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Dynamic Headroom Control for Audio Amplifiers Using IV Sensing

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ABSTRACT

In a conventional amplifier and speaker setup for audio playback, a fixed voltage power supply, determined by the expected maximum peaks in input audio signal as well as a buffer value (headroom), is used to avoid distortion. A higher supply voltage is necessary to ensure sufficient headroom when the input audio has high peaks. A fixed headroom can cause high switching losses, reducing overall amplifier efficiency. This disclosure describes techniques to improve the efficiency of class-H amplifiers by dynamically changing the headroom based on distortion observed in audio output. A smart audio amplifier uses IV sense technology to measure the voltage and current from the speaker. The data are modeled to monitor the speaker's distortion. The input voltage to the amplifier is dynamically adjusted to prevent distortion while keeping headroom value within bounds to improve amplifier efficiency.

KEYWORDS

- Audio amplifier
- Audio distortion
- Dynamic headroom
- Amplifier headroom
- Class-H amplifier
- Class-D amplifier
- IV sensing
- Switching loss
- Amplifier efficiency

BACKGROUND

In a conventional amplifier and speaker setup for audio playback, a fixed voltage power supply is provided as input. The fixed power supply value is determined by the expected maximum peaks in input signal as well as a buffer value (headroom) to avoid distortion. To accommodate high peaks in the audio content with a high crest factor, a higher supply voltage is necessary to ensure sufficient headroom. A fixed headroom is often established based on the anticipated maximum output across the entire frequency spectrum. Class-H amplifiers may be used where input voltage can be modulated as per variations in audio content. However, higher switching losses at lower frequencies or at varying output power levels still occur as the headroom remains fixed. As higher input voltage is required to be supplied to the amplifier, overall amplifier efficiency is reduced.

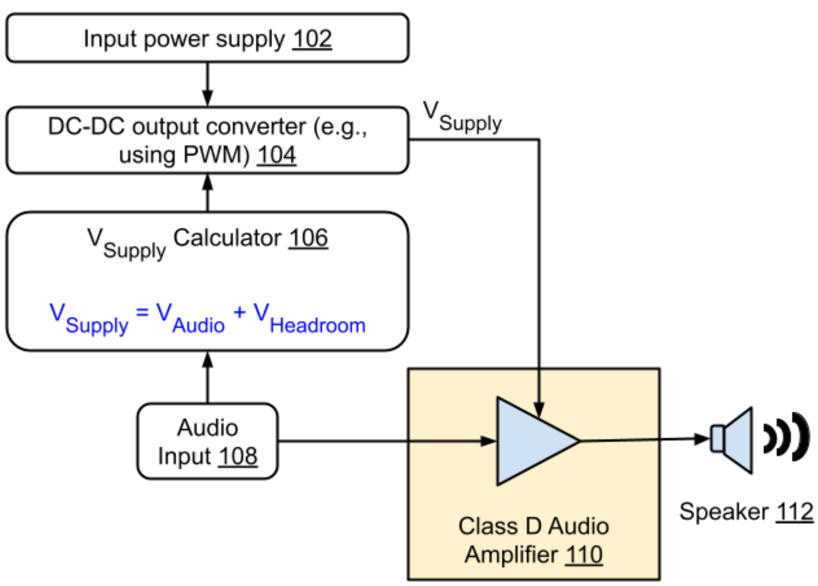

Fig. 1: Traditional Class-H amplifier operation

Fig. 1 shows traditional Class-H amplifier operation. As depicted in Fig. 1, a class-D audio amplifier (110) drives a speaker (112) to form a basic amplifier-speaker system. The audio input (108) is fed to the class D audio amplifier and is also used to calculate the required supply voltage. With a fixed headroom value and changing audio input, the supply voltage is calculated (106) as $V_{supply} = V_{audio} + V_{headroom}$.

Based on the calculated voltage supply, the input supply voltage (102) is modulated, e.g., using a DC-DC voltage output converter (104) which may use pulse width modulation (PWM). The modified supply voltage is provided to the audio amplifier.

DESCRIPTION

This disclosure describes techniques to improve the efficiency of class-H amplifiers by dynamically changing the headroom based on distortion observed in audio output. A smart audio amplifier uses IV sense technology to measure the voltage and current from the speaker. The data are modeled to monitor the speaker's distortion.

