

Description

BACK GROUND OF THE INVENTION

1. Field of the invention

The present invention relates to a gain controller for use in an apparatus comprising a frequency characteristic controller (hereinafter called tone controller) and, more particularly, to a gain controller of the type capable of controlling the gain in the apparatus by maintaining a good S/N ratio and preventing a clipping distortion caused by saturation in the tone controller.

2. Description of the prior art

Heretofore, an electronic volume control circuit has been used in an audio equipment such as shown in JP-Y-63-92418. In such electronic volume control circuit, a first depression detection signal is fed to a control circuit when a first push button switch is depressed for controlling the electronic volume controller to increase the resistance value thereof and a second depression detection signal is fed to the control circuit when a second push button switch is depressed for controlling the electronic volume controller to decrease the resistance value thereof. Thereby, if the first and the second depression detection signals are fed simultaneously to the control circuit, the electronic volume controller is so adjusted to a certain value under the control of the control circuit.

Further, JP-Y-63-111015 discloses another prior art tone control device for audio equipments.

In such tone control device, a tone characteristic for a reproduced sound is set by a tone quality setting unit and the selected tone qualities for respective sound sources are stored in a memory unit. The tone quality of an audio signal selected one out of several sound sources is controlled on the basis of the corresponding tone characteristic by means of a tone controller, and the tone characteristic that corresponds to the selected sound source is read from the memory unit, when the reproduction of the selected sound source is started, and fed to the tone controller by means of a control unit.

A further prior-art gain controller with the features included in the first part of claim 1 is known from JP-A-63-160405 in which noise is reduced by providing an electronic volume control to the pre-stage and post-stage of a phase-sound quality adjusting circuit. At the pre-stage the volume is controlled such that the attenuation is decreased from a prescribed value in proportion to an increase of a manipulated variable, while at the post-stage the volume is controlled such that the attenuation is reduced from an infinite value in proportion to the increase of the manipulated variable, so as to make the overall attenuation zero.

FIG. 1 shows a schematic diagram of an audio equipment comprising a prior art tone controller, wherein numeral 1 denotes a tone controller, numeral 6 denotes a fixed attenuator made up of fixed resistors and numeral 7 denotes a volume controller made up of a variable resistor.

The tone controller 1 is provided for changing the frequency characteristic by setting a gain and an attenuation against a specific frequency band, thereby the frequency spectrum of an audio signal can be varied.

On the other hand, the volume controller 7 is provided for attenuating the audio signal uniformly across the whole band by a discretionary amount of level.

The operation of the prior art will now be described more in detail, if the frequency characteristic of the tone controller 1 is so set as to be "0" dB gain within a lower frequency band A and "a" dB gain within a higher frequency band B. Relative gains in the frequency characteristic of the audio signal at input points between blocks will be shown in FIG. 2a - 2c. Firstly, the level of an input signal "I" to the fixed attenuator 6 of FIG. 1 is set to "0" dB as it is shown in FIG. 2a and this level is assumed to be an allowable amplitude for the tone controller 1. The level of an output signal "II" of the fixed attenuator 6 is attenuated by an amount of "b" dB in the whole frequency band as it is shown in FIG. 2b. Accordingly, there is needed the setting of the maximum input level in advance against the tone controller 1 in consideration of the maximum boosting (the maximum gain) value thereof.

In other words, it is necessary that the attenuation of "b" dB that conforms to a margin should be allocated within the allowable input value for the tone controller 1. Therefore, the amount of margin "b" dB is so selected as a value within which a voice signal is not clipped even at the maximum boosting in the tone controller 1. Then an output boosted by the amount of "a" dB at the higher frequency band B is attained from the tone controller 1 as it is shown in FIG. 2c.

As it has been described above, in the audio equipment comprising the prior art tone controller, the margin provided for the tone controller will be of no use if there is no boosting in the tone controller and result in an attenuation of the audio signal to a level less than required. This, in turn, impairs the S/N ratio and deteriorates the quality of the audio signal.

