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(72) Inventor: **KAWANO, Seiji, Sanyo Electric Co., Ltd
Moriguchi-shi, Osaka 570-8677 (JP)**

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(74) Representative: **Glawe, Delfs, Moll & Partner
Patentanwälte
Postfach 26 01 62
80058 München (DE)**

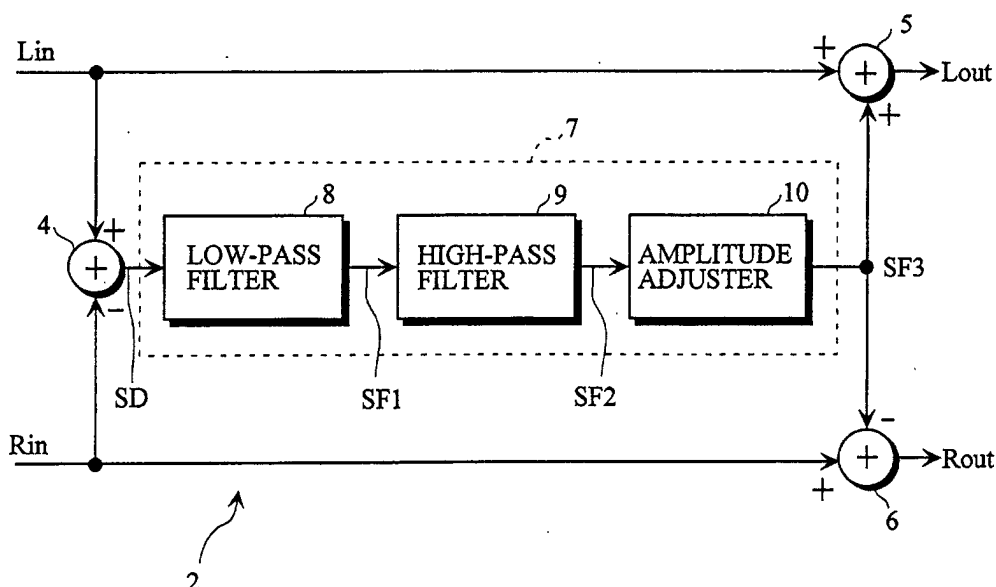
(71) Applicant: **Sanyo Electric Co., Ltd.
Moriguchi-shi, Osaka 570-8677 (JP)**

(54) **STEREO ACOUSTIC IMAGE AMPLIFIER**

(57) A stereo acoustic image amplifier comprises a first operation unit for subtracting a second input signal from a first input signal to generate a difference signal, a filter for filtering the difference signal from the first operation unit to generate a filter difference signal, a second operation unit for adding the first input signal and

the filter difference signal from the filter to generate a first output signal, and a third operation unit for subtracting from the second input signal the filter difference signal from the filter, the filter comprising a low-pass filter having a cut-off frequency of 5 kHz and a high-pass filter having a cut-off frequency of 200 Hz.

FIG. 2



Description

Technical Field

[0001] The present invention relates to a stereo acoustic image amplifier which is applied to electronic equipment, a game machine, and acoustic equipment, for example.

Background Art

[0002] A technique for mixing with a reproduced sound a sound 180° out of phase with the reproduced sound so that an acoustic image is oriented outside right and left speakers has been developed. If the technique is used, a stereo acoustic image can be amplified, thereby making it possible to significantly amplify a sound stage.

[0003] An example of a stereo acoustic image amplifier utilizing such a technique is one disclosed in JP-A-9-168200. The stereo acoustic image amplifier disclosed in JP-A-9-168200 is characterized by comprising a first operation unit for subtracting a second input signal from a first input signal to generate a difference signal, a filter for filtering the difference signal from the first operation unit to generate a filter difference signal, a second operation unit for adding the first input signal and the filter difference signal from the filter to generate a first output signal, and a third operation unit for subtracting from the second input signal the filter difference signal from the filter, the filter being comprised of a low-pass filter.

