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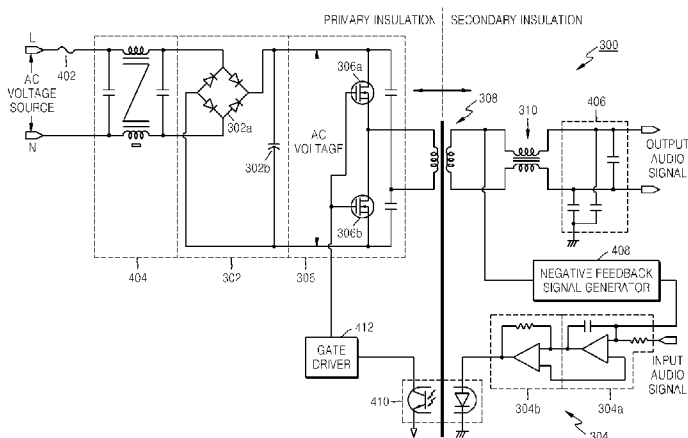
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(54) Title: DIGITAL AUDIO AMPLIFIER AND DIGITAL AUDIO AMPLIFYING METHOD THEREFOR



(57) Abstract: A digital audio signal amplifier and a digital audio signal amplifying method therefor are provided. More particularly, a digital audio signal amplifier in which both safety and power efficiency are achieved by integrating a switching mode power supply and a digital audio amplifier into one, and a digital audio signal amplifying method appropriate to the amplifier are provided. The digital audio amplifier includes: a pulse modulation unit generating a pulse modulated audio signal by pulse-modulating an input audio signal; a switching unit switching a DC voltage based on the pulse modulated audio signal; an insulation transformer transforming the output of the switching unit and outputting the result of the transforming; and a low-pass filter obtaining an audio signal corresponding to the input audio signal by low-pass filtering the output of the insulation transformer, and outputting the output audio signal. By integrating a switching mode power supply and a digital audio amplifier into one, the digital audio amplifier satisfies the insulation requirement and at the same time increases power efficiency.



WO 2007/049898 A1

Description

DIGITAL AUDIO AMPLIFIER AND DIGITAL AUDIO AMPLIFYING METHOD THEREFOR

Technical Field

- [1] The present invention relates to a digital audio amplifier, and more particularly, to a digital audio signal amplifier in which both safety and power efficiency are achieved by integrating a switching mode power supply and a digital audio amplifier into one body, and a digital audio signal amplifying method appropriate for the amplifier are provided.

Background Art

- [2] In general, a digital audio system includes a direct current (DC) voltage supply unit generating a DC voltage from a commercial alternating current (AC) voltage; and a digital audio amplifier pulse-modulating the DC voltage using an audio signal, low-pass filtering the pulse-modulated DC voltage, and obtaining an output audio signal corresponding to the input audio signal.
- [3] Here, for the safety of users, the DC voltage supply unit is required to have a function of insulating the commercial AC voltage from the digital audio amplifier. Accordingly, a switching mode power supply (SMPS) having an insulation transformer is generally used as the DC voltage supply unit. Meanwhile, the digital audio amplifier is generally a D class digital audio amplifier to increase the output power.
- [4] FIG. 1 is a block diagram of the structure of a conventional digital audio system. The audio system 100 of FIG. 1 includes an SMPS 110 and a D class audio amplifier 130.
- [5] The SMPS 110 converts an input commercial AC voltage into a DC voltage using a first rectifying and smoothing unit 112, switches the DC voltage in a switching unit 116 operating at a rate corresponding to a pulse width modulation (PWM) signal having a frequency of tens to hundreds of kHz or higher generated in a PWM modulation unit 114, transforms the switched DC voltage with an insulation transformer having an appropriate winding ratio, rectifies the output of the insulation transformer 118 through a second rectifying and smoothing unit 120, and outputs the DC voltage. Also, though it is not shown, an error signal is fed back to adjust the frequency of a pulse modulated signal, and a duty rate, so that a constant DC voltage can be output irrespective of changes in the input voltage or output current.
- [6] The insulation transformer 118 insulates the primary side, i.e., the commercial AC voltage source, from the second side, i.e., the digital audio amplifier 130. Also, an error signal detected in the secondary side is fed back to the PWM modulation unit 114

of the primary side through a photo coupler (not shown) to provide electrical isolation.

[7] Meanwhile, the D class digital audio amplifier 130 switches the DC voltage provided by the SMPS 110 at a D class output end 134 by a PWM audio signal generated in the PWM modulation unit 132, low-pass filters the switched DC voltage through a low-pass filter 136, and generates an output audio signal corresponding to the original audio signal. Meanwhile, though it is not shown, in order to stabilize the audio output a negative feedback signal is generated from the output of the insulation transformer 118 to control the pulse modulation of the PWM modulation unit 114.

[8] FIG. 2 illustrates waveform diagrams showing the operation of the D class digital audio amplifier 130 shown in FIG. 1. Referring to FIG. 2, a PWM audio signal is obtained by modulating a 180kHz or higher triangular wave carrier with an input audio signal of 20kHz or lower. The switched DC voltage is obtained by switching the DC voltage with this PWM audio signal. Also, the output audio signal is obtained by low-pass filtering the switched DC voltage. As shown in FIG. 2, the input audio signal is similar to the output audio signal.

Disclosure of Invention

Technical Problem

[9] However, the conventional digital audio system as shown in FIG. 1 has a problem that the power efficiency is low and the manufacturing cost is high.

[10] For example, assuming that the power efficiency of the SMPS 110 is P_1 and the power efficiency of the digital audio amplifier 130 is P_2 , the power efficiency P_t of a conventional digital audio system 100 is $P_1 \times P_2$. Here, since each of P_1 and P_2 has a value less than 1, P_t becomes less than P_1 and P_2 , respectively. Accordingly, it can be seen that the conventional digital audio system 100 inevitably has low power efficiency.

[11] Meanwhile, in the SMPS 110 and the digital audio amplifier 130 shown in FIG. 1, the PWM modulation units 114 and 132 perform the same PWM modulation, the rectifying and smoothing units 112 and 120 perform the same rectifications, and the switching unit 116 and the D class output end 134 perform the same switching operation. That is, it can be seen that the units performing the same operation are disposed redundantly, accordingly manufacturing costs are wasted.

Technical Solution

[12] The present invention provides a digital audio amplifier capable of increasing power efficiency and reducing manufacturing costs by eliminating redundant parts in an SMPS and a digital audio amplifier.