SUMMARY OF THE INVENTION

It is therefore an object of this invention to eliminate the problems as described above and to provide a gain controller comprising a tone controller from which an audio signal of good S/N ratio is derived at all times regardless of the amount of boosting, includ-

ing no boosting as well as of small amount of boosting.

This object is met by the gain controller set forth in claim 1.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram showing an arrangement of a prior art audio equipment;

FIG. 2a - 2c are diagrams showing frequency characteristics for illustrating amounts of attenuations at various points in the prior art audio equipment;

FIG. 3 is a block diagram showing a gain controller in accordance with an embodiment of this invention;

FIG. 4 is a diagram showing a frequency characteristic of a tone controller in the embodiment above;

FIG. 5 is a diagram showing a frequency characteristic for illustrating the sum of attenuations of the first and second electronic volume controllers in the embodiment above;

FIG. 6a - 6c are diagrams showing frequency characteristics for illustrating amounts of attenuations at the various points of the gain controller in accordance with the invention with reference to the characteristics shown in FIG. 4 and FIG. 5;

FIG. 7 is a block diagram for illustrating the signal level change along the blocks of the gain controller in accordance with this invention with reference to the characteristics shown in FIG. 4 and FIG. 5; and

FIG. 8 is a flow chart showing the operation of the microprocessor in the embodiment of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A preferred embodiment of the present invention will now be described more in detail with reference to the accompanying drawings. Referring now to FIG. 3, there is shown an embodiment of this invention in a block diagram, wherein numeral 1 denotes a tone controller to be used as a frequency characteristic controller, numeral 2 denotes a first electronic volume controller to be used as an attenuator and provided at the front stage of the tone controller 1, numeral 3 denotes a second electronic volume controller to be used another attenuator and provided at the rear stage of the tone controller 1 and numeral 4 denotes a microprocessor.

The tone controller 1, the first electronic volume controller 2 and the second electronic volume controller 3 are operated in a cooperative manner under the control of the microprocessor 4. More specifically, the amount of attenuation of the first electronic vol-

ume controller 2 and that of the second electronic volume controller 3 are determined by the microprocessor 4 in response to the frequency characteristic which has been set in the tone controller 1.

As seen, the first electronic volume controller 2, the second electronic volume controller 3 and the microprocessor 4 constitute the gain controller 5 of the present invention. The frequency characteristics at the various points of the gain controller are illustrated in FIG. 6a - 6c provided that the frequency characteristic of the tone controller 1 is so selected as to have "a" dB gain within a higher frequency band B as it is shown in FIG. 4 and the total attenuation of the gain controller 5 or the sum of the attenuations of the first and second electronic volume controllers 2, 3 is so selected as to be "c" dB within the whole frequency band as it is shown in FIG. 5. (i) - (iv) denote audio signals inbetween the blocks of FIG. 3.

Referring to FIG. 6a, the shown frequency characteristic illustrates the input signal level of 0 dB of the first electronic volume controller 2. This is an allowable signal level for the tone controller 1 not to cause clipping distortions when the frequency characteristic thereof is set to zero in the amount of boosting (or no amplification).

Accordingly, the microprocessor 4 controls the first electronic volume controller 2 to attenuate the input signal (i) by the amount of "a" dB within the whole frequency band since the frequency characteristic of the tone controller has been set to that shown in FIG. 4. The attenuated input signal is shown by (ii) in FIG. 6b. Therefore, the gain frequency characteristic for the signal at the output point of the tone controller 1 is shown by (iii) in FIG. 6b and 6c and the maximum level never exceeds 0 dB.

If the input signal is not attenuated at the first electronic volume controller 2, the signal will exceed the 0 dB level at the maximum level thereof in the tone controller as it is shown by (iia) in FIG. 6b and this will result in the clipping distortion to be encountered in the tone controller 1.

The microprocessor 4 then controls the second electronic volume controller 3 to attenuate the signal by an amount of "c - a" dB, which is the difference between the total attenuation "c" dB of the gain controller 5 and the attenuation "a" dB at the first volume controller 2 as they are shown in FIG. 6c, for providing the final gain frequency characteristic shown by (iv) in FIG. 6c.