[0004] Consider a case where the filter is comprised of only a low-pass filter. In the case of such a stereo sound source that a sound in a very low frequency region, for example, a sound of a bass or a bass drum which is a musical instrument in a musical piece is recorded by being only panned, a low frequency difference signal is added or subtracted to or from both right and left channels. Accordingly, irrespective of the fact that the low frequency signal is more easily recognized by a listener, the sound volume is increased. Moreover, the panning is strengthened, so that an outputted sound enters an offset state. As a result, the outputted sound becomes a sound having a significantly uncomfortable feeling.

[0005] Particularly the increase in the sound volume in the low frequency region is a fatal problem in reproduction using a small-sized speaker which cannot reproduce the low frequency region.

[0006] JP-A-8-509104 (published patent gazette) discloses that a filter is comprised of a band-pass filter. However, the band of the band-pass filter is as narrow as 300 Hz to 2 KHz, as disclosed in JP-A-8-509104. Consequently, a natural reproduced sound cannot be obtained.

[0007] An object of the present invention is to provide a stereo acoustic image amplifier in which even in a low

frequency signal (e.g., a sound of a bass or a bass drum) which is only panned with the right and left channels being in phase or slightly out of phase, the ratio of the amplitudes of the right and left channels does not vary, and an uncomfortable feeling to be emphasized is also eliminated.

Disclosure of Invention

[0008] A stereo acoustic image amplifier according to the present invention is characterized by comprising a first operation unit for subtracting a second input signal from a first input signal to generate a difference signal; a filter for filtering the difference signal from the first operation unit to generate a filter difference signal; a second operation unit for adding the first input signal and the filter difference signal from the filter to generate a first output signal; and a third operation unit for subtracting from the second input signal the filter difference signal from the filter, the filter comprising a low-pass filter having a cut-off frequency of 5 kHz and a high-pass filter having a cut-off frequency of 200 Hz.

[0009] The filter further comprises a gain adjuster for limiting the amplitude of the difference signal which has been filtered by the low-pass filter and the high-pass filter.

Brief Description of Drawings

[0010]

Fig. 1 is a block diagram showing the configuration of a stereo acoustic image amplifying system.

Fig. 2 is a block diagram showing the configuration of a stereo acoustic image amplifier shown in Fig. 1.

Fig. 3 is a graph showing the frequency characteristics of a low-pass filter shown in Fig. 2.

Fig. 4 is a graph showing the frequency characteristics of a high-pass filter shown in Fig. 2.

Fig. 5 is a graph showing composite characteristics of the low-pass filter and the high-pass filter.

Best Mode for Carrying Out the Invention

[0011] Referring now to the drawings, an embodiment of the present invention will be described.

[0012] Fig. 1 illustrates the configuration of a stereo acoustic image amplifying system utilizing a stereo acoustic image amplifier.

[0013] The stereo acoustic image amplifying system comprises an external device 1, a stereo acoustic image amplifier 2, a left speaker 3a, and a right speaker 3b.

[0014] Examples of the external device 1 include an electronic musical instrument, a game machine, acoustic equipment, and so forth having output terminals of a left channel signal and a right channel signal. A left channel input signal (a first input signal) Lin and a right channel input signal (a second input signal) Rin which

are generated in the external device 1 are outputted to the stereo acoustic image amplifier 2. The stereo acoustic image amplifier 2 processes the left channel input signal Lin and the right channel input signal Rin, to generate a left channel output signal (a first output signal) Lout and a right channel output signal (a second output signal) Rout and respectively output the signals to the speakers 3a and 3b.

[0015] Fig. 2 illustrates the configuration of the stereo acoustic image amplifier 2.

[0016] The left channel input signal Lin from the external device 1 is fed to a first operation unit 4 and a second operation unit 5. The right channel input signal Rin from the external device 1 is fed to the first operation unit 4 and a third operation unit 6.

[0017] The first operation unit 4 subtracts the right channel input signal Rin from the left channel input signal Lin, to generate a difference signal SD. When the first operation unit 4 is comprised of an operational amplifier, for example, when the left channel input signal Lin is an analog signal, while being comprised of a DSP (Digital Signal Processor) or a CPU (Central Processing Unit), for example, when the left channel input signal Lin is a digital signal.

[0018] The difference signal SD outputted from the first operation unit 4 is fed to a filter 7. The filter 7 comprises a low-pass filter 8, a high-pass filter 9, and an amplitude adjuster 10.