[13] The present invention also provides a digital audio signal amplifying method capable of increasing power efficiency and reducing manufacturing costs.

Advantageous Effects

[14] According to experiments performed by the applicant, when the SMPS and the D class digital audio amplifier were used, the power consumption was 130 watts. However, according to the present invention, the power consumption was 111 watts, that is, power consumption was reduced by 19 watts. As a result, by lowering the current rates of a variety of filters preventing EMI, a bridge rectifier to rectify an AC voltage, and a smoothing condenser, a digital audio amplifier can be manufactured at a lower cost.

[15] According to the digital audio amplifier of the present invention, by integrating a switching mode power supply and a digital audio amplifier into one, the digital audio amplifier satisfies the insulation requirement and at the same time increases power efficiency.

Description of Drawings

[16] The above and other features and advantages of the present invention will become more apparent by describing in detail exemplary embodiments thereof with reference to the attached drawings in which:

[17] FIG. 1 is a block diagram of the structure of a conventional digital audio system;

[18] FIG. 2 illustrates waveform diagrams showing the operation of a D class digital audio amplifier shown in FIG. 1;

[19] FIG. 3 is a block diagram of a structure of a digital audio amplifier according to an embodiment of the present invention;

[20] FIG. 4 is a circuit diagram of a digital audio amplifier according to an embodiment of the present invention;

[21] FIG. 5 illustrates an example of a full-bridge type digital audio amplifier according to an embodiment of the present invention;

[22] FIG. 6 illustrates an operation of a Schmitt trigger shown in FIG. 5;

[23] FIG. 7 is a circuit diagram of a digital audio amplifier according to an embodiment of the present invention;

[24] FIG. 8 is a circuit diagram of a digital audio amplifier according to another embodiment of the present invention; and

[25] FIG. 9 is a circuit diagram of a digital audio amplifier according to still another embodiment of the present invention.

Best Mode

[26] According to an aspect of the present invention, there is provided a digital audio amplifier including: a pulse modulation unit generating a pulse modulated audio signal by pulse-modulating an input audio signal; a switching unit switching a direct current (DC) voltage based on the pulse modulated audio signal; an insulation transformer

transforming the output of the switching unit and outputting the result of the transforming; and a low-pass filter obtaining an audio signal corresponding to the input audio signal by low-pass filtering the output of the insulation transformer, and outputting the audio signal.

[27] The switching unit and the low-pass filter may be disposed on the primary side and on the secondary side, respectively, of the insulation transformer, and the digital audio amplifier may further include a photo coupler photo-coupling the pulse modulated audio signal and providing the result to the switching unit. The pulse modulation unit may pulse-width modulate the input audio signal.

[28] According to another aspect of the present invention, there is provided a digital audio amplifying method including: generating a pulse modulated audio signal by pulse-modulating an input audio signal; switching a DC voltage based on the pulse modulated audio signal and generating a switched DC voltage ; transforming the switched DC voltage through an insulation transformer; and low-pass filtering the output of the insulation transformer and outputting an output audio signal corresponding to the input audio signal.

Mode for Invention

[29] FIG. 3 is a block diagram showing the structure of a digital audio amplifier according to an embodiment of the present invention. The digital audio amplifier 300 shown in FIG. 3 includes a rectifying and smoothing unit 302, a pulse modulation unit 304, a switching unit 306, an insulation transformer 308, and a low-pass filter 310.

[30] The rectifying and smoothing unit 302 converts a commercial AC voltage into a DC voltage. The pulse modulation unit 304 pulse-modulates an input audio signal and provides the obtained pulse modulated audio signal to the switching unit 306. The switching unit 306 switches the DC voltage provided by the rectifying and smoothing unit 302 using the pulse modulated audio signal and generates a switched DC voltage. The insulation transformer 308 transforms and outputs the switched DC voltage output from the switching unit 306. The low-pass filter 310 low-pass filters the output of the insulation transformer 308 and outputs an output audio signal corresponding to the input audio signal. The output audio signal is provided to a speaker.

[31] Here, the commercial AC voltage is insulated from the low-pass filter 310 by the insulation transformer 308.

[32] Referring to FIG. 3, it can be seen that compared to the conventional digital audio system 100 shown in FIG. 1, the problem of redundancy of the rectifying and smoothing units, the pulse modulation units, and the switching units is solved. Accordingly, power efficiency and manufacturing costs are improved.

[33] FIG. 4 is a circuit diagram of the digital audio amplifier 300 according to an embodiment of the present invention. According to the embodiment shown in FIG. 4,

the pulse modulator 304 is disposed on the secondary side of the insulation transformer 308, and the PWM audio signal that is the output of the pulse modulator 304 is provided to the switching unit 306 disposed on the primary side of the insulation transformer 308, through a photo coupler 410.

[34] Referring to FIG. 4, the digital audio amplifier 300 includes a fuse 402, a filter 404 for preventing electromagnetic interference (EMI), capacitors 406 for noise-filtering between signal lines or between signal lines and the chassis, a negative feedback signal generator 408, the photo coupler 410 photo for coupling the pulse modulated audio signal generated in the pulse modulation unit 304, and a gate driver 412 for amplifying the output of the photo coupler 410 to a level which is enough to drive switching transistors 306a and 306b of the switching unit 306.

[35] The rectifying and smoothing unit 302 includes a bridge rectifier 302a and a smoothing condenser 302b. The switching unit 306 includes switching transistors 306a and 306b operating complementary to each other. The switching unit 306 shown in FIG. 4 performs a switching operation corresponding to a half-bridge type D class digital audio amplifier. However, it should be noted that the present invention is not limited to this and can be constructed to perform a switching operation corresponding to a full-bridge type D class digital audio amplifier.

[36] FIG. 5 illustrates an example of a full-bridge type digital audio amplifier according to an embodiment of the present invention.

[37] The insulation transformer 308 is composed of a ferrite core in order to reduce EMI and enhance efficiency.

[38] The pulse modulator 304 includes an integration circuit 304a and a Schmitt trigger 304b. The integration circuit 304a integrates an audio signal and a negative feedback signal, and the output of the Schmitt trigger 304b is oscillated by the output of the integration circuit 304a. A PWM audio signal is obtained through the integration circuit 304a and the Schmitt trigger 304b.

