the hearing device comprising: a microphone for converting audio into an audio signal; a preprocessing unit for analog processing of the audio signal and having an input and an output, wherein the input is connected to an output of the microphone; an A/D converter for converting the processed analog audio signal into a digital audio signal, the A/D converter having an input and an output, wherein the input is connected to the output of the preprocessing unit; and a processing unit for digital processing of A/D converter output, wherein the processing unit is connected to the preprocessing unit. The preprocessing unit is configured to apply a first transfer function to the audio signal in a first mode of operation and a second transfer function with a second cutoff frequency to the audio signal in a second mode of operation, depending on a control signal from the processing unit.

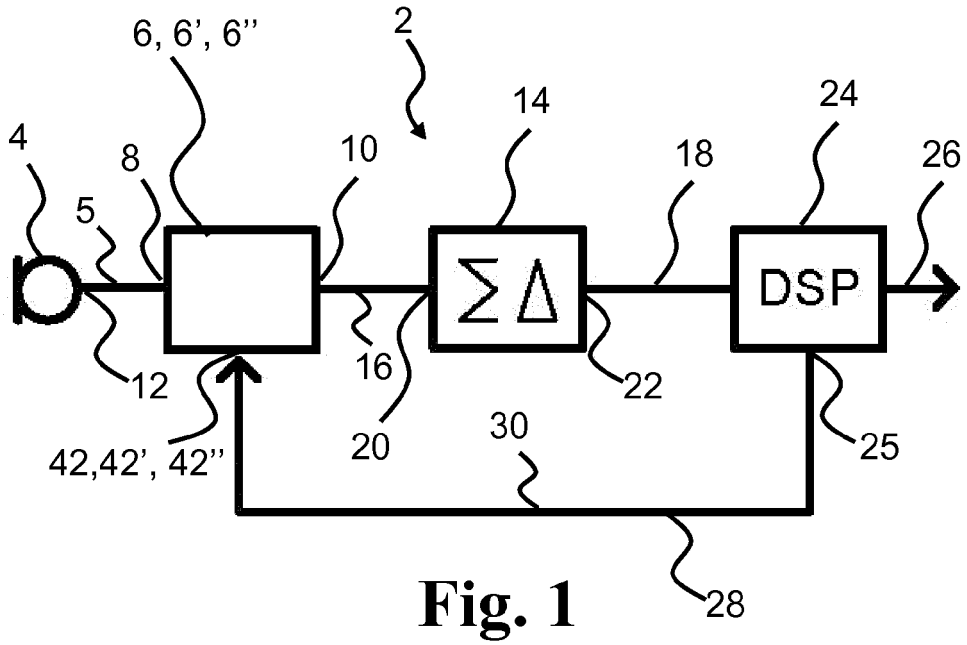

Fig. 1

EP 2 739 069 A1

Description

[0001] The present invention relates to a hearing device or hearing aid with analog filtering and associated method. In particular, the present invention relates to a hearing aid having improved wind noise reduction.

BACKGROUND

[0002] Wind noise is experienced as very unpleasant by a hearing device user and considerably reduces the userfriendliness of a hearing device. Known methods for reducing wind noise in hearing devices include filtering in the digital domain. Further, it is known to reduce the gain of a preamplifier to remove the uncomfortable sound levels. This however is at the expence of normal sound processing basically getting destroyed rendering the hearing device somewhat unusable.

SUMMARY

[0003] Despite the known solutions, there is still a need for improving the hearing device processing during windy conditions and to improve the signal to noise ratio (SNR) in the hearing device.

[0004] Accordingly, a hearing device is provided, the hearing device comprising: a microphone for converting audio into an audio signal; a preprocessing unit for analog processing of the audio signal and having an input and an output, wherein the input is connected to an output of the microphone; an A/D converter for converting the processed analog audio signal into a digital audio signal, the A/D converter having an input and an output, wherein the input is connected to the output of the preprocessing unit; and a processing unit for digital processing of A/D converter output, wherein the processing unit is connected to the preprocessing unit. The preprocessing unit is configured to apply a first transfer function to the audio signal in a first mode of operation and a second transfer function with a second cutoff frequency to the audio signal in a second mode of operation, depending on a control signal from the processing unit.

[0005] Also disclosed is a method for operating a hearing aid comprising a microphone, a preprocessing unit, an A/D converter, and a processing unit is provided, the method comprising: applying, in the preprocessing unit, a first transfer function to an audio signal from the microphone; converting the preprocessed audio signal to a digital audio signal; determining one or more noise parameters including a first noise parameter: and applying, in the preprocessing unit, a second transfer function, e.g. with a second cutoff frequency, to the audio signal from the microphone depending on a noise criterion, e.g. a first noise criterion, based on the one or more noise parameters. The method may comprise determining the one or more noise parameters while applying the second transfer function, and applying, in the preprocessing unit, the first transfer function or a third transfer function to the audio signal from the microphone depending on a noise criterion, e.g. a second noise criterion.

[0006] It is an advantage of the present invention that saturation of A/D converter of the hearing device is reduced thereby providing improved SNR in the hearing device processing.

[0007] Further, the hearing device and method enable a more efficient use of signal processing ressources by removing undesired noise at an early stage in the signal processing of the hearing device. Thereby, improved power management is provided.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] The above and other features and advantages of the present invention will become readily apparent to those skilled in the art by the following detailed description of exemplary embodiments thereof with reference to the attached drawings, in which:

Fig. 1 schematically illustrates an exemplary hearing device,

Fig. 2 schematically illustrates an exemplary preprocessing circuit of the hearing device in Fig. 1,

Fig. 3 schematically illustrates an exemplary preprocessing circuit of the hearing device in Fig. 1,

Fig. 4 shows an exemplary resistance circuit with a variable resistance value,

Fig. 5 shows an exemplary capacitance circuit with a variable capacitance value,

Fig. 6 shows exemplary first and second transfer functions,

Fig. 7 is a flow diagram of an exemplary method,

Fig. 8 is a flow diagram of an exemplary method, and

Fig. 9 shows an exemplary processing unit.

