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A Class-D Audio Amplifier with Feedforward PWM-Intermodulated-Distortion Reduction Technique

具前饋式脈寬調變互調失真抑制技術之D類音頻放大器

隊伍名稱

新響事成 / Musical dreams come true

隊長

黃俊嘉 成功大學電機工程研究所

指導教授

郭泰豪 成功大學電機工程研究所

作品摘要 Abstract

常見的音頻放大器有兩大類 – 傳統AB類放大器及D類放大器。傳統AB類放大器的功率轉換效率較差，通常介於30%~50%，D類放大器則可達90%以上。因D類放大器可大量減少功率損耗，所以漸漸取代AB類放大器。而與AB類放大器相比，卻有較大的總諧波失真的問題。會受限於穩定度，無法達到很好的效能。

本作品提出創新的前饋式脈寬調變互調失真抑制技術，可降低閉迴路D類放大器因脈寬調變的高頻訊號造成的諧波失真，並使原本閉迴路濾波器在設計上，首次使穩定性和高迴圈增益可以同時達成，在相近的成本及功率消耗下，可以得到更低的總諧波失真。

本技術以TSMC 0.25 μm BCDMOS製程實現單晶片D類音頻放大器，其具有輸出功率10W，最大訊號雜訊比106dB，總諧波失真加雜訊最低為0.009%及最高效率92%。與IEEE旗艦會議ISSCC及頂尖期刊JSSC之文獻相比，在相關類比輸入D類音頻放大器中，具有最低的失真，完全取代AB類之龐大市場指日可待。為近年類比輸入D類音頻放大器之最重大關鍵性突破。

Conventional class-AB amplifiers and class-D amplifiers are the two commonly-used classifications in audio amplifier applications. Class-AB amplifiers have poor efficiency, which is usually 30~50%; On the other hand, the efficiency of class-D amplifier can reach over 90%. Therefore, class-D amplifiers gradually replace the class-AB amplifiers due to its feature of ultra-low power loss. However, compared with class-AB amplifiers, open-loop class-D amplifiers have larger total harmonic distortion (THD). The Amplifier's performance is limited by stability.

This work proposes a feedforward PWM-Intermodulated Distortion Reduction PIDR technique, which reduces the harmonic distortion caused by the intermodulation with high-frequency components in closed-loop class-D amplifiers. In addition, it achieves high loop gain without decreasing the stability in loop-filter design. It is the first technique to improve distortion without degrading the loop stability.

An integrated class-D audio amplifier is realized in TSMC 0.25 μm BCDMOS process. It delivers 10-W output power into an 8 Ω load and achieves an SNR of 106dB, a THD of 0.009% and peak efficiency of 92%. Compared with the state-of-the-art analog-input class-D amplifiers published in the IEEE top conference ISSCC and top journal JSSC, the proposed technique has the lowest distortion. Based on this technique, the complete replacement of class-AB amplifiers with class-D amplifiers has become possible. It is the most critical breakthrough in analog-input class-D audio amplifier design in recent years.