[39] FIG. 6 illustrates an operation of the Schmitt trigger shown in FIG. 5. The Schmitt trigger 304b has two threshold voltages. For example, if an input voltage (V_{in}) becomes greater than a first threshold, the output voltage (V_{out}) is transited to logic level 1. Once the output voltage (V_{out}) becomes logic level 1, logic level 1 is maintained while the input voltage is between the first threshold voltage and a second threshold voltage. If the input voltage (V_{in}) becomes less than the second threshold voltage, the output voltage (V_{out}) returns to logic level 0.

[40] Accordingly, it can be seen that the Schmitt trigger 304a outputs a pulse width modulated signal corresponding to the change in the output of the integration circuit 304a.

[41] The PWM audio signal output from the pulse modulation unit 304 is provided to

the gate driver 410 through the photo coupler 410. The gate driver 410 amplifies the output of the photo coupler 410 to a level which is enough to drive the switching transistors 306a and 306b of the switching unit 306.

- [42] The DC voltage is switched, i.e., pulse width modulated, by a switching operation of the switching unit 306. The output of the switching unit 306 is transformed through the insulation transformer 308, and low-pass filtered through the low-pass filter 310 and output as an output audio signal.
- [43] The negative feedback signal generator 408 is used to provide a stable output audio signal regardless of change in the input voltage and the output current. The negative feedback signal generator 408 generates a negative feedback signal corresponding to the magnitude of the output audio signal, from the output of the insulation transformer 308. The negative feedback signal generator 408 can be implemented simply, for example, by a resistor.
- [44] The negative feedback signal is provided to the integration circuit 304a. The integration circuit 304a integrates the audio signal and the negative feedback signal, that is, amplifies the synthesized signal of the audio signal and the negative feedback signal.
- [45] If the level of the output audio signal rises over a normal level due to a change in the input voltage and output current when the output audio is in a stable state, that is, a state in which the negative feedback signal has a constant value, the negative feedback signal decreases, and as a result, the duty rate of the PWM audio signal decreases. Accordingly, the duty rate of the switched DC voltage decreases and therefore the level of the output signal falls.
- [46] Conversely, if the level of the output audio signal falls below a normal level due to a change in the input voltage and output current, the negative feedback signal increases, and as a result, the duty rate of the PWM audio signal increases. Accordingly, the duty rate of the switched DC voltage increases and therefore the level of the output signal rises.
- [47] FIG. 7 is a circuit diagram of a digital audio amplifier according to an embodiment of the present invention. In the embodiment of FIG. 7, a pulse modulator 304 is disposed on the secondary side of an insulation transformer 308, and the PWM audio signal output from the pulse modulator 304 is provided to a switching unit 306 disposed on the primary side of the insulation transformer 308 through a photo coupler 410 as in the embodiment of FIG. 4. However, the embodiment of FIG. 7 is different from that of FIG. 4 in that a comparator 304c is employed instead of the Schmitt trigger 304b.
- [48] The comparator 304c compares the output of an integration circuit 304a and a triangular wave carrier and outputs a PWM audio signal. The operations of the

comparator 304c and the digital audio amplifier 300 can be clearly understood with reference to the waveforms shown in FIG. 2.

[49] FIG. 8 is a circuit diagram of a digital audio amplifier 300 according to another embodiment of the present invention. Unlike the embodiment of FIG. 4, in the embodiment of FIG. 4, a pulse modulator 304 is disposed on the primary side of an insulation transformer 308, and an input audio signal and a negative feedback signal are provided to the pulse modulator 304 through photo couplers 802 and 804, respectively. By doing so, insulation of the audio signal and the negative feedback signal is achieved.

[50] FIG. 9 is a circuit diagram of a digital audio amplifier 300 according to still another embodiment of the present invention. In the embodiment of FIG. 9, a pulse modulator 304 is disposed on the primary side of an insulation transformer 308, and an input audio signal and a negative feedback signal are provided to the pulse modulator 304 through photo couplers 802 and 804, respectively, as in the embodiment of FIG. 8.

[51] However, the embodiment of FIG. 9 is different from that of FIG. 8 in that a comparator 304c is employed instead of the Schmitt trigger 304b.

[52] If the digital audio amplifier according to the present invention is employed, the PWM modulation units and switching units which are usually used in both the SMPS and the D class digital audio amplifier can be simplified such that the number of parts and components, manufacturing cost, and installation space can be reduced.

[53] In addition, since the circuit becomes simplified, reliability is increased.

[54] Also, if the digital audio amplifier according to the present invention is used, the SMPS can be omitted, which improves power efficiency reduces the space required for heat radiation.

Industrial Applicability

[55] The present invention relates to a digital audio signal amplifier in which both safety and power efficiency are achieved by integrating a switching mode power supply and a digital audio amplifier into one body, and a digital audio signal amplifying method appropriate for the amplifier are provided.

Sequence List Text

[56]

Claims

- [1] 1. A digital audio amplifier comprising:
a pulse modulation unit generating a pulse modulated audio signal by pulse-modulating an input audio signal;
a switching unit switching a direct current (DC) voltage based on the pulse modulated audio signal;
an insulation transformer transforming the output of the switching unit and outputting the result of the transforming; and
a low-pass filter obtaining an audio signal corresponding to the input audio signal by low-pass filtering the output of the insulation transformer, and outputting the audio signal.
2. The amplifier of claim 1, wherein the switching unit and the low-pass filter are disposed on the primary side and on the secondary side, respectively, of the insulation transformer, and
the digital audio amplifier further comprises a photo coupler photo-coupling the pulse modulated audio signal and providing the result to the switching unit.
3. The amplifier of claim 2, wherein the pulse modulation unit pulse-width modulates the input audio signal.
4. The amplifier of claim 3, wherein the pulse modulation unit comprises:
an integration circuit integrating the input audio signal; and
a Schmitt trigger whose output is oscillated with respect to the output of the integration circuit, wherein the pulse modulation unit pulse-width modulates the input audio signal through the integration circuit and the Schmitt trigger.
5. The amplifier of claim 4, further comprising a negative feedback signal generator generating a negative feedback signal from the output of the insulation transformer, wherein the integration circuit integrates the input audio signal and the negative feedback signal.
6. The amplifier of claim 3, wherein the pulse modulation unit comprises:
an integration circuit integrating the input audio signal; and
a comparator comparing the output of the integration circuit and a triangular wave carrier, wherein the input audio signal is pulse-width modulated through the integration circuit and the comparator.
7. The amplifier of claim 6, further comprising a negative feedback signal generator generating a negative feedback signal from the output of the insulation transformer,
wherein the integration circuit integrates the input audio signal and the negative feedback signal.

