

TITLE OF THE INVENTION

Analog Signal Amplifier and Audio Signal Amplifier

FIELD OF THE INVENTION

The present invention relates to an analog signal amplifier for amplifying the analog signal of an audio signal or the like, and an audio signal amplifier for amplifying an input audio signal and supplying the amplified audio signal to a speaker reproducing device.

BACKGROUND OF THE INVENTION

In recent years, an audio signal amplifier used for amplifying a sound signal has been roughly divided, in view of its operating state during its power amplifying stage, into three kinds of amplifiers including an A class amplifier, a B class amplifier and an AB class amplifier. The rate of amplifiers other than the above mentioned amplifiers which have been used has been extremely lower than that of them.

Most of the A class amplifiers, the B class amplifiers and the AB class amplifiers have use push-pull emitter followers, as the final constructions of their power amplifying stages.

This push-pull emitter follower includes a power device having two components with different polarities as one pair. If the power device is a power transistor, the power device includes an NPN type power transistor and a PNP type power transistor as one pair.

A brief explanation will be given as to the A class amplifier,

the B class amplifier and the AB class amplifier respectively hereinafter. The A class amplifier is provided with the above described two power transistors which constantly operate in an active state. In the B class amplifier, one of the two power transistors operates so as to be always located in a cut-off area when the other is in an activated state. Further, the AB class amplifier serves to make an intermediate operation between the A class amplifier and the B class amplifier and operate so that one power transistor is located in an active area or a cut-off area when the other transistor is in an active area.

Now, the above mentioned push-pull emitter follower will be described specifically. A set of power devices forming the push-pull emitter follower connected in series between a supply power source and a speaker reproducing device which is a load. Specifically, when the power device is employed as an example of the power device, current is supplied sequentially from the supply power source to a supply power source (ground) through the collector terminal of the power transistor, the emitter terminal of the power transistor and the speaker reproducing device.

It is apparent from the above described construction that supply source voltage is divided into voltage applied to a part between the collector terminal and the emitter terminal of the power transistor, and voltage applied to the speaker reproducing device as a load. In other words, since the current supplied to the speaker reproducing device serving as the load always passes

between the collector terminal and the emitter terminal of the power transistor, and the above mentioned voltage is applied between these terminals, electric power is consumed in this power transistor. Further, since this electric power is not supplied to the speaker reproducing device as the load, power loss is undesirably generated. As a result, heat is produced in an P-N junction of the power transistor. When it is assumed that the power loss consumed in this power transistor is P_d , the power loss p_d of the B class amplifier which is the smallest among those of the A class amplifier, the B class amplifier and the AB class amplifier are shown approximately by the formula:

$$P_d = \frac{2 \times V_{cc} \times V_{out}}{\pi \times R_L} - \frac{V_{out}^2}{2 \times R_L} \quad \dots (1)$$

(where a supply source voltage value is $\pm V_{cc}$, the amplitude value of output voltage is V_{out} and the value of load is R_L .)

As apparent from this relational expression, the power loss P_d is a value which depends on the supply source voltage value V_{cc} . Generally, when the amplitude value V_{out} of the output voltage and the value R_L of the load are kept constant, the value of the power loss P_d becomes large as the supply source voltage value grows large. This fact is applicable to both of the A class amplifier and the AB class amplifier.

In the meantime, when it is assumed that the maximum output power value of an audio signal amplifier employed for amplifying a sound signal is W_{MAX} , W_{MAX} is shown approximately by a formula mentioned below, irrespective of its operating class, namely, the A class amplifier, the B class amplifier and the AB class amplifier.

$$W_{MAX} = \frac{V_{CC}^2}{2 \times R_L} \dots (2)$$

It can be understood from this formula that the maximum output power value W_{MAX} of the audio signal amplifiers is a value which only depends on the supply source voltage value V_{CC} when the value R_L of the load is maintained constant.

