Issue Article

LX1720: AudioMAX High-Efficiency Class-D Amplifier

Application Note
AN-11
Summary

The LX1720 controller IC contains the necessary functions to implement a stereo Class-D audio amplifier.
A Class-D amplifier is a "switching" amplifier that converts a low-level, analog, audio input signal into a high-power, pulse-width modulated (PWM) output.

The switching frequency is much higher than the audio band which allows high frequency out-of-band components to be removed with a simple LC filter.

The LX1720 generates a PWM output by controlling external MOSFET's connected in a full-bridge configuration. Because the MOSFET's are either full "on" or full "off", their power dissipation is minimal allowing maximum power to be delivered to the speaker.

The LX1720 can deliver 10 Watts (rms) per channel into an 8 ohm load using a single 15-volt supply.

THEORY OF OPERATION

The block diagram for a single channel is shown in Figure 1. Each channel consists of a control loop that adjusts the PWM output to "track" the audio input signal.

Output Stage

Four external MOSFETs are connected in a full-bridge configuration connected between a single supply (PVDD) and ground (PGND).

The output of the MOSFET bridge drives a differential LC filter which removes the switching frequency components of the PWM output prior to driving the speaker. In practice, the bridge alternately connects the LC filter inputs between PVDD and PGND as shown in Figure 1. (Note that no multiple or split-supplies are required - all large currents flow between PVDD and PGND.)

Feedback Amplifier

The bridge output also drives two single-pole RC lowpass filters consisting of components R_1, C_9 and R_2, C_{10}. The RC filter outputs provide the feedback for the control loop via the FBK+ and FBK- inputs.

Inside the LX1720, these two differential inputs are converted to a single-ended signal by the feedback amplifier. The feedback amplifier also attenuates the feedback signals and level shifts its output to 2.5 volts.

Input Amplifier

The single-ended audio input is AC coupled into the LX1720 via external capacitor C_{24}. An op-amp inside the LX1720 level shifts the input signal to 2.5 volts and also provides gain.

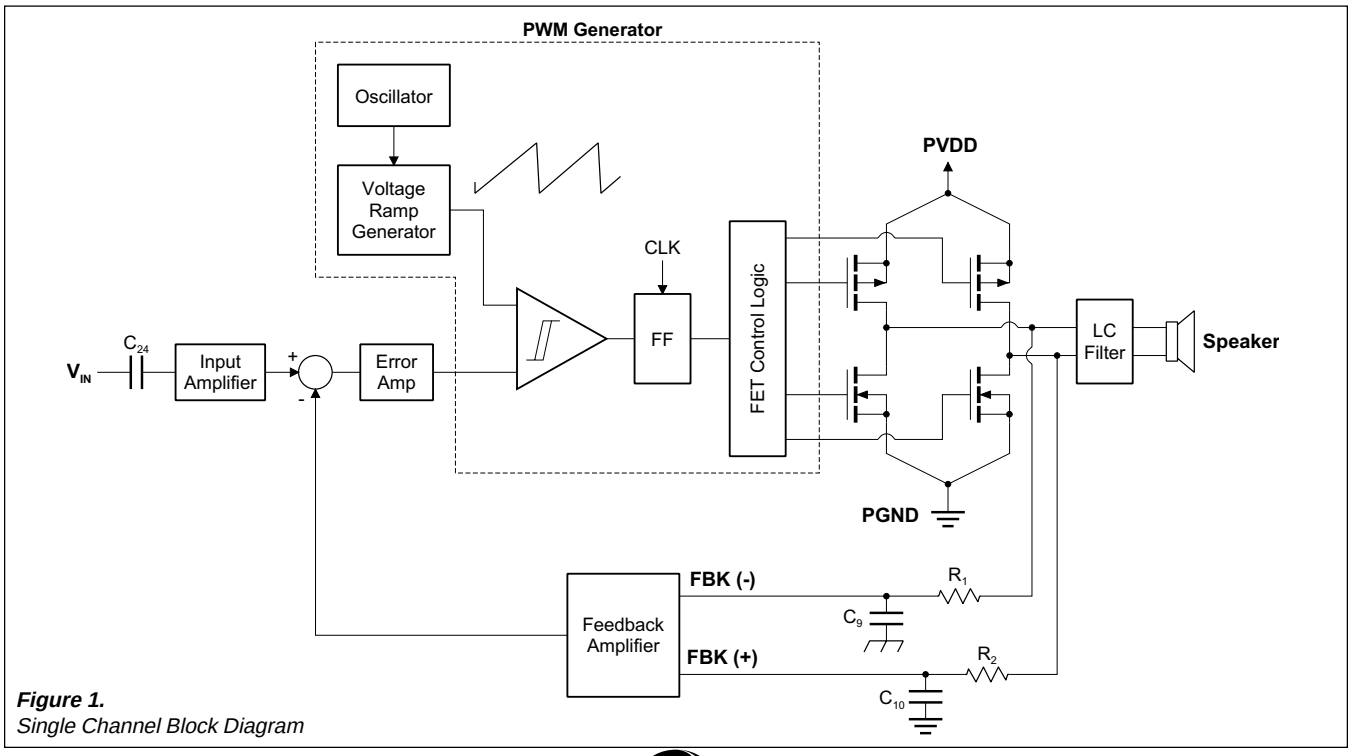

Figure 1.
Single Channel Block Diagram

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Error Amplifier

The input amplifier's output is fed to the error amplifier. The output of the feedback amplifier is also fed to the error amplifier. The error amplifier integrates the "error signal" i.e. it integrates the difference between the audio input and the feedback signal. The output of the error amplifier represents the desired audio output signal.