8. The amplifier of claim 1, wherein the switching unit and the low-pass filter are disposed on the primary side of the insulation transformer, and the digital audio amplifier further comprises a second photo coupler photo-coupling the input audio signal and providing the result to the pulse modulation unit.
9. The amplifier of claim 8, wherein the pulse modulation unit pulse-width modulates the output of the second photo coupler.
10. The amplifier of claim 9, wherein the pulse modulation unit comprises: an integration circuit integrating the output of the second photo coupler; and a Schmitt trigger whose output is oscillated with respect to the output of the integration circuit, wherein a pulse-width modulated audio signal corresponding to the input audio signal is obtained through the integration circuit and the Schmitt trigger.
11. The amplifier of claim 10, further comprising:
a negative feedback signal generator generating a negative feedback signal from the output of the insulation transformer; and
a third photo coupler photo-coupling the negative feedback signal and providing the result to the integration circuit,
wherein the integration circuit integrates the outputs of the second and third photo couplers.
12. The amplifier of claim 9, wherein the pulse modulation unit comprises: an integration circuit integrating the second photo coupler; and a comparator comparing the output of the integration circuit and a triangular wave carrier, wherein a pulse-width modulated audio signal corresponding to the input audio signal is obtained through the integration circuit and the comparator.
13. The amplifier of claim 12, further comprising:
a negative feedback signal generator generating a negative feedback signal from the output of the insulation transformer; and
a third photo coupler photo-coupling the negative feedback signal,
wherein the integration circuit integrates the outputs of the second and third photo couplers.
14. The amplifier of claim 1, wherein the insulation transformer comprises a ferrite core.
15. The amplifier of claim 1, further comprising a rectifying and smoothing unit rectifying and smoothing an alternating current (AC) voltage and providing a direct current (DC) voltage .
16. The amplifier of claim 1, further comprising a gate driver amplifying the level of the modulated audio signal to a level which is enough to drive the switching unit.

17. A digital audio amplifying method comprising:
generating a pulse modulated audio signal by pulse-modulating an input audio signal;
switching a DC voltage based on the pulse modulated audio signal and
generating a switched DC voltage ;
transforming the switched DC voltage through an insulation transformer; and
low-pass filtering the output of the insulation transformer and outputting an
output audio signal corresponding to the input audio signal.

