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The invention relates to a method for operating a hearing apparatus as specified in claim 1 and a hearing apparatus with a frequency separating filter as specified in claim 6.

5 In hearing apparatuses, in particular in hearing devices, frequency-distorting algorithms are used for different purposes and at different points in signal processing. For example a hearing device with a combination of audio compression and feedback suppression is known from DE 699 22 940 T2. All frequency-distorting algorithms share the fact that they are generally only intended to be
10 active from what is known as a threshold frequency, because distortions of low frequencies interfere tremendously with the auditory impression while distortions of high frequencies are less critical.

Figure 1 shows a block circuit diagram of an exemplary realization of frequency
15 distortion in a hearing device. An input signal 100 is split by a frequency separating filter 1 (split-band filter) with a predefinable threshold frequency GF (split frequency) into a low-frequency and a high-frequency signal component 101, 102. The high-frequency signal component 102 is then distorted in a frequency distorter 2. The distorted output signal 103 is fed to an input of an adding unit 3.
20 The low-frequency signal component 101 passes through an all-pass filter 4, which rotates the phase of the signal component 101 so that a subsequent signal addition in the adding unit 3 does not result in signal cancellations in the region of the threshold frequency GF. The phase-rotated low-frequency signal component 104 is fed to a further input of the adding unit 3. The sum of the two
25 signal components 103, 104 is available as an output signal 105 at the output of the adding unit 3.

Frequency separating filters are not ideal and have finite frequency overlapping at their threshold frequency GF. Figure 2 by way of example shows the frequency
30 response of a frequency separating filter in a hearing device with the threshold frequency GF 1800 Hz. The curves K1, K2 show the attenuation D in dB as a function of the frequency F in Hz in the range 0 to 4000 Hz. The curve K1 shows a low-pass characteristic and the curve K2 a high-pass characteristic.

If a low-pass K1 filtered signal component is not distorted and a high-pass K2 filtered signal component is distorted, addition of the signal components K1, K2 results primarily in the region of the threshold frequency GF in non-negligible overlay of both signal components, which is perceived in an output signal of the hearing device as modulation or significant roughness. Both effects are very disruptive and are perceived by a hearing device wearer generally to a far greater extent than the frequency distortion per se.

As well as this “electrical” signal overlay, an acoustic overlay of a frequency-distorted and a non-frequency-distorted signal can also result. Acoustic overlay cannot be ignored, particularly in low frequency ranges and with an open hearing device supply. Direct sound is overlaid with the frequency-distorted signal component output by the hearing device, which in turn produces the artefacts described above.

WO 93/20669 A1 discloses a hearing apparatus with a variable high-pass filter, which attenuates a low-frequency range of a microphone signal of the hearing apparatus to suppress noise interference.

The object of the invention is to overcome the described disadvantages and provide a method for operating a hearing apparatus and a hearing apparatus with a frequency separating filter, which reduce the occurrence of artefacts when undistorted and frequency-distorted signal components are overlaid.

According to the invention the stated object is achieved with the method for operating a hearing apparatus in the independent claim 1 and the hearing apparatus in the independent claim 5.

The invention claims a method for operating a hearing apparatus by splitting an input signal into a low-frequency and a high-frequency signal component using a frequency separating filter and by setting a threshold frequency of the frequency separating filter based on an analysis of the input signal so that arte-

facts in an output signal of the hearing apparatus are reduced. The invention has the advantage that artefacts resulting from signal overlay can be avoided.

5 A development of the method can comprise a distortion, for example a compression or displacement, of the high-frequency signal component and an overlaying of the low-frequency signal component and the distorted high-frequency signal component to form the output signal, in which process it is possible for artefacts to be formed.

10 A further embodiment of the method can comprise a determination of the threshold frequency by analyzing the signal level or tonality of the input signal.

The method can preferably comprise setting the threshold frequency to a frequency, at which the input signal has the lowest possible signal level and/or the
15 lowest possible tonality. This effectively minimizes artefacts which result from overlapping bands of the frequency separating filter.

The method can also comprise feedback detection, with the threshold frequency being momentarily lowered when feedback is identified. This has the advantage
20 that feedback whistling as a result of an unfavourable threshold frequency is avoided.

The invention also claims a hearing apparatus having a frequency separating filter characterized by a threshold frequency, which splits an input signal into a
25 low-frequency and a high-frequency signal component. The hearing apparatus also comprises a first means, which can be used to set the threshold frequency of the frequency separating filter based on an analysis of the input signal so that artefacts in an output signal of the hearing device are reduced. The first means can be a switching logic unit.