The state of gain variation for the audio signal along each block of the gain controller is shown in FIG. 7, whereby the frequency characteristic of the tone controller 1 is set as it is shown in FIG. 4. More specifically, it is assumed that the input signal (i) to the first electronic volume controller 2 has the maximum allowable level of 0 dB for the tone controller 1. The first electronic volume controller 2 is then controlled by the microprocessor 4 in accordance with a

control signal I for attenuating the input signal by an amount of a dB which equals the amount of boosting for attaining the selected frequency characteristic in the tone controller 1. The signal is amplified by the amount of "a" dB within the frequency band B in the tone controller 1 in accordance with a control signal II fed by the microprocessor 4 without causing any level change in the frequency band A. The microprocessor also generates a control signal III simultaneously with the control signal I for the second electronic volume controller 3 and thereby controls the attenuation in the second electronic volume controller 3 to attenuate the signal by the amount of "c - a" dB which is given by subtracting "a" dB or the attenuation in the first electronic volume controller 2 from "c" dB or the total attenuation of the gain controller 5.

Consequently, the output signal (iv) of the second electronic volume controller 3 is equivalent to the input signal (i) attenuated by the amount of "c" dB in the frequency band A and "c - a" dB in the frequency band B.

It will be apparent from the foregoing description that the output level (iii) of the tone controller never exceeds 0 dB level and the setting of the frequency characteristic at the tone controller 1 is well reflected in the output signal.

Besides the present invention, it may be possible to keep the input signal not to exceed the maximum allowable input level of the tone controller by attenuating the input signal level sufficiently low in consideration of an estimated amplification at the tone controller, however, this makes the S/N ratio worse and spoils the tone quality considerably. Therefore, the gain controller in accordance with this invention is significant in respect of the S/N ratio.

In the embodiment of the present invention as described above, the total attenuation of the gain controller 5 has been considered to be larger than the gain attained in either frequency band of the tone controller; however, if the total attenuation of the gain controller is less than the gain to be attained in the tone controller, the amount of attenuation at the first electronic volume controller 2 should be limited not to exceed the amount of attenuation set for the whole system provided that the attenuation at the second electronic volume controller 3 is 0 dB.

The invention has been described with reference to the preferred embodiment wherein the signal in a certain frequency band is amplified in the tone controller 1; however, in case of attenuating the signal in the tone controller, no attenuation will be made at the first electronic volume controller 2 under the control of the microprocessor 4.

The operation of the microprocessor 4 will now be described with reference to the flow chart shown in FIG. 8. The microprocessor initiates the operation with a first step S1 wherein the whole system is initially set to have a predetermined amount of attenu-

ation with an input device such as a switch (not shown) and the power source is turned ON. The set value "c" dB for the attenuation of the whole system is detected by the microprocessor 4 at step S2 from the status of the input device such as the switch. It is then determined by the microprocessor 4 at step S3 whether or not an amount of boosting has been set in the tone controller 1 from the status of another input device such as a switch and the like (not shown). If it has, the amount of boosting "a" dB is detected at step S4. Whereas if it has not, the program goes directly to step 7. An amount of attenuation of the first electronic volume controller 2 is determined at step S5 on the basis of the detected value "a" dB and the control of the microprocessor 4. An amount of attenuation "b" dB of the second electronic volume controller 3 is in turn determined at step S6. The amount of attenuation is determined from the equation $b = c - a$ dB. The control operation will end at step 7.

While the invention has been described with reference to an embodiment wherein the tone controller 1 is used for the frequency characteristic controller. It will, however, be apparent that many modification may be made. For example, a graphic equalizer, which is one of the frequency characteristic compensators, that can control a gain independently for a plurality of frequencies, may be substituted for the tone controller.

In the modification considered above, it is obvious to those skilled in the art that the amounts of attenuation of the first and the second electronic volume controllers 2, 3 are determined similarly by the microprocessor 4 based on the frequency characteristic set on the graphic equalizer.