DETAILED DESCRIPTION

[0009] The figures are schematic and simplified for clarity, and they merely show details which are essential to the understanding of the invention, while other details have been left out. Throughout, the same reference numerals are used for identical or corresponding parts.

[0010] The preprocessing unit processes the audio signal from the microphone and has an input and an output. The input comprises a first input terminal connected to an output, e.g. a first output terminal, of the microphone. The preprocessing unit may comprise one or more control terminals for receiving and/or sending control signal(s) from/to the processing unit.

[0011] The preprocessing unit may comprise a first capacitor circuit with a first capacitance value. The first capacitance value may be variable, e.g. the first capacitance value may depend on the control signal from the processing unit. The preprocessing unit may comprise a second capacitor or second capacitor circuit having a second capacitance value. The second capacitance value may be variable, e.g. the second capacitance value may depend on the control signal from the processing unit. A variable first and/or second capacitance circuit may reduce the microphone requirements with regard to DC biasing or drifting. A capacitor or capacitor circuit has a first and a second terminal having a capacitance value therebetween.

[0012] The preprocessing unit may comprise a first resistor circuit with a first resistance value. The first resistance value may be variable, e.g. the first resistance value may depend on the control signal from the processing unit. The preprocessing unit may comprise a second resistor circuit with a second resistance value. The second resistance value may be variable, e.g. the second resistance value may depend on the control signal from the processing unit. A resistor or resistor circuit has a first and a second terminal having a resistance value therebetween.

[0013] The preprocessing unit may be a passive unit or an active unit. Accordingly, the preprocessing unit may comprise an amplifier. The amplifier has a first and optionally a second input terminal and an output terminal. The preprocessing unit may comprise a first part or unit and a second part or unit, where the first part is a passive filter part with adjustable filter parameters via the control signal and the second part is an active part with an amplifier. Accordingly, the preprocessing unit may comprise a passive adjustable filter unit followed by an active amplifier unit with adjustable gain.

[0014] The processing unit comprises an input with one or more input terminals including a first input terminal. The processing unit comprises one or more control terminals connected to corresponding control terminals of the preprocessing unit for sending and/or receiving control signal(s) indicative of mode of operation to/from the preprocessing unit.

[0015] The processing unit is configured to send a control signal to the preprocessing unit indicative of a mode of operation. The control signal may comprise one or more bits, e.g. depending on the number number of modes/transfer functions. The control signal may have a first value indicative of the first transfer function (e.g. Bit1=0) and a second value indicative of a second transfer function (e.g. Bit1=1). The processing unit may comprise a detector unit configured to determine one or more noise parameters including a first noise parameter and/or a second noise parameter. The noise parameter(s) may be indicative of the amount of wind noise in the audio signal. The processing unit may be configured to send a control signal indicative of mode of operation to the preprocessing unit depending on a noise criterion based on one or more of the noise parameters. The detector unit may be configured to determine a saturation parameter indicative of whether the A/D converter is close to or in saturation. The processing unit may be configured to send a control signal indicative of mode of operation to the preprocessing unit based on the saturation parameter.

[0016] A noise criterion may be applied for determining the mode of operation. For example, a first mode (first transfer function) may be selected when a noise criterion, e.g. a first noise criterion, based on noise parameter(s) is not fulfilled, e.g. if a first noise parameter is less than, equal to or larger than a noise threshold (e.g. a first noise threshold). Further, a second mode (second transfer function) may be selected when a noise criterion, e.g. the first noise criterion or a second noise criterion, based on the noise parameter(s) is fulfilled, e.g. if the first noise parameter is less than, equal to or larger than a noise threshold (e.g. the first noise threshold or a second noise threshold). Different criteria may be applied depending on the mode of operation.

[0017] In an exemplary hearing device, a noise parameter may be based on the sound pressure level (SPL) of the digital audio signal and/or the sound pressure level (SPL) in one or more frequency bands of the digital audio signal, e. g. a first frequency band F_1 and/or a second frequency band F_2. It is contemplated that a noise criterion and/or the noise parameter may be based on SPL or other suitable input signal properties determined by the detector unit or other sound classification units in the hearing device.

[0018] In an exemplary hearing device, a noise criterion in the first mode of operation is given by

$$SPL_{total} > T_1$$

where the first noise parameter SPL_{total} is the sound pressure level of the digital audio signal and T_1 is a first noise threshold. A first transfer function is applied (first mode of operation) if the noise criterion is not fulfilled (false, indicative of no or little wind noise) and a second transfer function is applied (second mode of operation) if the noise criterion is fulfilled (true, indicative of wind noise present).

[0019] In an exemplary hearing device, the noise criterion in the first mode of operation is given by

$$SPL_{F1} > T_1$$

where the first noise parameter SPL_{F1} is the sound pressure level of the digital audio signal in a first frequency band F_1 and T_1 is a first noise threshold. A first transfer function is applied (first mode of operation) if the noise criterion is not fulfilled (false, indicative of no or little wind noise) and the preprocessing unit switches to applying a a second transfer function (second mode of operation) if the noise criterion is fulfilled (true, indicative of wind noise present).