In these days, in order to mainly lower the production cost of products, the structures and parts to be used in a variety of products has needed to be standardized. In these circumstances, it is urgently needed that the audio signal amplifier and its supply power source be rapidly standardized.

The central problem in standardizing the audio signal amplifier and its supply power source resides in the relations between the above described supply source voltage value and the maximum output power value of the audio signal amplifier, and the power loss in a step of power amplification.

Now, it is supposed that the standardization of the audio signal amplifier and its supply power source progress, and the

audio signal amplifier having different maximum output power values under the same supply source voltage value is obtained.

Generally, in the case of an ordinary audio signal amplifier, a heat radiator is mounted on a power device for amplifying an electric power in order to suppress the rise of temperature due to power loss generated during the step of power amplification. In this case, a designer may initially desire to mount a smaller heat radiator on the audio signal amplifier having a small maximum output power value. On the contrary, since a larger heat radiator cannot be mounted on the audio signal amplifier because the limitation of the size of a product or the like, or the output current of the supply power source cannot be sufficiently increased, it may be preferable that the maximum output power value of the audio signal amplifier is limited.

As a method to realize the audio signal amplifier having the different maximum output power voltage values under the same supply source voltage value V_{cc} , as mentioned above, It may be preferable that the maximum value of signal voltage input to the audio signal amplifier is limited by in consideration of the finish gain of the audio signal amplifier. In this case, the output voltage of the audio signal amplifier is expressed by:

$$(\text{input signal voltage}) \times (\text{finish gain of audio signal amplifier}).$$

Therefore, when the maximum value of the signal voltage input to the audio signal amplifier is limited, the maximum output power value of the audio signal amplifier is also limited.

As stated above, however, since the power P_a consumed in the power transistor greatly depends on the supply source voltage value V_{cc} , even if the maximum output power value is limited by specifying the maximum input voltage value, the value of the power P_a consumed in the power transistor for power amplification is hardly changed as compared with that of the audio signal amplifier having an original maximum output power value. Therefore, the heat radiator must have a size similar to that of the audio signal amplifier having its original maximum output power. Consequently, the limitation of the maximum voltage value of the signal to be inputted will mean nothing .

In addition, as another method for limiting the maximum output power value while the supply source voltage value V_{cc} is maintained to be constant, a method may be considered in which the magnitude of the maximum input voltage is predicted and the finish gain of the audio signal amplifier is set based on the magnitude. With this method, however, it is impossible to make the value of the power P_a consumed in the power transistor smaller than that of the power P_a consumed in the power transistor of an audio signal amplifier having an original maximum output power value.

In conclusion, when the speaker reproducing device acting as a load is determined, only by lowering the supply source voltage to be supplied to the audio signal amplifier, the maximum output power value in the A class amplifier, B class amplifier and the AB class amplifier which are currently used can be limited, the power

loss during the step of power amplification can be reduced, and the heat radiator can be made compact.

It is to be noted that the same problems, as mentioned above, arise when the supply power source of a signal amplifier for various analog signals such as video signals, sensor signals of measuring instruments, etc., as well as the audio signal amplifier is standardized.

SUMMARY OF THE INVENTION

One object of the present invention is to provide an improved analog signal amplifier and an improved audio signal amplifier in which a maximum output power value can be varied and a heat radiator can be made compact depending on the limiting operation due to power loss, while a supply source voltage value is kept constant and standardized.

In order to achieve the above mentioned object, in accordance with one aspect of the present invention, there is provided an analog signal amplifier including an input limiting means for limiting the maximum signal voltage value of an input analog signal, and a power amplifying means for converting the signal output from the input limiting means into a switching signal included in a low frequency component, amplifying power and outputting the power amplified switching signal.

Further, in accordance with another aspect of the present invention, an audio signal amplifier is provided for amplifying an

input audio signal, and for supplying the amplified audio signal to a speaker reproducing device, including an input limiting means for limiting the maximum signal voltage value of the input audio signal, and a voltage/power amplifying means which convert signal voltage output from the input limiting means into information in the direction of timing axis, to amplify and output it as power.