[0019] Fig. 3, Fig. 4, and Fig. 5 respectively illustrate frequency characteristics of the low-pass filter 8, frequency characteristics of the high-pass filter 9, and composite filter characteristics of the low-pass filter 8 and the high-pass filter 9. Fig. 5 (a) and Fig. 5 (b) respectively illustrate composite frequency characteristics of the low-pass filter 8 and the high-pass filter 9 and composite phase characteristics of the low-pass filter 8 and the high-pass filter 9.

[0020] The low-pass filter 8, whose cut-off frequency is 5 kHz, removes a high frequency component of the difference signal SD from the first operation unit 4, to output a first filter output signal SF1. The high-pass filter 9, whose cut-off frequency is 200 Hz, removes a low frequency component of the first filter output signal SF1 from the low-pass filter 8, to output a second filter output signal SF2. An amplitude adjuster 10 multiplies the second filter output signal SF2 by a predetermined multiplication factor in order to limit the amplitude of the second filter output signal SF2 to output a filter difference signal SF3.

[0021] When the difference signal SD inputted to the filter 7 is an analog signal, a well-known analog low-pass filter can be used as the filter 7. On the other hand, when the difference signal SD is a digital signal, a digital filter comprising a delay element, a factor multiplier, and an adder can be used as the filter 7. Further, when the difference signal SD is a digital signal, the functions of the delay element, the factor multiplier and the adder can be also realized by processing performed by the DSP

or the CPU. It is possible to use as the filter 7 a primary IIR (Infinite Impulse Response) digital low-pass filter having a cut-off frequency of 5 kHz and a primary IIR digital high-pass filter having a cut-off frequency of 200 Hz, for example.

[0022] An example of the amplitude adjuster 10 is one for adjusting, when the second filter output signal SF2 is an analog signal, the amplitude of the second filter output signal SF2 by resistance or the like. When the second filter output signal SF2 is a digital signal, the multiplying function of the amplitude adjuster 10 can be also realized by processing performed by the DSP or the CPU. Values from 0 to 1, for example, can be used as a multiplication factor of the amplitude adjuster 10.

[0023] The operations of the stereo acoustic image amplifier 2 will be described. A left channel input signal Lin and a right channel input signal Rin are inputted to the stereo acoustic image amplifier 2 from the external device such as the game machine. The left channel input signal Lin inputted to the stereo acoustic image amplifier 2 is inputted to the first operation unit 4 and the second operation unit 5. Further, the right channel input signal Rin inputted to the stereo acoustic image amplifier 2 is inputted to the first operation unit 4 and the third operation unit 6.

[0024] The first operation unit 4 subtracts the right channel input signal Rin from the inputted left channel input signal Lin, to output a difference signal SD.

[0025] The difference signal SD outputted from the first operation unit 4 is inputted to the filter 7 in the succeeding stage. The difference signal SD inputted to the filter 7 is filtered by the low-pass filter 8, so that a first filter output signal SF1 is outputted from the low-pass filter 8. The first filter output signal SF1 is filtered by the high-pass filter 9, so that a second filter output signal SF2 is outputted from the high-pass filter 9. The second filter output signal SF2 is fed to the amplitude adjuster 10.

[0026] In the amplitude adjuster 10, the amplitude of the second filter output signal SF2 is multiplexed by a predetermined factor in order to limit the amplitude of the second filter output signal SF2, so that a filter difference signal SF3 which is the result of the multiplication is outputted from the amplitude adjuster 10.

[0027] The filter difference signal SF3 outputted from the filter 7 is inputted to the second operation unit 5 and the third operation unit 6. The second operation unit 5 adds the left channel input signal Lin and the filter difference signal SF3, and outputs the result of the addition as a left channel output signal Lout. The third operation unit 6 subtracts the filter difference signal SF3 from the right channel input signal Rin, and outputs the result of the subtraction as a right channel output signal Rout.

[0028] The left channel output signal Lout outputted from the second operation unit 5 is fed to a left speaker (not shown), and the right channel output signal Rout outputted from the third operation unit 6 is fed to a right speaker (not shown). Consequently, a listener can listen

to an amplified acoustic image.