[0020] The noise criterion may be based on a plurality of noise parameters. In an exemplary hearing device, the noise criterion in the first mode of operation is given by

$$(SPL_{total} > T_1) \text{ AND } (SPL_{F1} > T_2)$$

where the first noise parameter SPL_{total} is the sound pressure level of the digital audio signal, T_1 is a first noise threshold, the second noise parameter SPL_{F1} is the sound pressure level of the digital audio signal in a first frequency band F_1, and T_2 is a second noise threshold.

[0021] A first noise criterion may be applied in a first mode of operation and a second noise criterion different from the first noise criterion may be applied in a second mode of operation. The hearing device may be configured to operate in the second mode for a predetermined time period and then switch back to the first mode. For example, the second noise criterion may consist of or include whether the hearing device has operated in the second mode for a certain period of time. A noise criterion may comprise one or more logical expressions.

[0022] The preprocessing unit may be configured to apply a third transfer function with a third cutoff frequency to the audio signal in a third mode of operation depending on the control signal from the processing unit.

[0023] The preprocessing unit is configured to apply a plurality of different transfer functions including a first transfer function and a second transfer function to the output signal from the microphone in different modes of operation, e.g. depending on control signal(s) from the processing unit.

[0024] The first transfer function may be a high pass filter function having a first cutoff frequency f_1. The first cutoff frequency may be selected in the range from 5 Hz to 1 kHz. Exemplary first cutoff frequencies are 20 Hz, 50 Hz, 80 Hz, 100 Hz, 200 Hz, 400 Hz, 600 Hz, 1 kHz or any ranges therebetween.

[0025] The second transfer function may be a high pass filter function. The second cutoff frequency f_2 may be selected in the range from 50 Hz to 2 kHz. Exemplary second cutoff frequencies are 50 Hz, 80 Hz, 100 Hz, 200 Hz, 400 Hz, 600 Hz, 800 Hz, 1 kHz, 2 kHz or any ranges therebetween. The first cutoff frequency may be less than the second cutoff frequency, e.g. f_1=80Hz and f_2=400 Hz .

[0026] The transfer functions applied in different modes may be band-pass filter functions with lower cutoff corresponding to the first and second cutoff frequencies, respectively.

[0027] The processing unit may be configured to send a control signal indicative of a second mode of operation to the preprocessing unit when a first noise criterion is fulfilled in a first mode of operation where a first transfer function is applied. Additionally or as an alternative, the processing unit may be configured to send a control signal indicative of a first mode of operation to the preprocessing unit when a second noise criterion is fulfilled in a second mode of operation where a second transfer function is applied.

[0028] The method according to the present invention comprises applying, in the preprocessing unit, a second transfer function with a second cutoff frequency to the audio signal from the microphone if the noise parameter fullfils a criterion. The method may comprise determining the noise parameter(s) while applying the second transfer function, and applying, in the preprocessing unit, the first transfer function or a third transfer function to the audio signal from the microphone if the noise parameter(s) fullfils a criterion. A first criterion may be applied when the first transfer function is applied in the preprocessing unit and a second criterion different from the first criterion may be applied when the second transfer

function is applied in the preprocessing unit.

[0029] The hearing device according to the present invention provides improved degree of freedom in the design of the hearing device by reducing the requirements to microphone performance.

[0030] Further, the present invention allows for utilizing low frequency audio signals for secondary applications not necessarily related to hearing loss compensation.

[0031] Fig. 1 schematically illustrates an exemplary hearing device. The hearing device 2 comprises a microphone 4 for converting audio into an audio signal 5, and a preprocessing unit 6 for analog processing of the audio signal 5. The preprocessing unit has an input 8 for audio signal 5 and an output 10, wherein the input 8 is connected to an output 12 of the microphone 4. Further, the hearing device 2 comprises an A/D converter 14 for converting the processed analog audio signal 16 into a digital audio signal 18, the A/D converter 14 having an input 20 and an output 22, wherein the input 20 is connected to the output 10 of the preprocessing unit 6. The hearing device comprises a processing unit 24 for digital processing of the digital audio signal 18. The processed digital audio signal 26 is fed to a receiver device (not shown) for conversion of the processed digital audio signal 26 into a compensated audio signal. The processing unit 24 is connected to the preprocessing unit 6 on connection 28 for feeding and/or receiving control signal(s) to/from the preprocessing unit.

[0032] The preprocessing unit 6 is configured to apply a first transfer function H_1 to the audio signal in a first mode of operation and a second transfer function H_2 with a second cutoff frequency to the audio signal in a second mode of operation, depending on a control signal 30 on connection 28 from the processing unit 24.

[0033] Fig. 2 shows an exemplary preprocessing unit 6' of the hearing aid 2. The preprocessing unit 6' comprises a first capacitance circuit 40 with a variable first capacitance value C1 depending on a control signal on control terminal(s) 42. Further, the preprocessing unit 6' comprises a second capacitance circuit 44 with a second capacitance value C2. The preprocessing unit 6' comprises a first resistance circuit 46 with a variable first resistance value R1 depending on a control signal on control terminal(s) 42'. The preprocessing unit 6' is an active unit comprising an amplifier or amplifier circuit 48 having a first input terminal 49A, a second input terminal 49B, and output terminal 50 coupled to the capacitance and resistance circuits 40, 44, 46. The first capacitance circuit 40 is coupled between a first input terminal 47 of the preprocessing unit input 8 and the first input terminal 49A. The second capacitance circuit 44 and the first resistance circuit 46 are coupled in parallel between the first input terminal 49A and the output terminal 50. The second input terminal 49B is connected to virtual ground.