FIG. 1

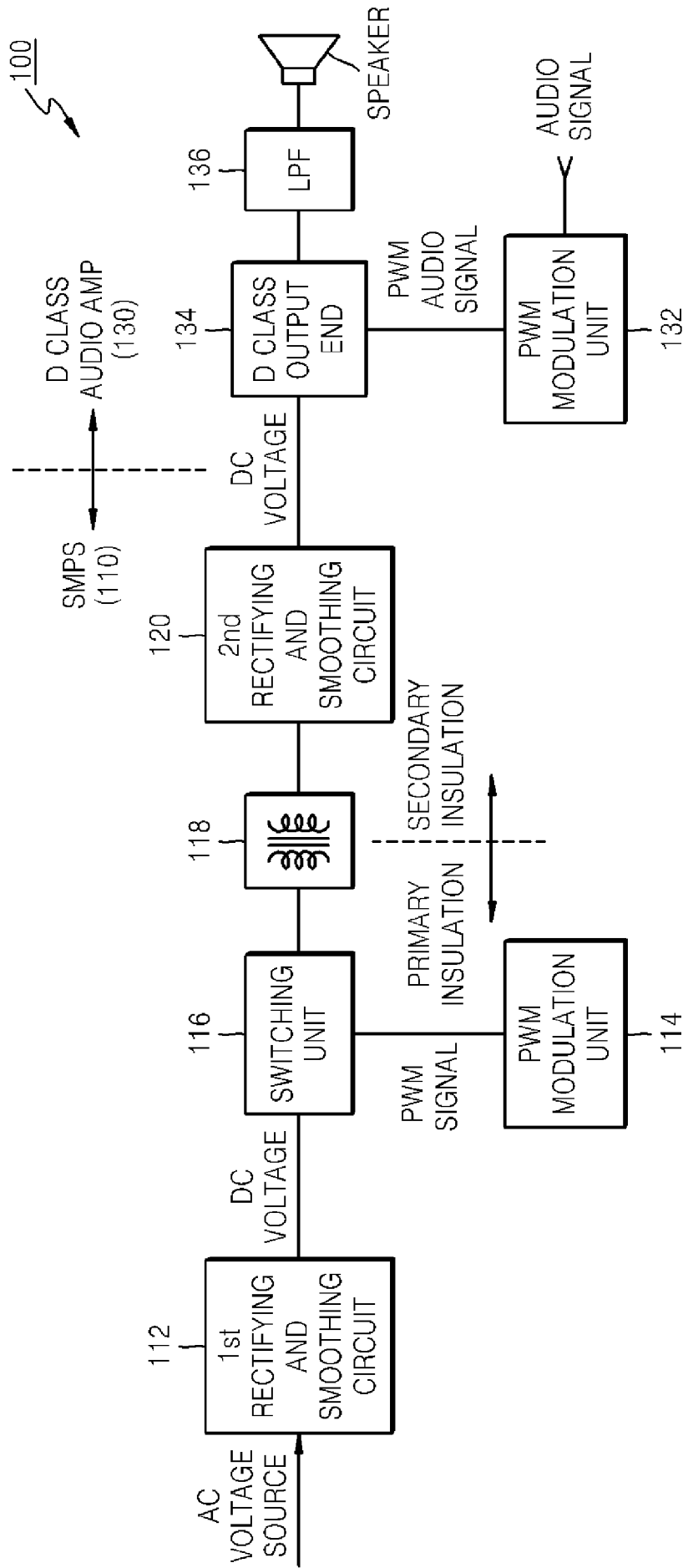


FIG. 2

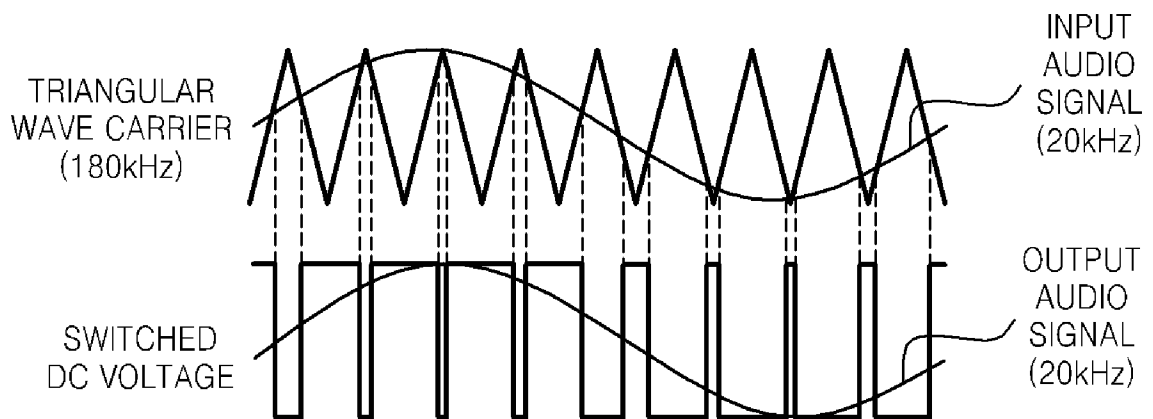


FIG. 3

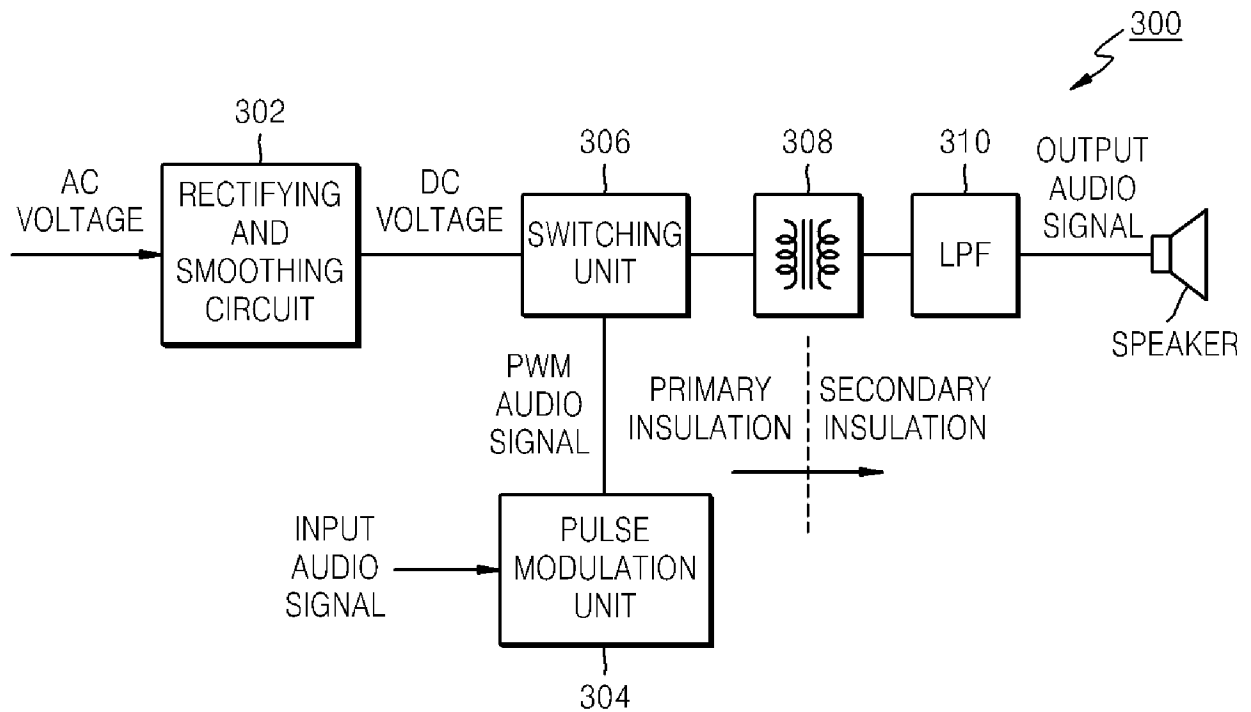


FIG. 4

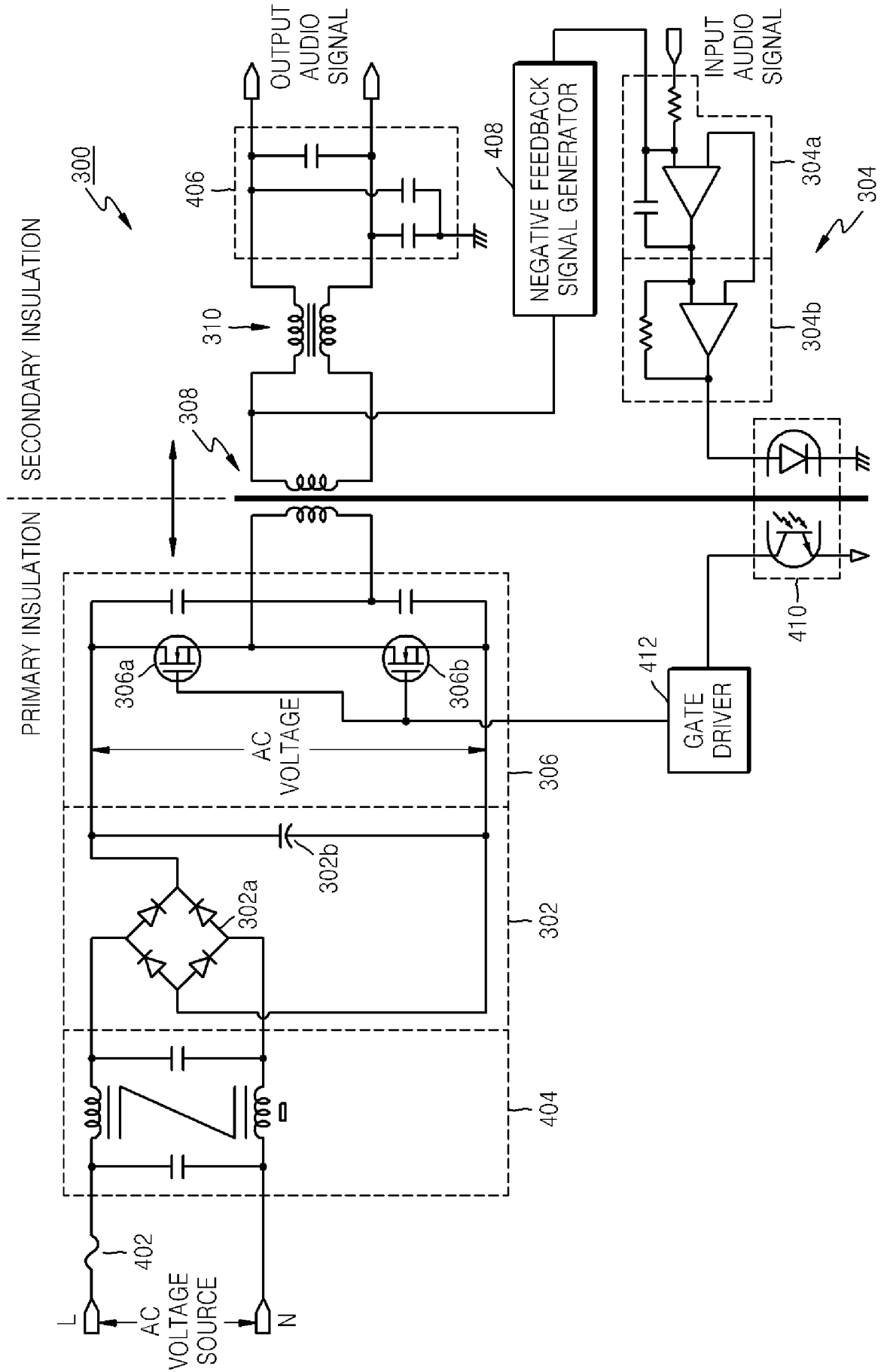


FIG. 5

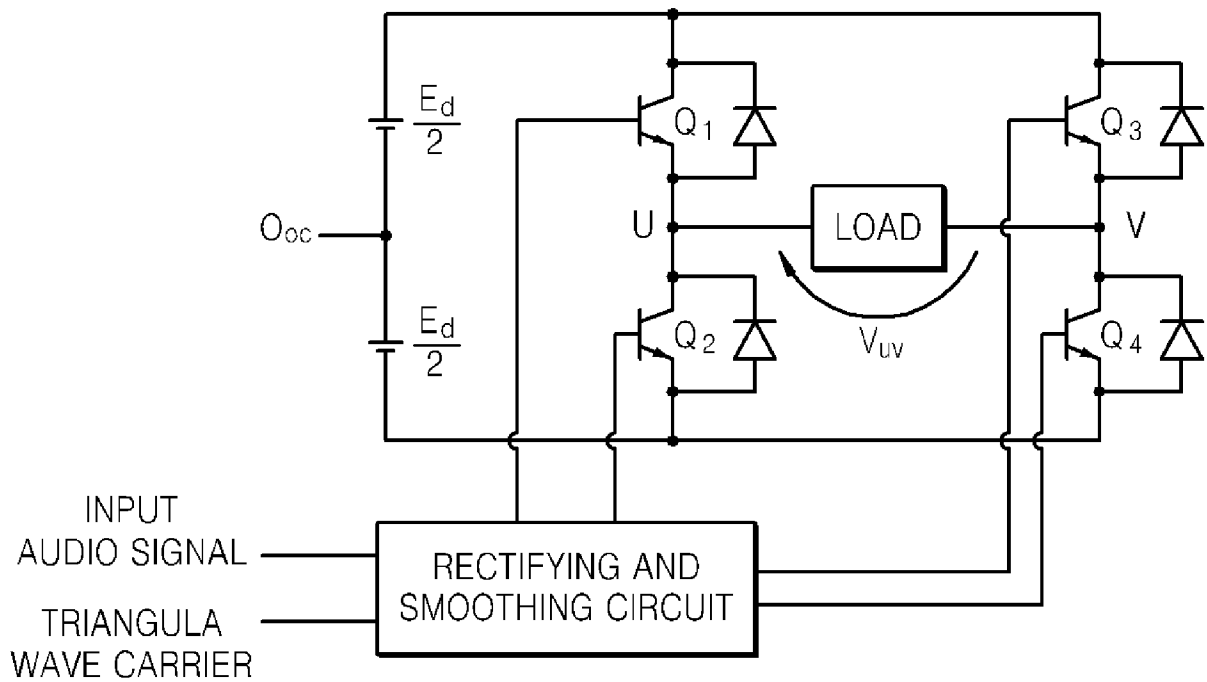


FIG. 6

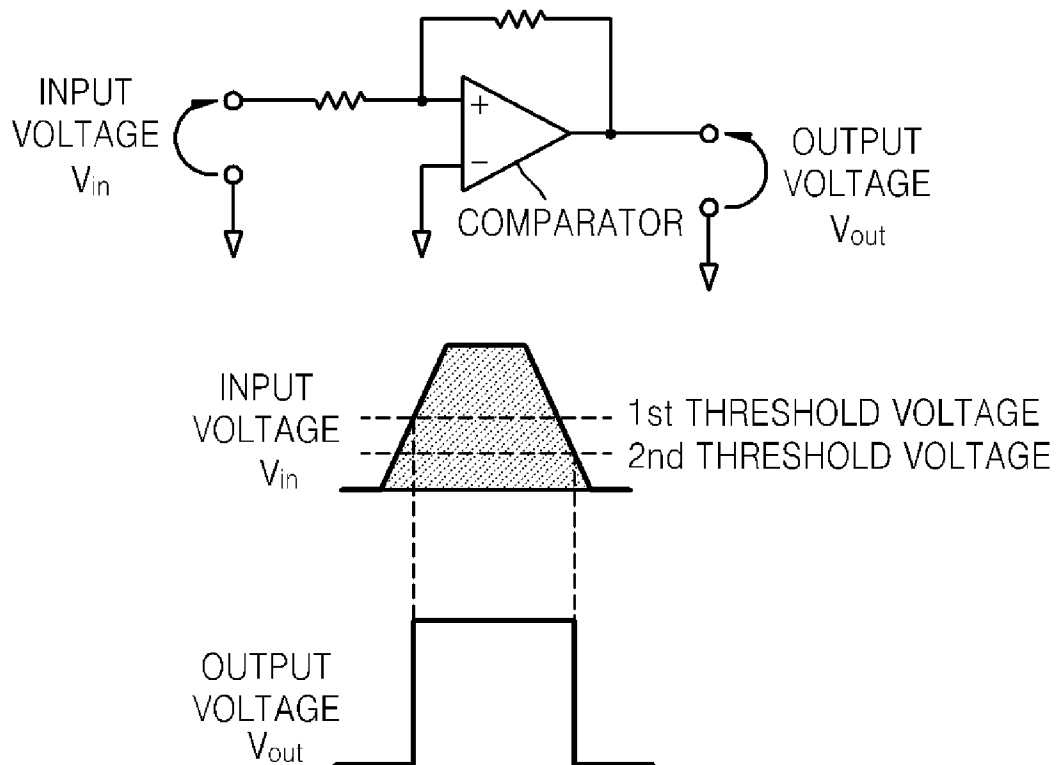


FIG. 7

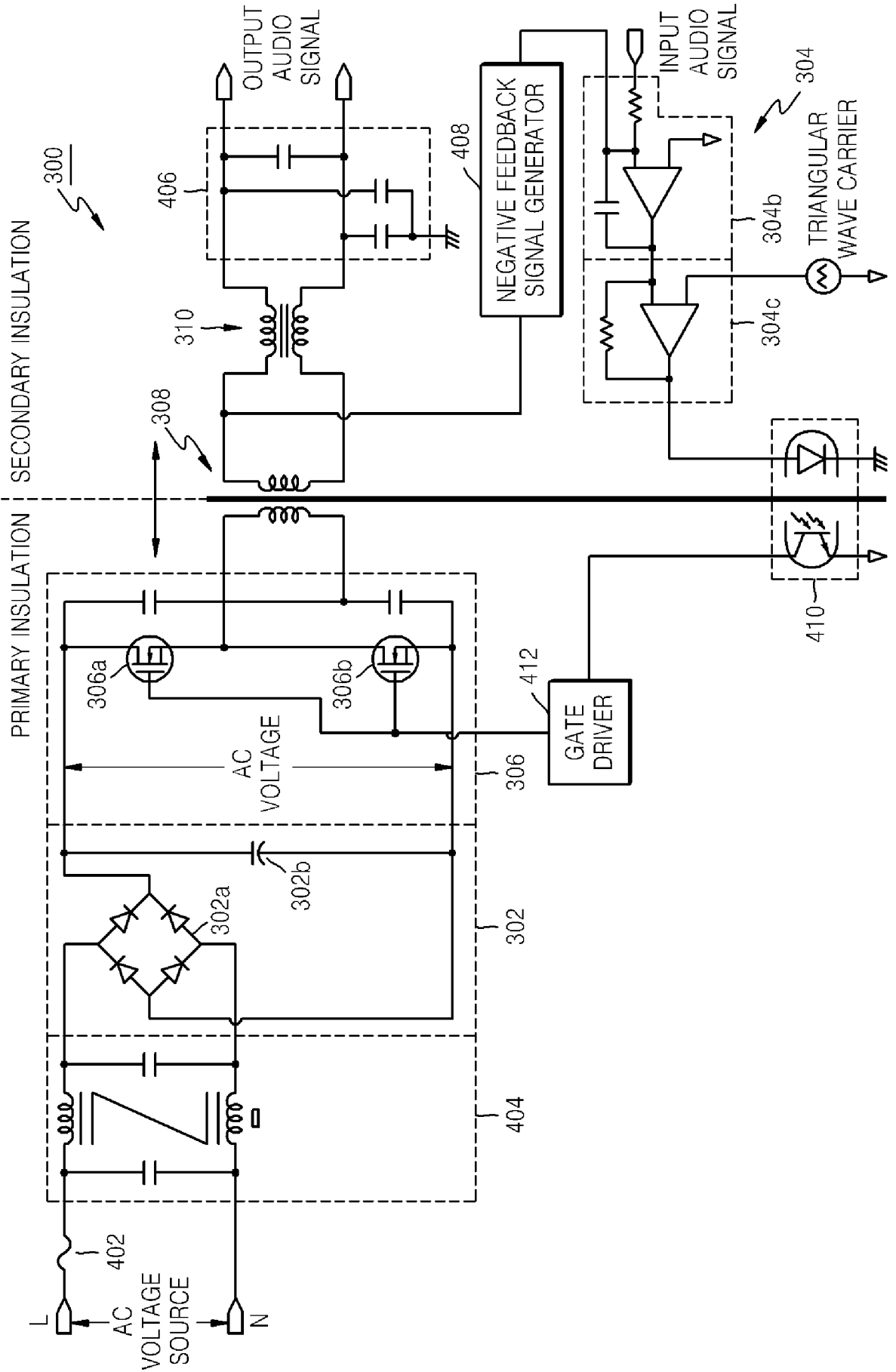


FIG. 8

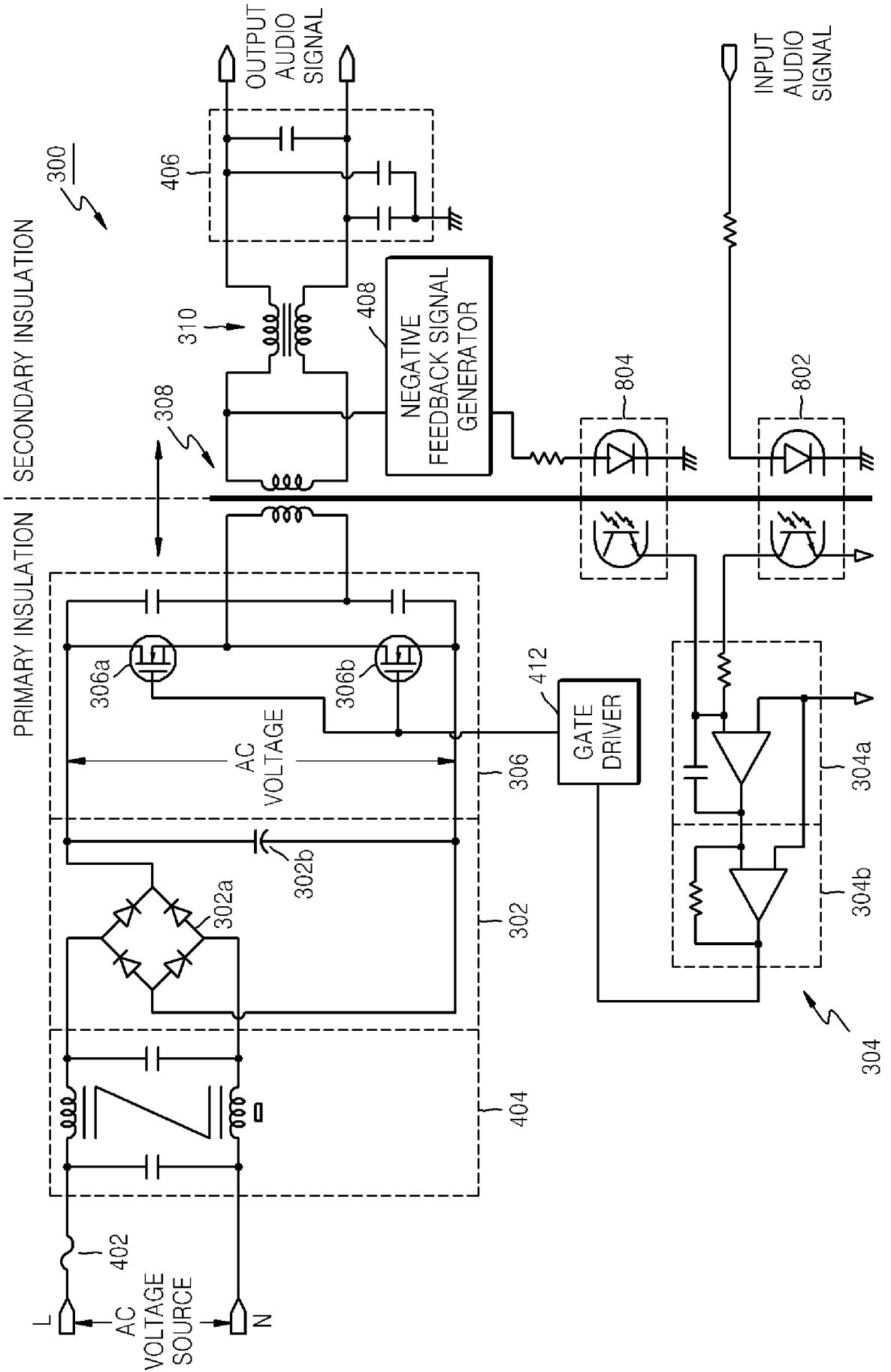