[0029] Although in the above-mentioned example, the first input signal is taken as a left channel input signal Lin, and the second input signal is taken as a right channel input signal Rin, the first input signal may be taken as a right channel input signal Rin, and the second input signal may be taken as a left channel input signal Lin. In this case, the first output signal becomes a right channel output signal Rout, and the second output signal becomes a left channel output signal Lout.

[0030] Although in the above-mentioned embodiment, even in a low frequency signal (e.g., a sound of a bass or a bass drum) which is only panned with right and left channels being in phase or slightly out of phase, the ratio of the amplitudes of the right and left channels does not vary, and an uncomfortable feeling to be emphasized is also eliminated.

Claims

1. A stereo acoustic image amplifier
characterized by comprising:

a first operation unit for subtracting a second input signal from a first input signal to generate a difference signal;
a filter for filtering the difference signal from the first operation unit to generate a filter difference signal;
a second operation unit for adding the first input signal and the filter difference signal from the filter to generate a first output signal; and
a third operation unit for subtracting from the second input signal the filter difference signal from the filter,
the filter comprising a low-pass filter having a cut-off frequency of 5 kHz and a high-pass filter having a cut-off frequency of 200 Hz.

2. The stereo acoustic image amplifier according to claim 1, **characterized in that** the filter further comprises a gain adjuster for limiting the amplitude of the difference signal which has been filtered by the low-pass filter and the high-pass filter.