[0034] Fig. 3 shows an exemplary preprocessing unit 6" of the hearing aid 2. The preprocessing unit 6" comprises a first resistance circuit 46 with a variable first resistance value R1 depending on a control signal on control terminal(s) 42'. Further, the preprocessing unit 6" comprises a second resistance circuit 52 with a variable second resistance value R2 depending on a control signal on control terminal(s) 42".

[0035] The preprocessing unit 6" is an active unit comprising an amplifier or amplifier circuit 48 having a first input terminal 49A, a second input terminal 49B, and output terminal 50. The first resistance circuit 46 is coupled between the second input terminal 49B and the output terminal 50. The second resistance circuit 52 is coupled between the second input terminal 49B and the second input terminal 47" of the preprocessing unit.

[0036] A capacitance circuit (not shown) is coupled external to the preprocessing unit between the second input terminal 47' and ground. As an alternative or in combination, a first capacitance circuit (C1) may be incorporated in the preprocessing unit 6" in series with the second resistance circuit 52 between ground and the second input terminal 49B.

[0037] Fig. 4 shows an exemplary resistance circuit with a variable resistance value. Different resistance values may be selected by controlling the switches 56 (open or closed) with a control signal in order to couple or decouple resistors 54.

[0038] Fig. 5 shows an exemplary capacitance circuit with a variable capacitance value. Different capacitance values may be selected by controlling the switches 56 (open or closed) with a control signal in order to couple or decouple capacitors 58.

[0039] Fig. 6 shows exemplary first and second transfer functions applied to the audio signal in first and second modes of operation, respectively. The first transfer function 90 is a high pass filter with a first cutoff frequency f_1 of about 100 Hz. The second transfer function 92 is a high pass filter with a second cutoff frequency f_2 of about 400 Hz.

[0040] Fig. 7 illustrates an exemplary method for operating a hearing aid comprising a microphone, a preprocessing unit, an A/D converter, and a processing unit according to the present invention. The method 100 comprises applying 102, in the preprocessing unit, a first transfer function H_1 to an audio signal from the microphone and converting 104 the preprocessed audio signal to a digital audio signal with the A/D converter.

[0041] Further, the method comprises determining 106 one or more noise parameters including a first noise parameter and/or a second noise parameter of the digital audio signal, and applying 110, in the preprocessing unit, a second transfer function H_2 with a second cutoff frequency f_2 to the audio signal from the microphone depending on a noise criterion 108 based on the one or more noise parameters. In the method 100, the noise criterion applied in 108 depends on the mode of operation. If the preprocessing unit applies a first transfer function corresponding to the first mode of operation, a first criterion based on sound pressure levels is applied. If the first criterion is fulfilled, e.g. one or more sound pressure levels (total and/or selected bandwidths) are larger than respective thresholds, a control signal indicative of second

mode is fed to the preprocessing unit and the preprocessing unit applies a second transfer function 110. If the first criterion is not fulfilled (indicative of no wind noise), the preprocessing unit continues applying the first transfer function corresponding to the hearing device operating in the first mode of operation. If the preprocessing unit applies a second transfer function corresponding to the second mode of operation, a second criterion is applied in 108. The second criterion may be fulfilled if the hearing device has operated in the second mode for a certain time period, i.e. if $t_2 > T_1$, where t_2 is the present time of operation in the second mode and T_1 is a threshold time, e.g. in the range from 1 second to 60 seconds. If the second criterion is fulfilled, a control signal indicative of first mode is fed to the preprocessing unit and the preprocessing unit applies a first transfer function 102. If the second criterion is not fulfilled (indicative of wind noise present), the preprocessing unit continues applying the second transfer function and the hearing device continues operating in the second mode of operation.

[0042] Fig. 8 illustrates an exemplary method for operating a hearing aid comprising a microphone, a preprocessing unit, an A/D converter, and a processing unit according to the present invention. The method 100' comprises applying 102, in the preprocessing unit, a first transfer function H_1 to an audio signal from the microphone and converting 104 the preprocessed audio signal to a digital audio signal with the A/D converter.

[0043] Further, the method comprises determining 106 one or more noise parameters including a first noise parameter and/or a second noise parameter of the digital audio signal. Further, an operation mode of the hearing device is determined based on the one or more noise parameters and the current mode of operation in 106. The operation mode may be selected from two or more operation modes with corresponding transfer functions. In 110, the transfer function corresponding to the mode of operation determined in 106 is applied to the audio signal and the method returns to determining the mode of operation and accordingly the transfer function to be applied in the preprocessing unit.

[0044] Fig. 9 shows an exemplary processing unit 24. The processing unit 24 receives the digital audio signal 18 at input 93. The digital audio signal 18 is fed to detector unit 94 and hearing compensation processing unit 96. The detector unit 94 is configured to determine at least a first noise parameter of the digital audio signal 18. The noise parameter(s) are fed to mode selector 98 configured to determine the mode of operation of the hearing aid, e.g. based on the noise parameter(s) and/or current mode of operation. The mode selector 98 may be embedded in the hearing compensation processing unit 96. The mode selector 98 is configured to send a control signal 30 indicative of mode of operation to the preprocessing unit via processing unit control output 25.