Specifically, in accordance with the analog signal amplifier, the maximum voltage value of the input analog signal is limited by the limiting means, the output thereof is sent to the power amplifying means and converted into a switching signal so that the input signal becomes the low frequency component, and then power is amplified.

Further, in accordance with the audio signal amplifier, the maximum voltage value of the input audio signal is limited by the input limiting means, the output thereof is sent to the power amplifying means, and converted into the information in the direction of timing axis. Then the converted information is amplified and output as the power.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram illustrating the schematic construction of an audio signal amplifier as an embodiment according to the present invention.

Fig. 2 is a block diagram illustrating the schematic construction of an example of an input limiting circuit 3 employed

for the audio signal amplifier shown in Fig. 1.

Fig. 3 is a block diagram illustrating the schematic construction of an example of a power amplifying circuit 5 used for the audio signal amplifier shown in Fig. 1.

Fig. 4 is a waveform representation for explaining the operation of the circuit shown in Fig. 3 .

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, a description will be given as to an embodiment of an audio signal amplifier according to the present invention.

In an audio signal amplifier of an embodiment of the present invention, as shown in Fig. 1, an input signal in the form of voltage change which is supplied from a signal source 1 is received through an input terminal 2, a voltage value is limited in an input limiting circuit 3, an electric power is amplified by using a power amplifying circuit 5, and a sound signal is supplied to a speaker reproducing device 7. Herein, the power amplifying circuit 5 serves to convert the signal from the input limiting circuit 3 to a switching signal to be a low frequency component, amplify the power and output the switching signal. For example, in such a power amplifying circuit, by temporarily converting the amplitude information of input signal voltage into the information of a timing axis direction by a pulse width modulation (PWM) or the like, it is not correlated with a supply source voltage value to

the audio signal amplifier, and then the converted information is supplied to a so-called D class amplifying part which is a switching circuit for the power amplification and the power is amplified.

Now, the construction and operation of respective components will be described in detail.

The input signal voltage supplied from the signal source 1 through the input terminal 2 is supplied to the input limiting circuit 3. This input limiting circuit 3 serves to limit the input voltage value depending on the limitation of the maximum output power value of the audio signal amplifier. The power limited output is supplied to the power amplifying circuit 5. The input limiting circuit 3, as shown in Fig. 2, includes an attenuation part 31 and a limiter part 32. The attenuation part 31 is a circuit controlled by an input signal voltage setting circuit 4 and controls the amplitude of the input signal voltage depending on a signal supplied from this circuit 4. The signal voltage output from the attenuation part 31 is sent to the limiter part 32 in which the maximum value of the above described signal voltage is determined. In other words, this input limiting circuit 3 determines the final maximum output voltage value of the audio signal amplifier according to the present embodiment of the invention.

Assuming that a maximum signal voltage value capable of passing through the input limiting circuit 3 is V_{IMAX} , and the

finish gain of the audio signal amplifier is A_G , the final maximum output voltage value V_{MAX} of the audio signal amplifier can be expressed by:

$$V_{MAX} = V_{INMAX} \times A_G \quad \dots(3)$$

Herein, the maximum signal voltage value passing through the input limiting circuit 3 is determined by the limiter part 32 in the input limiting circuit 3, as mentioned above. Based on the relation of (the maximum output voltage value of an audio signal amplifier to be set)/ A_G , the maximum signal voltage value of the input limiting circuit 3 is set by the limiter part 32 in this input limiting circuit 3.

As the attenuation part 31 of the input limiting circuit 3, for example, a variable attenuator such as an electronic volume may be used and the amount of attenuation may be varied by the input signal voltage value setting circuit 4. As the limiter part 32, for example, an ordinary limiter circuit such as a diode limiter or a soft limiter circuit using level compression by a VCA (variable gain amplifier) or the like may be employed. When the maximum output power of the amplifier is made different from that of a previous one, the limiter part 32 may be replaced by a new one with different limit voltage, or the limit voltage may be changed by using a limiting circuit in which limit voltage can be somewhat adjusted.