Further, even in a digital signal processing, it is preferable that the attenuation of a signal level should be kept as small as possible and the upper limit of the signal level should be kept within the maximum value to be afforded. Accordingly, it is needless to say that the same advantages as heretofore described can also be attained by an preferred embodiment of this invention be attained by an preferred embodiment of this invention even in the digital signal processing.

It should be appreciated from the foregoing description that the present invention provides an improved gain controller for minimizing the attenuation for an input signal and preventing the deterioration of S/N ratio as well as the occurrence of clipping distortion at the frequency characteristic control stage.

Claims

1. A gain controller comprising
 - a first electronic volume controller (2) for attenuating an input signal (i),
 - a frequency characteristic controller (1) for accepting the output (ii) of the first volume



control signal I for attenuating the input signal by an amount of a dB which equals the amount of boosting for attaining the selected frequency characteristic in the tone controller 1. The signal is amplified by the amount of "a" dB within the frequency band B in the tone controller 1 in accordance with a control signal II fed by the microprocessor 4 without causing any level change in the frequency band A. The microprocessor also generates a control signal III simultaneously with the control signal I for the second electronic volume controller 3 and thereby controls the attenuation in the second electronic volume controller 3 to attenuate the signal by the amount of "c - a" dB which is given by subtracting "a" dB or the attenuation in the first electronic volume controller 2 from "c" dB or the total attenuation of the gain controller 5.

Consequently, the output signal (iv) of the second electronic volume controller 3 is equivalent to the input signal (i) attenuated by the amount of "c" dB in the frequency band A and "c - a" dB in the frequency band B.

It will be apparent from the foregoing description that the output level (iii) of the tone controller never exceeds 0 dB level and the setting of the frequency characteristic at the tone controller 1 is well reflected in the output signal.

Besides the present invention, it may be possible to keep the input signal not to exceed the maximum allowable input level of the tone controller by attenuating the input signal level sufficiently low in consideration of an estimated amplification at the tone controller, however, this makes the S/N ratio worse and spoils the tone quality considerably. Therefore, the gain controller in accordance with this invention is significant in respect of the S/N ratio.

In the embodiment of the present invention as described above, the total attenuation of the gain controller 5 has been considered to be larger than the gain attained in either frequency band of the tone controller; however, if the total attenuation of the gain controller is less than the gain to be attained in the tone controller, the amount of attenuation at the first electronic volume controller 2 should be limited not to exceed the amount of attenuation set for the whole system provided that the attenuation at the second electronic volume controller 3 is 0 db.

The invention has been described with reference to the preferred embodiment wherein the signal in a certain frequency band is amplified in the tone controller 1; however, in case of attenuating the signal in the tone controller, no attenuation will be made at the first electronic volume controller 2 under the control of the microprocessor 4.

The operation of the microprocessor 4 will now be described with reference to the flow chart shown in FIG. 8. The microprocessor initiates the operation with a first step S1 wherein the whole system is initially set to have a predetermined amount of attenu-

ation with an input device such as a switch (not shown) and the power source is turned ON. The set value "c" dB for the attenuation of the whole system is detected by the microprocessor 4 at step S2 from the status of the input device such as the switch. It is then determined by the microprocessor 4 at step S3 whether or not an amount of boosting has been set in the tone controller 1 from the status of another input device such as a switch and the like (not shown). If it has, the amount of boosting "a" dB is detected at step S4. Whereas if it has not, the program goes directly to step 7. An amount of attenuation of the first electronic volume controller 2 is determined at step S5 on the basis of the detected value "a" dB and the control of the microprocessor 4. An amount of attenuation "b" dB of the second electronic volume controller 3 is in turn determined at step S6. The amount of attenuation is determined from the equation $b = c - a$ dB. The control operation will end at step 7.

While the invention has been described with reference to an embodiment wherein the tone controller 1 is used for the frequency characteristic controller. It will, however, be apparent that many modification may be made. For example, a graphic equalizer, which is one of the frequency characteristic compensators, that can control a gain independently for a plurality of frequencies, may be substituted for the tone controller.

