Control of class-D power amplifier using negative feedback from output LC filter

Abstract

Detailed goals of the thesis are: 1) construction of class-D audio amplifier driven by low-cost signal processor, 2) method of feedback control using the output of low-pass LC filter, 3) analysis of practical application issues of the amplifier system. The class-D amplifier consists of multi-phase PWM power stage, output LC filter, and feedback loop with differential amplifier, ADC converter, and signal microcontroller. The whole system that provides amplification of the audio signal involves the class-D amplifier, control-management (CM) unit, and stabilized power supply. The amplifier and the CM unit communicate over high speed synchronous interface. Due to the LC filter and calculation time the amplifier is modeled by resonant transfer function with delay. PID algorithm is chosen for feedback control, with settings obtained by pole-zero cancellation and phase margin requirement. Optimized machine language program with pipeline processing implements the algorithm. Robustness with respect to parameters of the LC filter and loudspeaker load are examined. A method for practical application of the loaded audio system is developed, involving fast automatic measurement of frequency characteristics and calculation of controller settings. Performance of the amplifier can be improved by compensating the delay using additional feedback loop with Smith predictor also implemented in machine language. Final measurements demonstrate practical potential of the class-D power amplifier involving feedback with low-cost signal microcontroller.