Then, the power amplifying circuit 5 shown in Fig. 1 applies

a PMW modulation to the signal voltage traversing the input limiting circuit 3 so that the amplitude information of the signal voltage is converted into the information of a timing axis direction and a power amplification is carried out by, what is called, a D-class amplification. A D-class amplifier serves to control the switching of source power by a binary operation such as turning on / off a power transistor and output a PWM modulated power signal. The maximum value of power efficiency is 100% and, therefore, the consumed power of the transistor can be extremely reduced.

Fig. 3 illustrates an example of the specific construction of the above described power amplifying circuit 5. Fig. 4 illustrates the signal waveforms of the respective parts shown in Fig. 3. Referring to Fig. 3, for example, an output voltage from the input limiting circuit 3 as shown in Fig. 4A is supplied to an adding and integrating circuit 52 through an input terminal 51. For example, a square wave of 50 % duty as shown in B of Fig. 4 is supplied to the adding and integrating circuit 52 from a square wave generating circuit 53. These signals are added and integrated in the adding and integrating circuit 52, so that a signal with a waveform as shown in Fig. 4C is obtained and this signal is sent to a comparator 54. The waveform shown in Fig. 4C is formed by superimposing the signal with the waveform shown by broken lines and similar to that shown in Fig. 4A on a triangular wave. The resultant waveform is compared with 0 level in the comparator 54,

so that a rectangular wave signal as shown in Fig. 4D is obtained. This rectangular wave signal includes the signal A shown in Fig. 4 in its low frequency component. This rectangular wave signal is amplified by a so-called D class amplifier 55 to obtain a rectangular wave signal having the amplitude substantially equal to that of source voltage. The obtained rectangular wave signal is output from an output terminal 56. An output signal output from the output terminal 56 is supplied to a sound signal demodulating circuit 6 as the output of the power amplifying circuit 5 illustrated in Fig. 1.

The sound signal demodulating circuit 6 shown in Fig. 1 removes switching frequency included in the output signal of the power amplifying circuit 5 and demodulates this output signal to a signal similar to a signal of the original signal source. Then, the demodulated signal from the sound signal demodulating circuit 6 is supplied to the speaker reproducing device 7 so that the speaker reproducing device 7 is driven.

The sound signal demodulating circuit 6 includes a low-pass filter so that the switching frequency included in the output signal of the power amplifying circuit 5 is removed and the output signal is demodulated to a signal similar to that of the original signal source. This demodulated signal is supplied to the speaker reproducing device 7 so as to drive the device 7.

Generally, heat generated owing to power loss in the audio signal amplifier is caused during the step of power amplification.

According to the invention, since all the information of the input signal voltage is modulated into the information of a timing axis direction, the supply source voltage value applied to the power amplifying circuit 5 during the step of power amplification is not related to the power loss in this audio signal amplifier.

Assuming that the saturation voltage of a power transistor in the D class amplifying part of the power amplifying circuit 5 is V_{SAT} , output current is I_{OUT} , the basic switching period of the D class amplifying part is T , and the rise time t_r and the fall time t_f of a basic switching waveform (square wave) in the D class amplifying part are sufficiently short, the power loss P_{Dd} in the audio signal amplifier is approximately shown by the following formula:

$$P_{Dd} = \frac{1}{T} \times \int_0^T (V_{SAT} \times I_{OUT}) dt \quad \dots (4)$$

Herein, when it is assumed that V_{SAT} is constant, based on the output current, the power loss can be determined definitely.

Accordingly, since the limitation of the input signal voltage value causes the output current, to be limited, which is supplied through the sound signal demodulating circuit 6 to the speaker reproducing device 7 serving as a load, the power loss during the step of power amplification is also simultaneously restricted. Consequently, the maximum output power value can be varied without changing the supply source voltage value and a heat radiator can

be made compact in accordance with the limiting action of the power loss.