In the modification considered above, it is obvious to those skilled in the art that the amounts of attenuation of the first and the second electronic volume controllers 2, 3 are determined similarly by the microprocessor 4 based on the frequency characteristic set on the graphic equalizer.

Further, even in a digital signal processing, it is preferable that the attenuation of a signal level should be kept as small as possible and the upper limit of the signal level should be kept within the maximum value to be afforded. Accordingly, it is needless to say that the same advantages as heretofore described can also be attained by an preferred embodiment of this invention be attained by an preferred embodiment of this invention even in the digital signal processing.

It should be appreciated from the foregoing description that the present invention provides an improved gain controller for minimizing the attenuation for an input signal and preventing the deterioration of S/N ratio as well as the occurrence of clipping distortion at the frequency characteristic control stage.

Claims

1. A gain controller comprising
 - a first electronic volume controller (2) for attenuating an input signal (i),
 - a frequency characteristic controller (1) for accepting the output (ii) of the first volume



controller (2) and for setting a frequency characteristic,

a second electronic volume controller (3) for attenuating the output (iii) of the frequency characteristic controller (1), and

a control element (4) for controlling the first and second volume controllers (2, 3),

characterised in that the control element is a microprocessor (4) which controls the first volume controller (2), the second volume controller (3) and the frequency characteristic controller (1) in a cooperative manner so that the input signal (i) is attenuated by the first volume controller (2) by an amount equal to the maximum amount of boosting set at the frequency characteristic controller (1), and the output (iii) of the frequency characteristic controller (1) is attenuated by the second volume controller (3) by an amount equal to the difference between a desired overall attenuation and the attenuation provided by the first volume controller (2).

2. The gain controller of claim 1, wherein the frequency characteristic controller (1) comprises a tone controller for boosting the signal level at higher and/or lower frequency bands.
3. The gain controller of claim 1, wherein the frequency characteristic controller (1) comprises a tone controller for attenuating the signal level in higher and/or lower frequency bands.
4. The gain controller of claim 1, wherein the frequency characteristic controller (1) comprises a graphic equaliser.
5. The gain controller of any one of claims 1 to 4, wherein the first and second volume controllers (2, 3) comprise electronic variable resistors.
6. The gain controller of any one of claims 1 to 5, wherein the input signal (i) is a digital signal.
7. A gain controlling method which avoids signal clipping without unnecessarily decreasing signal quality, including boosting said signal in a frequency-selective manner, characterised in that prior to said boosting, the signal is attenuated by an amount equal to the greatest boosting amount applied to the signal during said boosting, and that after said boosting, the signal is attenuated by an amount equal to the difference between a desired overall attenuation and the attenuation applied in the first attenuating step.

Patentansprüche

1. Verstärkungsregler, umfassend
 - einen ersten elektronischen Volumenregler (2) zum Dämpfen eines Eingangssignals (i),
 - einen das Ausgangssignal (ii) des ersten Volumenreglers (2) aufnehmenden Frequenzgangregler (1) zur Einstellung eines Frequenzgangs,
 - einen zweiten elektronischen Volumenregler (3) zum Dämpfen des Ausgangssignals (iii) des Frequenzgangreglers (1), und
 - ein Steuerelement (4) zur Steuerung des ersten und des zweiten Volumenreglers (2, 3),
 dadurch gekennzeichnet, daß das Steuerelement ein Mikroprozessor (4) ist, das den ersten Volumenregler (2), den zweiten Volumenregler (3) und den Frequenzgangregler (1) zusammenwirkend derart steuert, daß das Eingangssignal (i) durch den ersten Volumenregler (2) um einen Betrag gedämpft wird, der gleich ist dem Höchstbetrag der an dem Frequenzgangregler (1) eingestellten Pegelanhebung, und das Ausgangssignal (iii) des Frequenzgangreglers (1) durch den zweiten Volumenregler (3) um einen Betrag gedämpft wird, der gleich ist der Differenz zwischen einer gewünschten Gesamtdämpfung und der von dem ersten Volumenregler (2) vermittelten Dämpfung.
2. Verstärkungsregler nach Anspruch 1, wobei der Frequenzgangregler (1) einen Klangregler zum Anheben des Signalpegels in höheren oder niedrigeren Frequenzbändern umfaßt.
3. Verstärkungsregler nach Anspruch 1, wobei der Frequenzgangregler (1) einen Tonregler zum Dämpfen des Signalpegels in höheren oder niedrigeren Frequenzbändern umfaßt.
4. Verstärkungsregler nach Anspruch 1, wobei der Frequenzgangregler (1) einen Graphic-Equaliser umfaßt.
5. Verstärkungsregler nach einem der Ansprüche 1 bis 4, wobei der erste und der zweite Volumenregler (2, 3) elektronische veränderbare Widerstände umfassen.
6. Verstärkungsregler nach einem der Ansprüche 1 bis 5, wobei das Eingangssignal (i) ein Digitalsignal ist.
7. Verfahren zur Verstärkungsregelung, das eine Signalbeschneidung ohne unnötige Herabsetzung der Signalqualität vermeidet, wobei der Signal frequenzselektiv angehoben wird, dadurch gekennzeichnet,