LIST OF REFERENCES

[0045]

2	hearing device
4	microphone
5	audio signal
6	preprocessing unit
8	preprocessing unit input
10	preprocessing unit output
12	microphone output
14	analog-digital (A/D) converter
16	processed analog audio signal
18	digital audio signal
20	A/D converter input
22	A/D converter output
24	processing unit

25	processing unit control output
26	processed digital audio signal
28	connection
30	control signal
40	first capacitance circuit
42, 42', 42"	control terminal(s)
44	second capacitance circuit
46	first resistance circuit
47	first input terminal
48	amplifier
49A	first input terminal of amplifier
49B	second input terminal of amplifier
50	output terminal of amplifier
52	second resistance circuit
54	resistor
56	switch
58	capacitor
90	first transfer function
92	second transfer function
93	digital audio input
94	detector unit
96	hearing compensation processing unit
98	mode selector

Claims

1. A hearing device comprising:

- a microphone for converting audio into an audio signal;
- a preprocessing unit for analog processing of the audio signal and having an input and an output, wherein the input is connected to an output of the microphone;
- an A/D converter for converting the processed analog audio signal into a digital audio signal, the A/D converter having an input and an output, wherein the input is connected to the output of the preprocessing unit; and
- a processing unit for digital processing of A/D converter output, wherein the processing unit is connected to the preprocessing unit;

wherein the preprocessing unit is configured to apply a first transfer function to the audio signal in a first mode of operation and a second transfer function with a second cutoff frequency to the audio signal in a second mode of operation, depending on a control signal from the processing unit.

2. A hearing device according to claim 1, wherein the preprocessing unit comprises a first capacitor circuit with a variable first capacitance value, wherein the first capacitance value depends on the control signal from the processing unit.

3. A hearing device according to any of claims 1-2, wherein the preprocessing unit comprises a first resistor circuit with a variable first resistance value, wherein the second resistance value depends on the control signal from the processing unit.

4. A hearing device according to claim 3, wherein the preprocessing unit comprises a second resistor circuit with a variable second resistance value, wherein the second resistance value depends on the control signal from the processing unit.

5. A hearing device according to any of the preceding claims, wherein the preprocessing unit comprises an amplifier.

6. A hearing device according to any of the preceding claims, wherein the processing unit comprises a detector unit configured to determine one or more noise parameters including a first noise parameter, and wherein the processing unit is configured to send a control signal indicative of mode of operation to the preprocessing unit depending on a noise criterion based on the one or more noise parameter(s).

7. A hearing device according to any of the preceding claims, wherein the processing unit is configured to send a control signal indicative of a second mode of operation to the preprocessing unit when a first noise criterion is fulfilled in a first mode of operation, and a control signal indicative of a first mode of operation to the preprocessing unit when a second noise criterion is fulfilled in a second mode of operation.

8. A hearing device according to any of the preceding claims, wherein the preprocessing unit is configured to apply a third transfer function with a third cutoff frequency to the audio signal in a third mode of operation depending on the control signal from the processing unit.

9. A hearing device according to any of the preceding claims, wherein the first transfer function is a high pass filter function and having a first cutoff frequency, wherein the first cutoff frequency is selected in the range from 100 Hz to 1 kHz.

10. A hearing device according to claim 9, wherein the second cutoff frequency is larger than the first cutoff frequency.

11. A hearing device according to any of the preceding claims, wherein the second transfer function is a high pass filter function and wherein the second cutoff frequency is selected in the range from 100 Hz to 2 kHz.

12. A method for operating a hearing aid comprising a microphone, a preprocessing unit, an A/D converter, and a processing unit, the method comprising:

- applying, in the preprocessing unit, a first transfer function to an audio signal from the microphone,
- converting the preprocessed audio signal to a digital audio signal,
- determining one or more noise parameters including a first noise parameter, and
- applying, in the preprocessing unit, a second transfer function with a second cutoff frequency to the audio signal from the microphone depending on a noise criterion based on the one or more noise parameters.

13. Method according to claim 12, the method comprising determining the one or more noise parameters while applying the second transfer function, and applying, in the preprocessing unit, the first transfer function or a third transfer function to the audio signal from the microphone depending on a noise criterion.