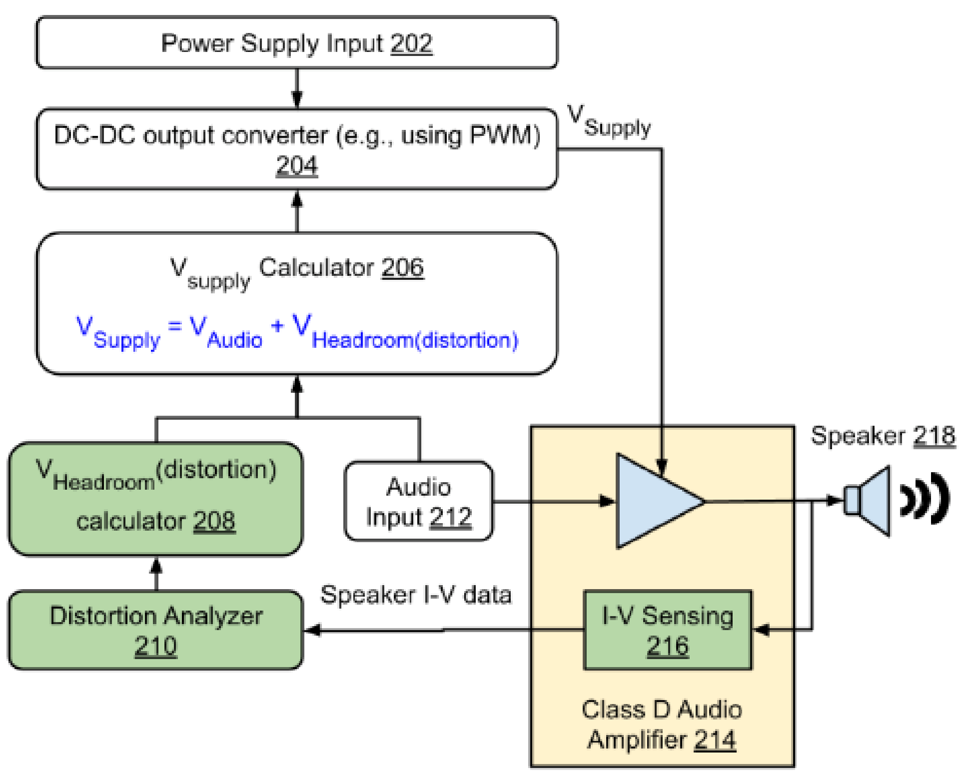

Fig. 2: Dynamic headroom control for Class-H amplifier with IV sensing

Fig. 2 illustrates a class-H amplifier with dynamic headroom control based on IV sensing from the audio output. The additional components (besides the traditional Class-H amplifier setup) are shown in green in Fig. 2. Audio input (212) is provided to a class-D audio amplifier (214).

IV sensing technology is used to measure the output current and voltage from a speaker (218). These are modeled to calculate the distortion in the output. The class-D audio amplifier is augmented with I-V sensing (216). The current and voltage data of audio output are obtained from a connection to the speaker.

This data can then be used to monitor and analyze the speaker load distortion with a distortion analyzer (210). Dynamic headroom, referred to as $V_{\text{headroom (distortion)}}$, can be determined (208) in various ways using the audio distortion as feedback and additional control (208). Example techniques to determine the headroom value include:

1. Based on the distortion level, a fixed headroom value can be set. For example, a distortion threshold is determined and if the observed distortion is above the threshold, a higher fixed headroom is used. If the distortion is less than threshold, a lower fixed headroom can be used. Additional distortion thresholds with different headroom levels can be used to optimize the switching loss.
2. Headroom can be determined as proportional to distortion value. Higher distortion can lead to a higher headroom value.
3. Headroom can be determined with a combination of above two approaches. For example, if the distortion is lower than pre-defined threshold, a lower headroom can be used. However, if the distortion is more than threshold, headroom can be determined as proportional to the distortion value.

The supply voltage then can be calculated (206) using dynamic headroom value and audio input (212) as: $V_{supply} = V_{audio} + V_{headroom}$ (distortion). Based on the calculated voltage supply, the input supply voltage (202) is modulated using a DC-DC voltage output converter (204) similar to traditional operation.

Use of dynamically changing headroom can lead to minimizing the switching losses and improve efficiency for class-H amplifiers. The described techniques can be used in any audio output device such as a smartphone, tablet, dock, smart display, smart speaker, or other audio product that uses audio amplifiers with IV sense. The proposed voltage adjustment techniques can execute on a main system-on-a-chip (SoC) of the device and/or a digital signal processor (DSP) integrated with the audio amplifier. Amplifier manufacturers can also use these techniques in in-house class-H amplifier control algorithms.

CONCLUSION

This disclosure describes techniques to improve the efficiency of class-H amplifiers by dynamically changing the headroom based on distortion observed in audio output. A smart audio amplifier uses IV sense technology to measure the voltage and current from the speaker. The data are modeled to monitor the speaker's distortion. The input voltage to the amplifier is dynamically adjusted to prevent distortion while keeping headroom value within bounds to improve amplifier efficiency.

REFERENCES

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