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A further embodiment of the invention can comprise a frequency distorter, which distorts, for example compresses or displaces, the high-frequency signal component. The hearing apparatus can also have an adding unit, which forms the

output signal by overlaying the low-frequency signal component with the distorted high-frequency signal component, in which process it is possible for artefacts to be formed.

- 5 In one development the first means can determine the threshold frequency by analyzing the signal level or tonality of the input signal.

The first means can preferably set the threshold frequency to a frequency, at which the input signal has the lowest possible signal level and/or the lowest
10 possible tonality.

The hearing apparatus can also comprise feedback suppression with a feedback detector, which momentarily lowers the threshold frequency when feedback occurs.

15

Further particular features and advantages of the invention will emerge from the descriptions which follow of an exemplary embodiment based on schematic drawings, in which:

- 20 Figure 1 shows a block circuit diagram of an arrangement with a frequency separating filter according to the prior art,

Figure 2 shows a graph of a frequency response of a frequency separating filter according to the prior art,

25

Figure 3 shows graphs of frequency responses in a hearing device according to the prior art,

Figure 4 shows graphs of frequency responses in an inventive hearing device
30 and

Figure 5 shows a block circuit diagram of an inventive arrangement.

Figure 3 shows three graphs illustrating the effect of the threshold frequency GF of a frequency separating filter in a hearing apparatus in a typical application. The top graph shows the frequency response K3 of a signal amplitude A in dB of an input signal, for example a microphone signal, as a function of the frequency F in Hz between 0 and 4000 Hz. A flute tone with a base tone P1 unfavourably coincides precisely with the threshold frequency GF 1800 Hz of the frequency separating filter.

The middle graph in Figure 3 shows the frequency response of the frequency separating filter with a threshold frequency GF at 1800 Hz. The curves K1, K2 show the attenuations D in dB as a function of the frequency F in Hz. The curve K1 shows a low-pass characteristic and the curve K2 a high-pass characteristic. A low-frequency and a high-frequency signal component are therefore available at the outputs of the frequency separating filter. The high-frequency signal component is now displaced upwards in frequency by 100 Hz.

If the high-frequency signal component, the frequency of which has been displaced by 100 Hz, and the undistorted low-frequency signal component are added together, a frequency response K4 according to the bottom graph in Figure 3 results. The curve K4 shows an output signal with a prominent duplicated mode P2, which is perceived as significant distortion.

According to the invention this significant distortion is avoided, in that the threshold frequency GF of the frequency separating filter is set for example to 1200 Hz. Figure 4 shows this effect of the invention in three graphs. As in Figure 3, the top graph shows the frequency response K3 of the signal amplitude A in dB of an input signal as a function of the frequency F in Hz between 0 and 4000 Hz. A flute tone has its base tone P1 at 1800 Hz.

The middle graph in Figure 4 shows the frequency response of the frequency separating filter with a threshold frequency GF displaced to 1200 Hz. The curves K1, K2 show the attenuations D in dB as a function of the frequency F in Hz. The curve K1 shows a low-pass characteristic and the curve K2 shows a

high-pass characteristic. A low-frequency and a high-frequency signal component are therefore available at the outputs of the frequency separating filter. The high-frequency signal component is now displaced upwards in frequency by 100 Hz.

5

If the high-frequency signal component, the frequency of which has been displaced by 100 Hz, and the undistorted low-frequency signal component are added together, a frequency response K5 according to the bottom graph in Figure 4 results. The curve K5 shows an output signal without a prominent duplicated
10 mode. The base tone P3 of the flute is reproduced almost without distortion.

With the inventive method it is therefore possible very effectively to avoid or render inaudible a disruptive "electrical" overlay. The inventive solution can be used independently of an on-off switching logic unit known from the prior art,
15 thereby rendering it more advantageous.

If the threshold frequency GF of the frequency separating filter can be set freely in a specified frequency range, it is possible to reduce overlap artefacts considerably, in that an input signal is analyzed either in respect of signal volume A
20 or tonality and the threshold frequency is then set accordingly. The threshold frequency is preferably set to a frequency, at which the input signal has particularly little signal amplitude A or is particularly lacking in tonality.

Figure 5 shows a block circuit diagram of a typical exemplary embodiment of
25 the invention. An input signal 100 of a hearing apparatus, for example a microphone signal, is split by a frequency separating filter 1 with a predefinable threshold frequency GF into a low-frequency and a high-frequency signal component 101, 102. The high-frequency signal component 102 is then distorted in a frequency distorter 2, its frequency being compressed or displaced for exam-
30 ple. An output signal 103 thus distorted is fed to an input of an adding unit 3. The low-frequency signal component 101 passes through an all-pass filter 4, which rotates the phase so that a subsequent signal addition in the adding unit 3 does not result in signal cancellations in the region of the threshold frequency

GF. The phase-rotated low-frequency signal component 104 is fed to a further input of the adding unit 3. An output signal 105 is available as a sum at the output of the adding unit 3.