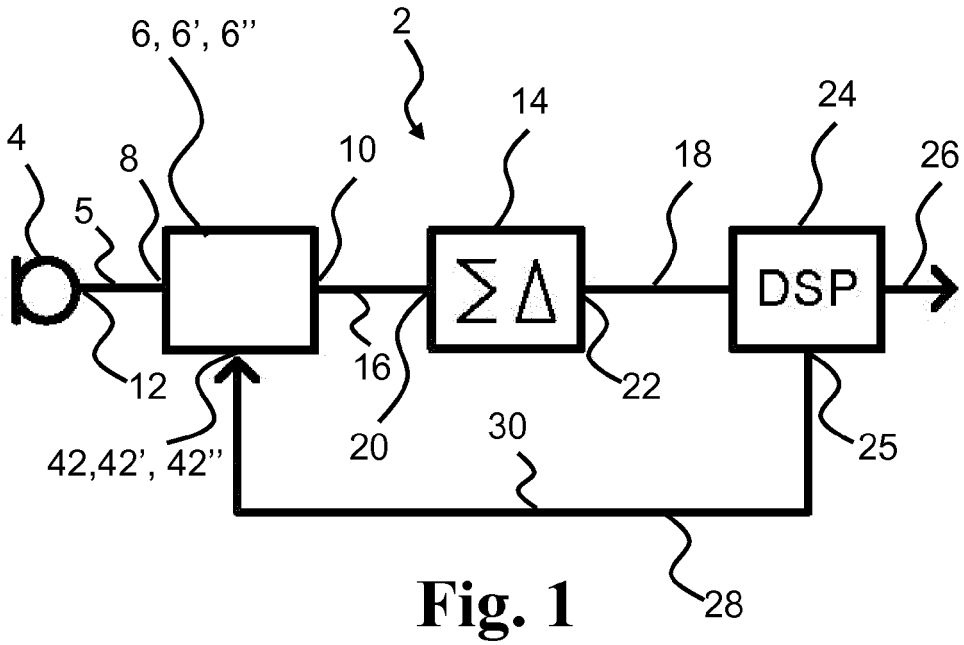

Fig. 1

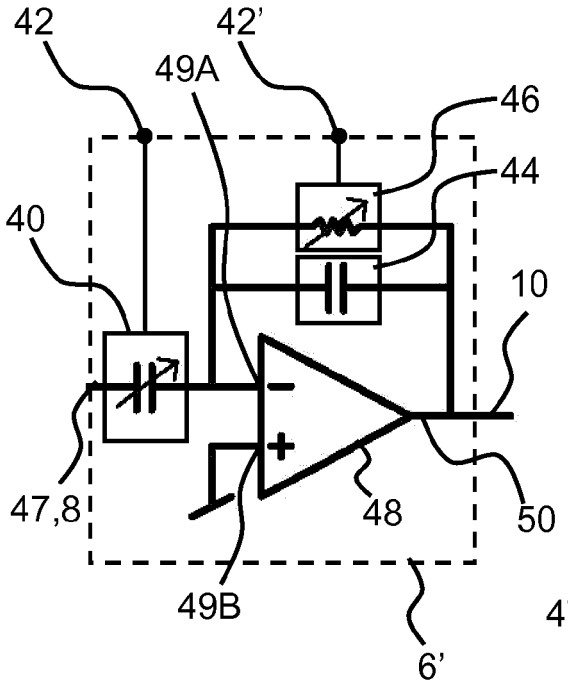

Fig. 2

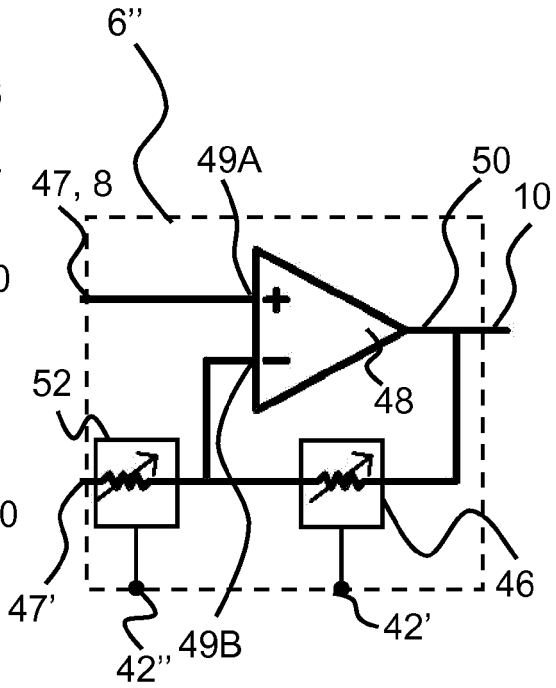

Fig. 3

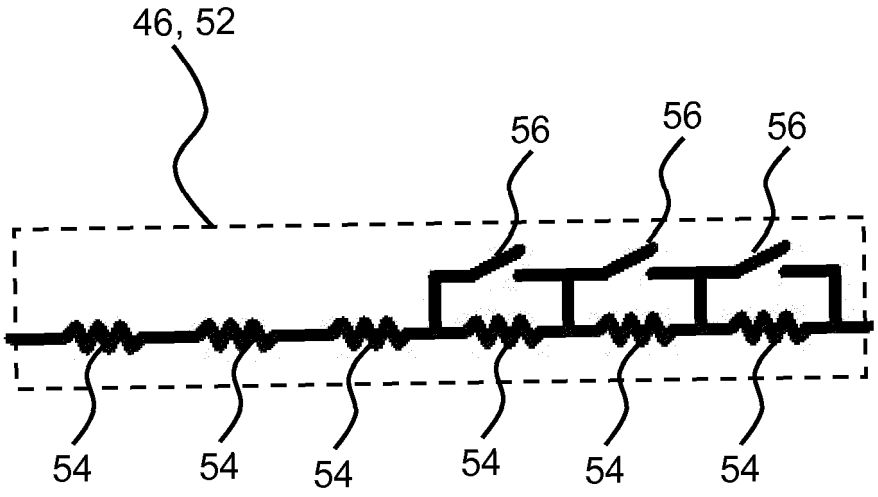

Fig. 4

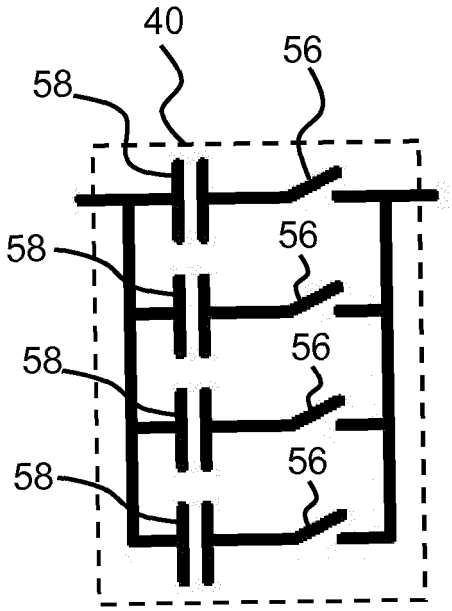