FIG. 1

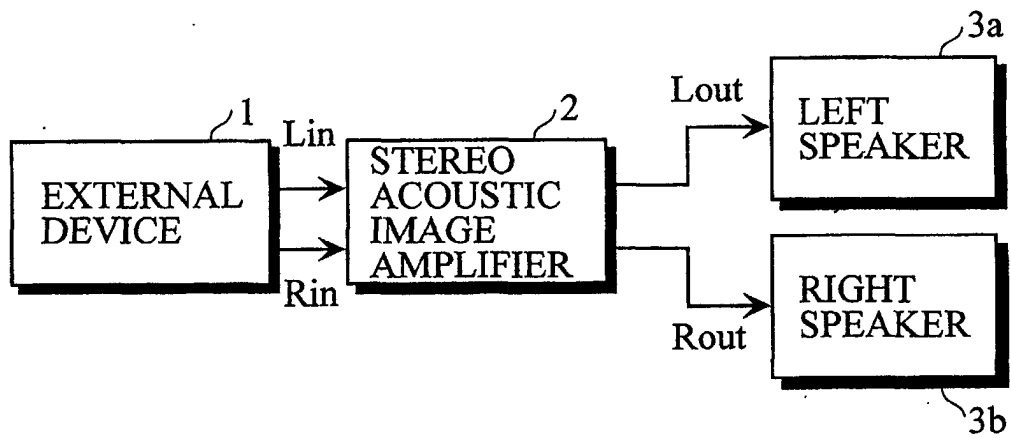


FIG. 2

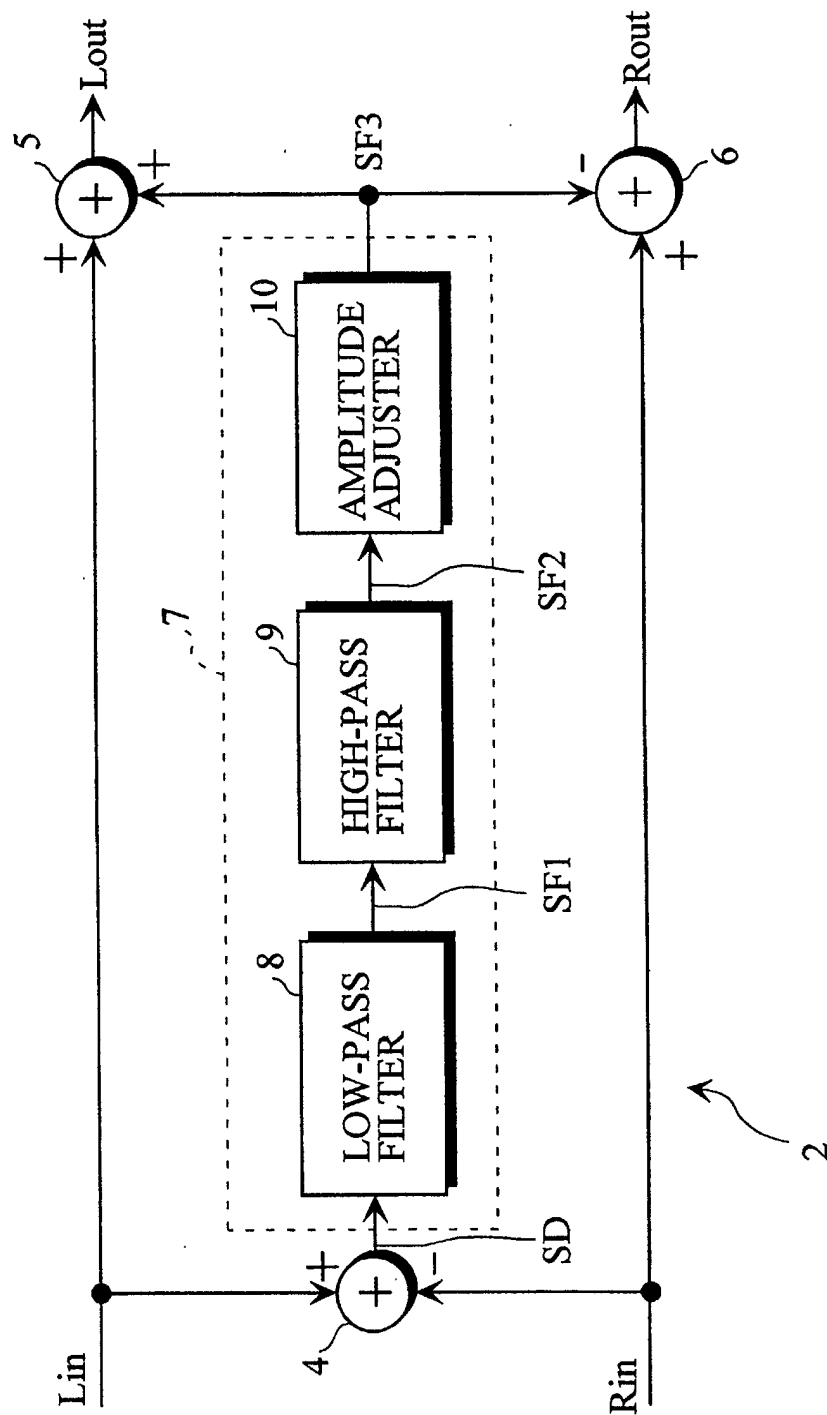


FIG. 3

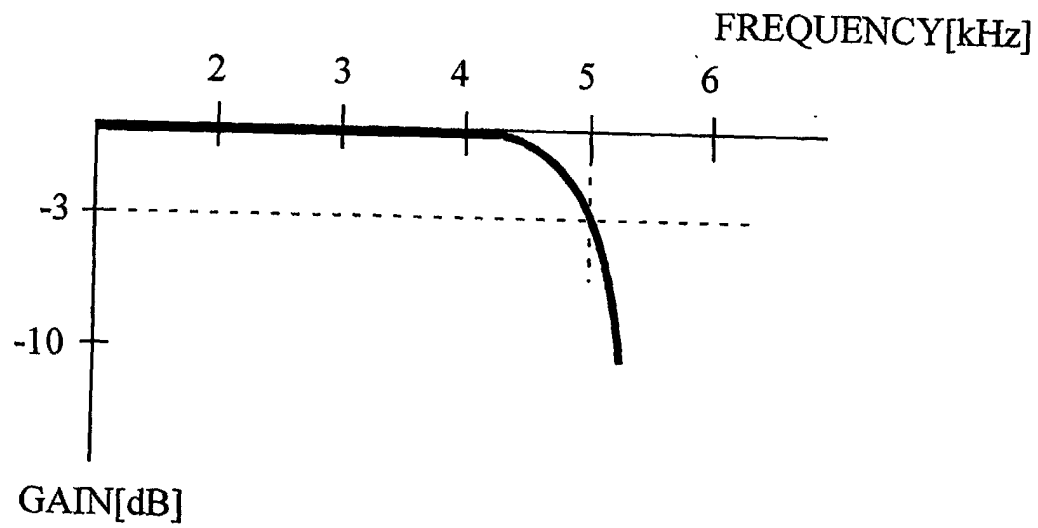


FIG. 4

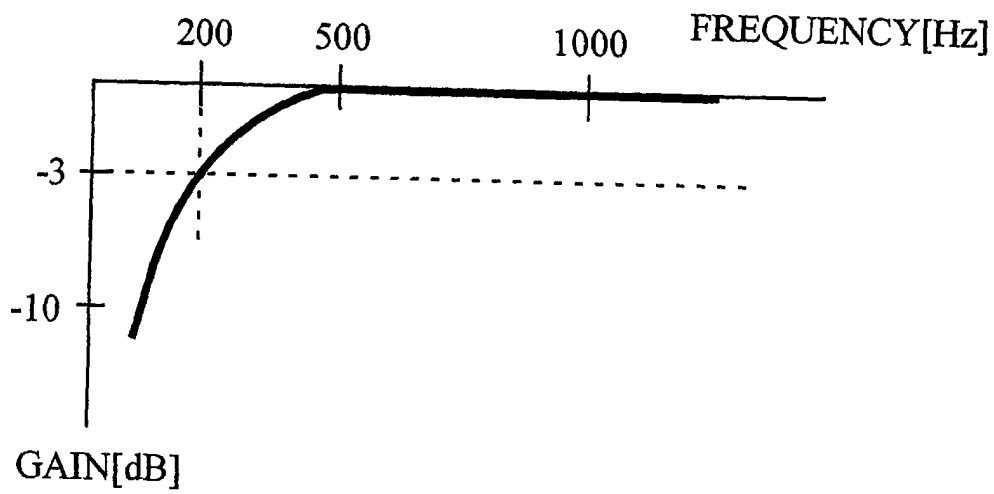
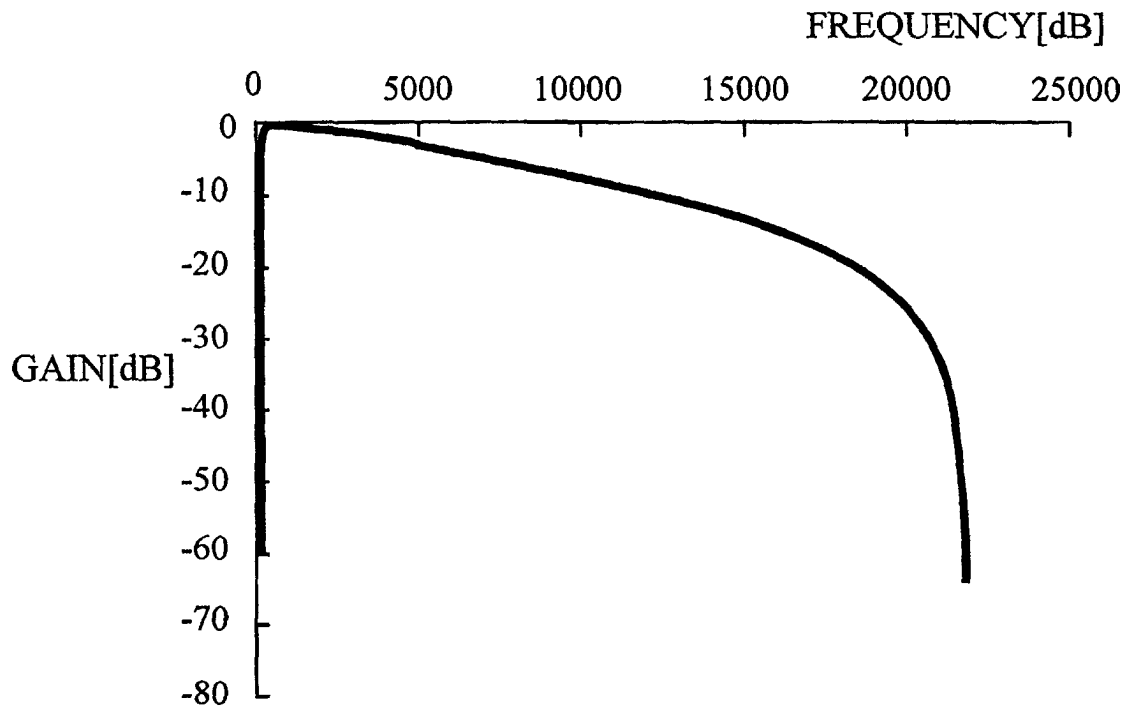
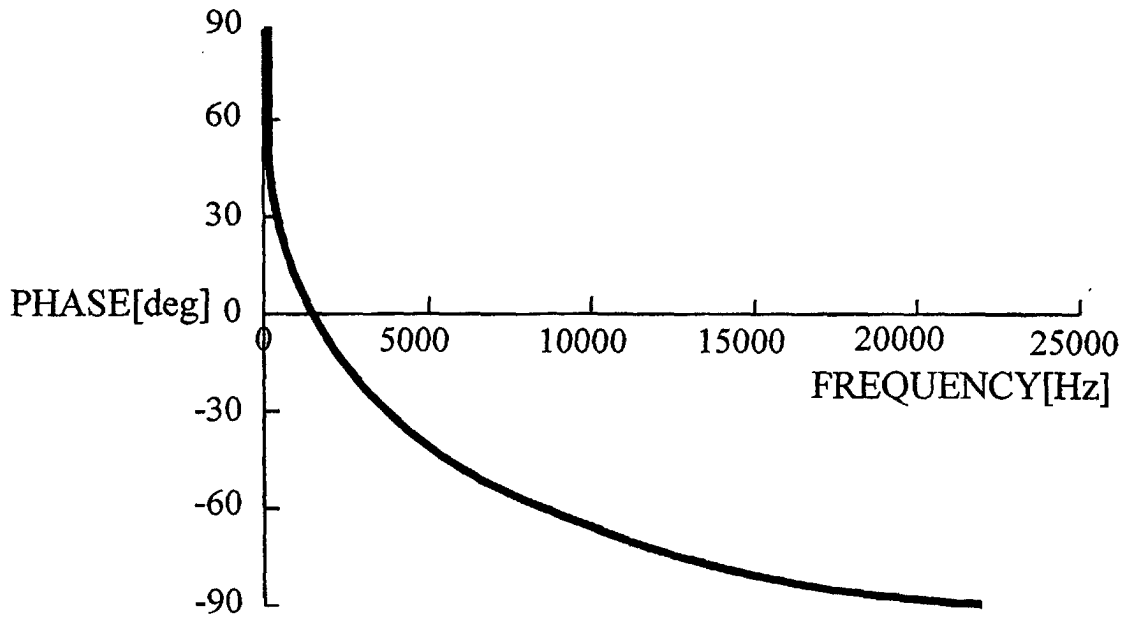


FIG. 5



(a) FREQUENCY CHARACTERISTICS



(b) PHASE CHARACTERISTICS

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP00/03379

A. CLASSIFICATION OF SUBJECT MATTER Int.Cl. ⁷ H04S1/00		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols) Int.Cl. ⁷ H04S1/00-7/00, G10H1/00-7/00		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Jitsuyo Shinan Koho 1922-1996 Toroku Jitsuyo Shinan Koho 1994-2000 Kokai Jitsuyo Shinan Koho 1971-2000 Jitsuyo Shinan Toroku Koho 1996-2000		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP, 57-005500, A (Mitsubishi Electric Corporation), 12 January, 1982 (12.01.82), page 2, upper left column, lines 11 to 19; Fig. 1 & US, 4394537, A	1-2
Y	JP, 63-317000, A (Sanyo Electric Co., Ltd.), 26 December, 1988 (26.12.88), page 2, upper right column, lines 13 to 16; page 2, lower right column, lines 6-18; Figs. 1 to 5 (Family: none)	1-2
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		
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Date of the actual completion of the international search 16 June, 2000 (16.06.00)		Date of mailing of the international search report 27 June, 2000 (27.06.00)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

Form PCT/ISA/210 (second sheet) (July 1992)