- 5 To set or regulate the threshold frequency GF in the inventive manner, the input signal 100 is broken down into frequency bands 106 with the aid of a filter bank 5. The bands are then analyzed in a switching logic unit 6 in respect of their signal amplitude. The threshold frequency close to which the signal level is as low as possible is selected from a predefinable list of possible threshold frequencies, for example 1000 Hz, 1250 Hz, 1500 Hz and 2000 Hz. The frequency separating filter 1 is now cross-faded to this selected threshold frequency GF with an output signal 107 of the switching logic unit 6. The displacement of the threshold frequency GF means that artefacts resulting from overlapping bands of the frequency separating filter 1 are minimized.

15

- Frequency distortion for better feedback suppression in hearing apparatuses can also produce an acoustic overlaying of sound from the hearing apparatus and sound reaching the eardrum in an acoustically direct manner in addition to the described "electrical" overlay, depending on the ear coupling. This occurs for physical reasons, particularly at low frequencies. The problem also occurs here that undistorted signal components by way of the physical path are overlaid with intentionally distorted signal components by way of the hearing apparatus in the same frequency band, producing unwanted artefacts. Since this preferably occurs at low frequencies, the countermeasure would be to raise the threshold frequency GF of the frequency separating filter 1 so high that the resulting overlay becomes insignificant. However this increases the risk of feedback whistling in the low frequency band.

- One advantageous remedy for this is to combine the inventive method with a feedback detector 7 according to Figure 5. If feedback whistling is detected - this generally being the more disruptive artefact - the threshold frequency GF is lowered appropriately by the feedback detector 7 and the feedback whistling is quickly suppressed. The overlay artefacts that in some instances occur for a

short time in this process and are described above represent the lesser evil here. Once the feedback whistling has been successfully suppressed and/or when dominant/tonal signal components occur in the lower band, it is possible to raise the threshold frequency GF of the frequency separating filter 1 again.

5

List of reference characters

1	Frequency separating filter/split-band filter
2	Frequency distorter
3	Adding unit
4	All-pass filter
5	Filter bank
6	Switching logic unit
7	Feedback detector
100	Input signal/microphone signal
101	Low-frequency signal
102	High-frequency signal
103	Distorted signal
104	Phase-compensated signal
105	Output signal
106	Frequency bands
107	Output signal of the switching logic unit
A	Signal amplitude
D	Attenuation
F	Frequency
GF	Threshold frequency
K1	Frequency response low-pass
K2	Frequency response high-pass
K3	Frequency response of the input signal 100
K4	Frequency response of the output signal 105
K5	Frequency response of the output signal 105 after displacement of the threshold frequency GF

P1	Base tone in the input signal 100
P2	Distorted base tone in the output signal 105/mode
P3	Undistorted base tone in the output signal 105

Patentkrav

1. Fremgangsmåde til drift af et høreapparat, og hvor man:

- 5 - opdeler høreapparatets indgangssignal (100) i en lavfrekvent signaldel og en højfrekvent signaldel (101,102) ved hjælp af en frekvensomskifter (1),
 - forvrænger (2) den højfrekvente signaldel (102), og
 - overlejer (3) den lavfrekvente signaldel (104) og den forvrængede højfrekvente signaldel (103), så at der dannes et udgangssignal (105)

10

kendetegnet ved, at

- man indstiller en i forvejen definerbar grænsefrekvens (GF) på frekvensomskifteren (1) ved at foretage en analyse af indgangssignalet (100), så at
15 "artefakter" i udgangssignalet (105) reduceres.

2. Fremgangsmåde ifølge krav 1, **kendetegnet ved, at**

- man indstiller (6) grænsefrekvensen (GF), ved at man analyserer signa-
20 niveauet (A) eller tonaliteten af indgangssignalet (100).

3. Fremgangsmåde ifølge et af de foregående krav, **kendetegnet ved, at**

- man indstiller grænsefrekvensen (GF) på en frekvens, hvor indgangssig-
25 nalet (100) har det lavest mulige signalniveau (A) og/eller den lavest muli-
 ge tonalitet.

4. Fremgangsmåde ifølge et af kravene 2-4, **kendetegnet ved, at**

- 30 - man konstaterer tilbagekoblingen (7), og at grænsefrekvensen (GF), når der konstateres en tilbagekobling, midlertidigt sænkes.