PWM Generator

The output of the error amplifier, EAOUT, is fed to a comparator that compares EAOUT to a voltage ramp waveform. The voltage ramp repeats at the switching frequency which is much greater than the audio band of interest.

At the beginning of the ramp, the comparator output is reset high. When the ramp voltage exceeds EAOUT, the comparator output switches low. Thus, the pulse-width or duty-cycle of the comparator output is proportional to the voltage at EAOUT.

The comparator output is latched into a flip-flop which drives the external MOSFETs to complete the control loop. The action of the control loop causes the PWM output to accurately track the audio input signal.

For the complete LX1720 application note, including implementation details and design equations, visit the Linfinity Division web site at www.linfinity.com. Soon to be released is a monophonic version of the AudioMAX Class D amplifier IC, with an enhanced circuit design that produces even better noise and distortion characteristics.

Output LC Filter

The output LC filter stages help to reconstruct the amplified audio signal and filter out the switching frequency. The design of these filters depends on the attenuation that is desired at the output. If the amplifier circuit is in close proximity to the speakers then even a single stage filter is sufficient. In the Figure 2 example, however, a four-element dual stage filter is used. Each bridge junction will have a two-stage filter section.

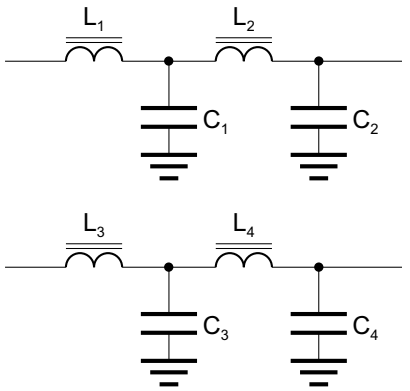

Figure 2. *Output LC Filter*

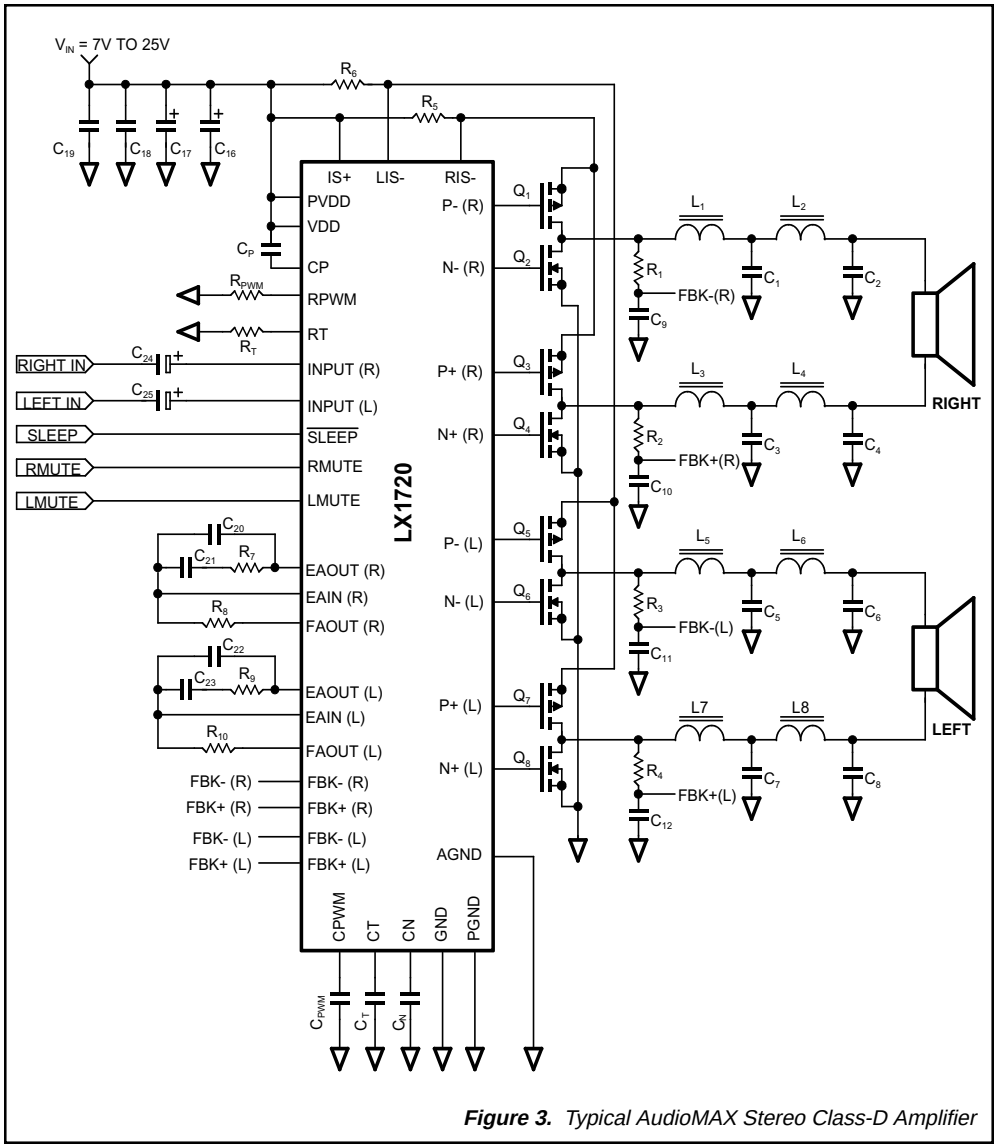

Figure 3. *Typical AudioMAX Stereo Class-D Amplifier*