daß das Signal vor der Pegelanhebung um einen Betrag gedämpft wird, der gleich ist dem größten während der Pegelanhebung auf das Signal angewandten Pegelanhebungsbetrag, und daß das Signal nach der Pegelanhebung um einen Betrag gedämpft ist, der gleich ist der Differenz zwischen einer gewünschten Gesamtdämpfung und der im ersten Dämpfungsschritt angewandten Dämpfung.

Revendications

1. Commande de gain comprenant :
 - une première commande électronique de volume (2) pour atténuer un signal d'entrée (i) ;
 - une commande de réponse en fréquence (1) pour recevoir la sortie (ii) de la première commande de volume (2) et pour régler une réponse en fréquence ;
 - une seconde commande électronique de volume (3) pour atténuer la sortie (iii) de la commande de réponse en fréquence (1), et
 - un élément de commande (4) pour commander les première et seconde commandes de volume (2, 3) ;
 caractérisée en ce que l'élément de commande est un microprocesseur (4) qui commande la première commande de volume (2), la seconde commande de volume (3) et la commande de réponse en fréquence (1) en coopération, de telle manière que le signal d'entrée (i) soit atténué par la première commande de volume (2) d'une valeur égale à la valeur d'amplification maximale réglée au droit de la commande de réponse en fréquence (1), et que la sortie (iii) de la commande de réponse en fréquence (1) soit atténuée par la seconde commande de volume (3) d'une valeur égale à la différence entre une atténuation globale souhaitée et l'atténuation fournie par la première commande de volume (2).
2. Commande de gain selon la revendication 1, dans laquelle la commande de réponse en fréquence (1) comprend un correcteur de tonalité pour amplifier le niveau de signal au droit de bandes de fréquences supérieure et/ou inférieure.
3. Commande de gain selon la revendication 1, dans laquelle la commande de réponse en fréquence (1) comprend un correcteur de tonalité pour atténuer le niveau de signal au droit de bandes de fréquences supérieure et/ou inférieure.
4. Commande de gain selon la revendication 1, dans laquelle la commande de réponse en fréquence (1) comprend un égaliseur graphique.
5. Commande de gain selon l'une quelconque des revendications 1 à 4, dans laquelle les première et seconde commandes de volume (2, 3) comprennent des résistances électroniques variables.
6. Commande de gain selon l'une quelconque des revendications 1 à 5, dans laquelle le signal d'entrée (i) est un signal numérique.
7. Procédé de commande de gain qui évite l'écrêtage de signal sans diminuer inutilement la qualité du signal, comprenant l'amplification dudit signal d'une manière sélective en fréquence ;
 - caractérisé :
 - en ce qu'avant ladite amplification, le signal est atténué d'une valeur égale à la valeur d'amplification la plus grande appliquée au signal pendant ladite amplification ; et,
 - en ce qu'après ladite amplification, le signal est atténué d'une valeur égale à la différence entre une atténuation globale souhaitée et l'atténuation appliquée dans la première étape d'atténuation.