5. Høreapparat med

- en ved hjælp af en grænsefrekvens (GF) karakteriseret frekvensomskifter (1), som kan opdele et indgangssignal (100) i en lavfrekvent og en højfrekvent signaldel (101, 102),
- en frekvensforvrængningsenhed (2), som forvrænger den højfrekvente signaldel (102), og
- en additionsenhed (3), som ved overlejring af den lavfrekvente signaldel (104) med den forvrængede højfrekvente signaldel (103) kan danne et udgangssignal (105),

10 **kendetegnet ved**, at det har

- et første organ (6), som indstiller grænsesekvensen (GF), på grundlag af en analyse af indgangssignalet (100) med det første organ, således at "artefakter" i et udgangssignal (105) fra høreapparatet reduceres.

15

6. Høreapparat ifølge krav 5, **kendetegnet ved**, at det første organ (6) er indrettet til ved analyse af signalniveauet (A) eller tonaliteten af indgangssignalet (100) at bestemme grænsefrekvensen (GF).

20 7. Høreapparat ifølge krav 5 eller 6, **kendetegnet ved**, at det første organ (6) kan indstille grænsefrekvensen (GF) på en frekvens, hvor indgangssignalet (100) har det lavest mulige signalniveau (A) og/eller den lavest mulige tonalitet.

25 8. Høreapparat ifølge et af kravene 5-7 med et organ til undertrykkelse af tilbagekoblingen, **kendetegnet ved**

- en tilbagekoblingsdetektor (7), som foreløbigt kan sænke grænsefrekvensen (GF), hvis en tilbagekobling konstateres.