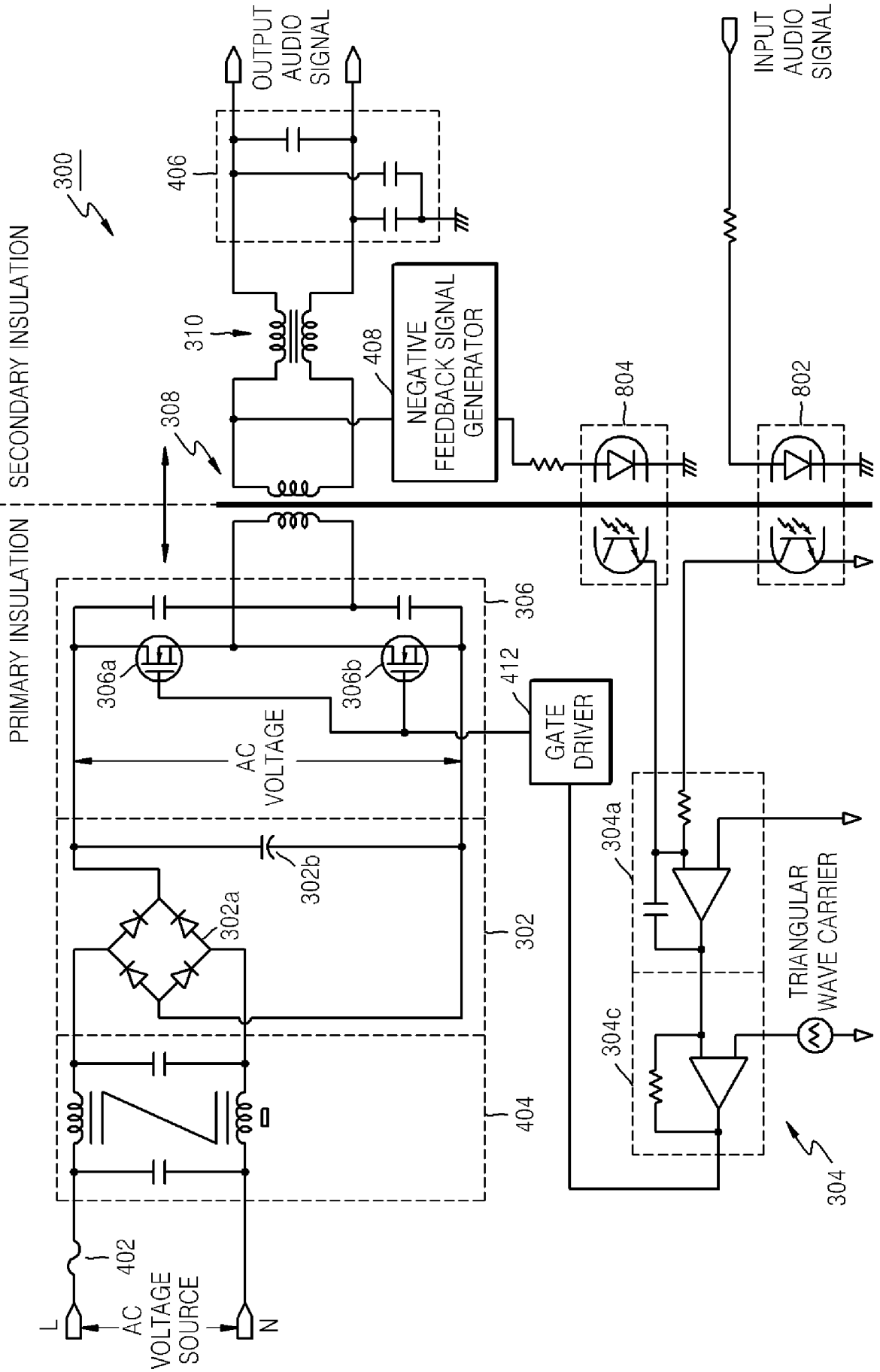


FIG. 9



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2006/004341**A. CLASSIFICATION OF SUBJECT MATTER****H03F 3/217(2006.01)i**

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)

IPC 8 : H03F 3/217

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean Patents and Applications for invention since 1975

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Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	KR 10-2005-0020353 (POSTECH FOUNDATION) 4 MAR 2005 See abstract, Fig 1-2, claims 1-3	1-17
A	JP P2005-72766 A (SHARP CORP) 17 MAR 2005 See abstract, Fig 1	1-17
A	US 5949282 (NGUYEN et al.) 7 SEP 1999 See abstract, Fig 1-5, column 3 - column 4	1-17
A	KR 10-2004-0050410 (SAMSUNG ELECTRONICS CO., LTD.) 16 JUN 2004 See abstract, Fig 1-2, claims 1-2	1-17
P, A	KR 10-2006-0016222 (SAMSUNG ELECTRONICS CO., LTD.) 22 FEB 2006 See abstract, Fig 2, claims 1-4	1-17

 Further documents are listed in the continuation of Box C. See patent family annex.

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30 JANUARY 2007 (30.01.2007)

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

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