As mentioned above, according to the audio signal amplifier of the present invention, the amplitude information of the input signal voltage is temporarily converted into information in the direction of a timing axis in the power amplifying circuit 5 so that it is not correlated with the source voltage value supplied to the power amplifying circuit 5 in the course of power amplification. As a result, the maximum output power value can be varied without changing the supply source voltage value and the volume of the heat radiator can be reduced as small as required depending on the limiting action of the power loss.

It is to be noted that the present invention is not limited only to the above described embodiment. As an input analog signal, for example, not only an audio signal but also various kinds of analog signals such as video signals, sensor signals of measuring instruments, etc., which require the power amplification, can be employed. In addition, instead of the PWM (pulse width modulation) in the power amplifying circuit, means capable of converting the output signal from the input limiting means into the switching signal having an original analog signal included in the low frequency component, such as a PPM (pulse phase modulation), a PNM (pulse number modulation) or $\Delta\Sigma$ modulation, may be employed.

As mentioned above, the analog signal amplifier of the present invention includes the input limiting means for limiting the

maximum signal voltage value of the input analog signal and the power amplifying means for converting the signal output from the input limiting means into the switching signal included in the low frequency component, and for amplifying the power and outputting the switching signal. Thus the maximum output power can be varied while the supply source voltage value is kept constant, the power loss can be reduced and the heat radiator or the like can be applied its maximum output power.

Further, according to the audio signal amplifier of the present invention, in addition to the above described effects, the maximum output power voltage to the speaker reproducing device can be varied the size of the heat radiator can be decreased depending on the restriction of the power loss.

WHAT IS CLAIMED IS:

1. An analog signal amplifier comprising:

an input limiting means for limiting the maximum signal voltage value of an input analog signal; and

a power amplifying means for converting a signal output from said input limiting means into a switching signal included in a low frequency component, amplifying its power and outputting the power amplified switching signal.

2. An analog signal amplifier according to claim 1, wherein a demodulating means is provided for taking out or removing said low frequency component from the output of said power amplifying means.

3. An analog signal amplifier according to claim 1, wherein said power amplifying means has a constant supply source voltage value.

4. An analog signal amplifier according to claim 1, wherein said power amplifying means modulates the pulse width of the input signal and amplifies the power of the modulated output.

5. An audio signal amplifier for amplifying an input audio signal and supplying the amplified input audio signal to a speaker reproducing device comprising:

an input limiting means for limiting the maximum signal voltage value of said input audio signal; and

a voltage/power amplifying means for converting the signal voltage output from the input limiting means into information in the direction of timing axis and amplifying and outputting the information as power.



6. An audio signal amplifier according to claim 5, wherein a demodulating means is provided for demodulating the output of said power amplifying means.

7. An audio signal amplifier according to claim 5, wherein said voltage/power amplifying means has a supply source voltage value kept constant.

8. An audio signal amplifier according to claim 5, wherein said voltage/power amplifying means converts the amplitude information of said signal voltage into the information in the direction of timing axis by a pulse width modulation and then, amplifies and outputs the information as the power.

9. An audio signal amplifier for amplifying an input audio signal and supplying the amplified input audio signal to a speaker reproducing device comprising:

a signal source for generating a signal;

a setting means for setting a voltage of said signal;

an input limiting means for limiting a voltage of said signal in accordance with said voltage set by said setting means;

an amplifying means for amplifying said signal output from said input limiting means;

a modulating means for modulating said signal output from said amplifying means; and

a reproducing means for reproducing said signal.

10. An audio signal amplifier according to claim 9, said input limiting means has an attenuation means and a limiter means.

11. An audio signal amplifier according to claim 9, said amplifying means has an integrating means, a square wave generating means, a comparator and D-class amplifier.