Fig. 5

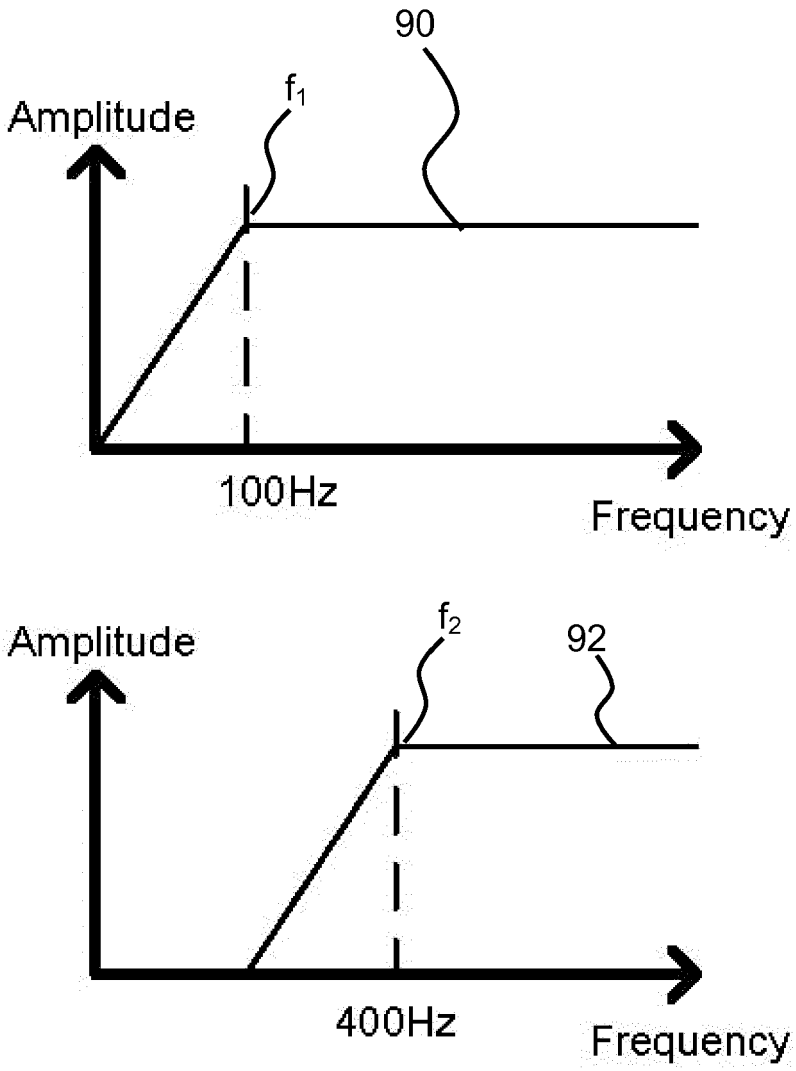
90
f_1
Amplitude
100Hz
Frequency
f_2
92
Amplitude
400Hz
Frequency

Fig. 6

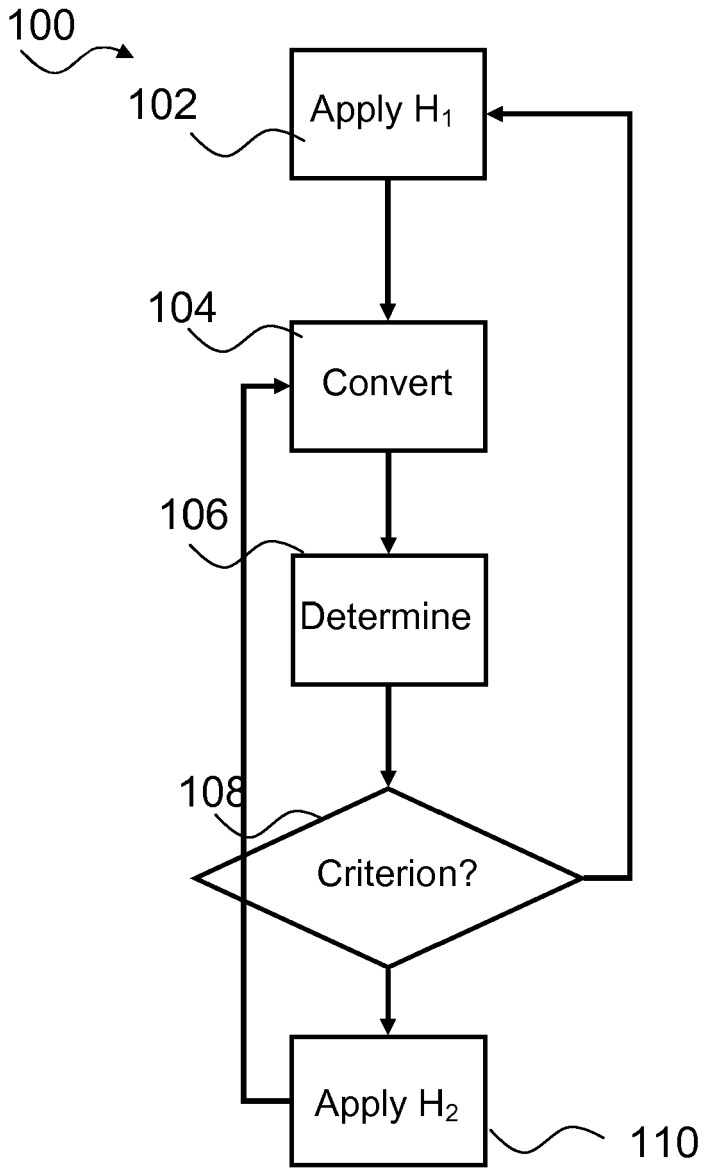
100
102
Apply H_1
104
Convert
106
Determine
108
Criterion?
Apply H_2
110