FIG 1

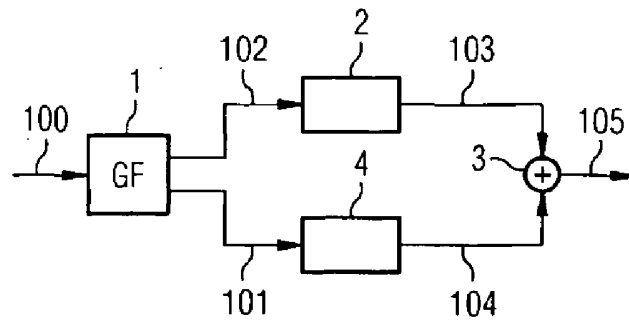


FIG 2

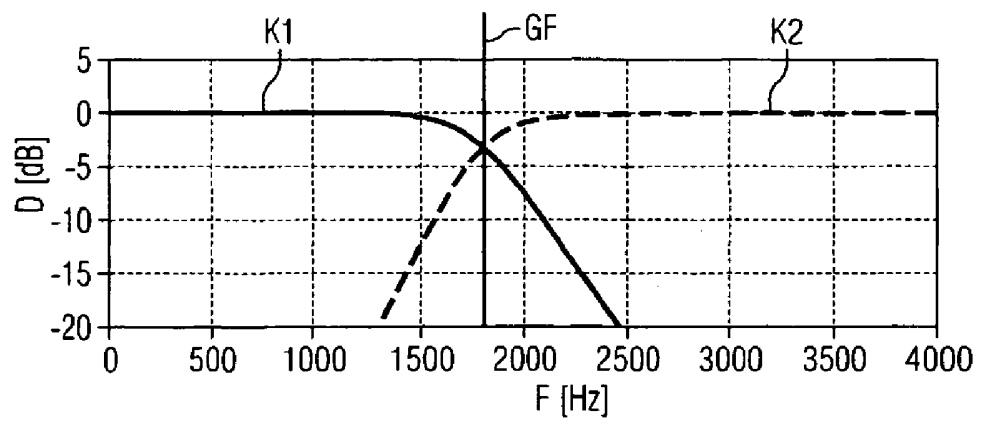


FIG 3

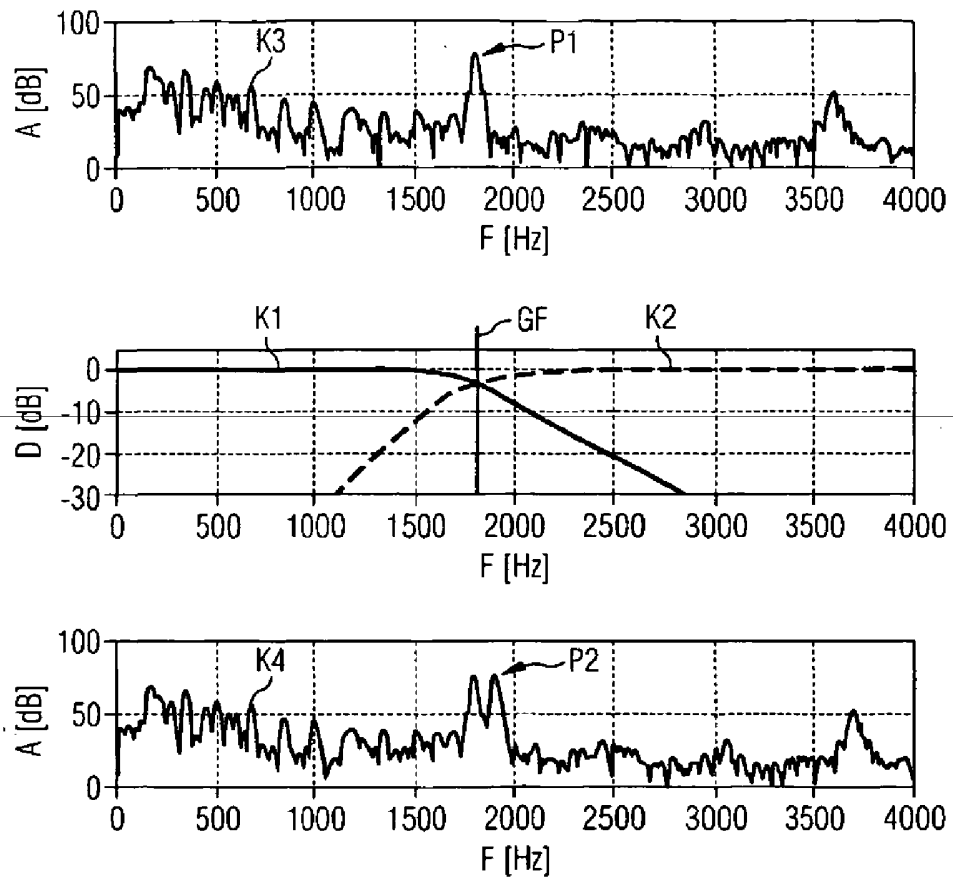


FIG 4

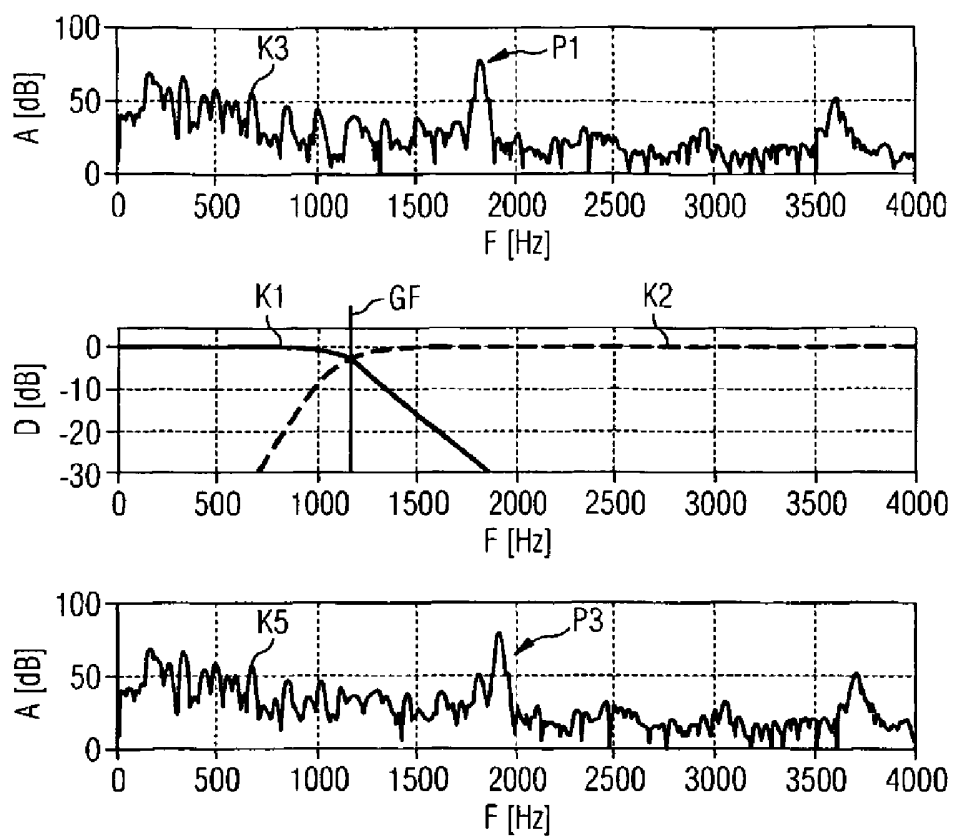


FIG 5