Fig. 7

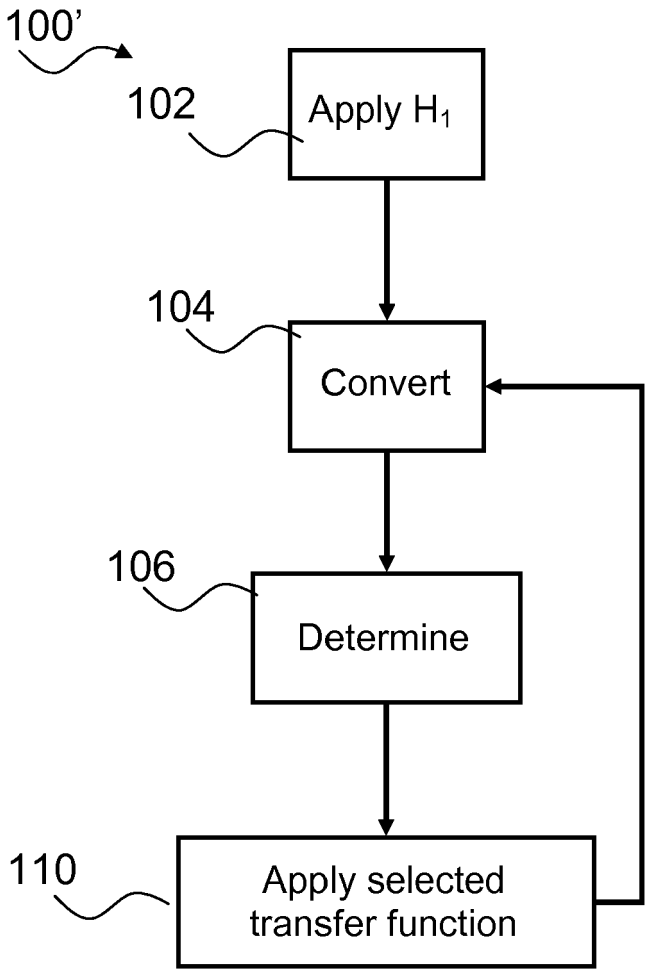
100'
102
Apply H_1
104
Convert
106
Determine
110
Apply selected transfer function

Fig. 8

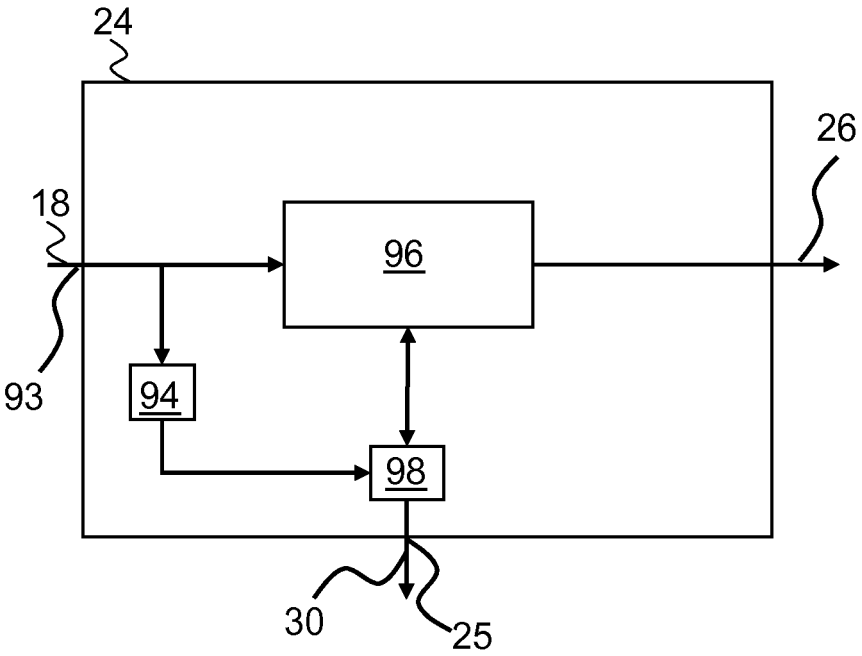

Fig. 9

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 12 19 5007

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	US 2004/175012 A1 (ROECK HANS-UELI [CH] ET AL) 9 September 2004 (2004-09-09) * paragraphs [0152] - [0167] *	1-13	INV. H04R25/00
A	US 5 170 434 A (ANDERSON JAMES R [US]) 8 December 1992 (1992-12-08) * figure 4 *	1-13	
A	WO 2011/006496 A1 (WIDEX AS [DK]; MOERKEBJERG MARTIN [DK]; LL CHUNJIAN [DK]) 20 January 2011 (2011-01-20) * figure 1 *	1-13	
A	EP 1 258 865 A2 (MICRONAS GMBH [DE]) 20 November 2002 (2002-11-20) * paragraph [0024]; figure 3 *	1-13	

TECHNICAL FIELDS SEARCHED (IPC)
H04R
G10L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	3 April 2013	Fruhmann, Markus

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 12 19 5007

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

03-04-2013

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2004175012 A1	09-09-2004	US 2004175012 A1	09-09-2004
		US 2007030987 A1	08-02-2007
		US 2009123009 A1	14-05-2009
US 5170434 A	08-12-1992	NONE	
WO 2011006496 A1	20-01-2011	AU 2009349918 A1	09-02-2012
		CA 2768142 A1	20-01-2011
		CN 102474694 A	23-05-2012
		EP 2454891 A1	23-05-2012
		JP 2012533244 A	20-12-2012
		KR 20120035216 A	13-04-2012
		SG 177623 A1	28-02-2012
		US 2012128163 A1	24-05-2012
		WO 2011006496 A1	20-01-2011
EP 1258865 A2	20-11-2002	DE 10124699 C1	19-12-2002
		EP 1258865 A2	20-11-2002
		JP 4141736 B2	27-08-2008
		JP 2003018691 A	17-01-2003
		US 2002173950 A1	21-11-2002

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82