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AnalogDialogue

StudentZone—ADALM2000 Activity: Audio Amplifier with Electret Microphone

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Objective

The objective of this lab activity is to design and build an audio amplifier that takes the small output voltage from an electret microphone and amplifies it such that it can drive a small loudspeaker.

Background

An electret microphone is a type of condenser (capacitor) microphone that has an essentially permanent charge on the capacitor plates, eliminating the requirement of external phantom power that is used to bias the capacitor in traditional condenser microphones. Most commercially available electret microphones, however, contain an integrated preamplifier—often an open-drain FET circuit—and therefore require a small amount of low voltage power.

Simple audio amplifiers can be designed using transistors, with or without negative feedback. Negative feedback, however, provides a very important improvement in distortion performance. In this experiment, we design and build an AC-coupled non-inverting operational amplifier with a desired voltage gain of 10, with an inside-the-loop emitter-follower on its output with AC coupling to the loudspeaker. The op amp section provides voltage gain, and the emitter-follower functions as a buffer, providing the current required to drive the loudspeaker. Placing the emitter-follower inside the feedback loop improves its overall performance.

Amplifier Design

The electret microphone includes an open-drain FET preamplifier and requires a drain resistor, R_D, with a value between 680 Ω and 2.2 kΩ, connected between its output and the 5 V supply as shown in Figure 1. The drain resistor is set at 2.2 kΩ in this design, which places the drain voltage at approximately 4.5 V with a 5.0 V supply.

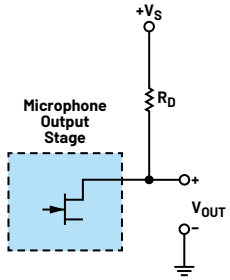

Figure 1. An electret microphone output stage.

The design goal is to drive a nominally 400 mV p-p signal into an 8 Ω loudspeaker, following AC coupling referenced to ground, requiring about ±25 mA. The amplifier is designed to operate from a single 5 V supply. Because of this, the op amp DC levels are biased to a mid-supply voltage of 2.5 V, and input, output, and feedback signals are AC-coupled. AC coupling of the input signal allows the DC level out of the microphone to differ from the DC level into the amplifier. For the op amp portion of the circuit, you can use the OP484 quad op amp provided in the ADALP2000 parts kit and for the emitter follower portion of the circuit you can use the 2N3904 NPN transistor contained in the kit.

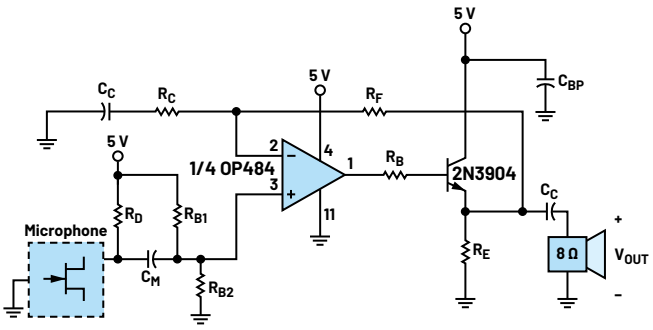

Figure 2. An overall amplifier schematic diagram.

Materials

- ADALM2000 Active Learning Module
- Solderless breadboard
- Jumper wires
- One OP484 rail-to-rail amplifier
- One electret microphone
- One 2N3904 NPN transistor
- One 8 Ω loudspeaker
- One 47 Ω resistor
- One 68 Ω resistor
- One 100 Ω resistor
- One 1 kΩ resistor
- One 2.2 kΩ resistor
- One 20 kΩ resistors
- One 4.7 µF capacitor
- One 47 µF capacitor
- One 220 µF capacitor

Hardware Setup

Build the circuit presented in Figure 3 on your solderless breadboard.

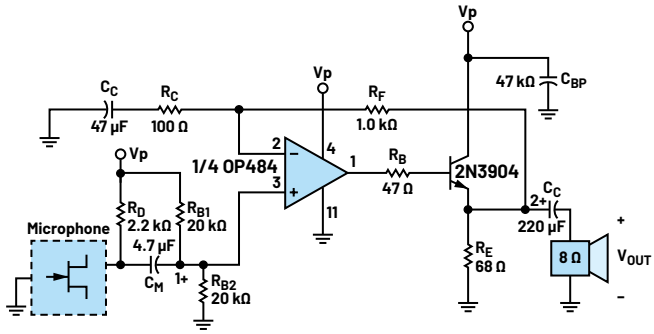

Figure 3. An audio amplifier with an electret microphone schematic diagram.

If you want to check the amplifier functioning, you can remove the microphone and the speaker from the circuit and use the oscilloscope tool. For this, the breadboard connections are presented in Figure 5.

Procedure

If you want to check the amplifier gain, build the setup presented in Figure 5. Open Scopy and enable the positive power supply to 5 V. Set the signal generator Channel 1 to a sine waveform with 50 mV amplitude peak-to-peak, 200 Hz frequency, and 2.5 V offset. You can increase the amplitude of the sine wave until clipping is observed. In the oscilloscope, monitor the input signal on Channel 1 and the amplifier output signal on Channel 2. Set the vertical resolution to 100 mV/div and the position to –2.5 V so you can see the signals in the oscilloscope window as in Figure 6.

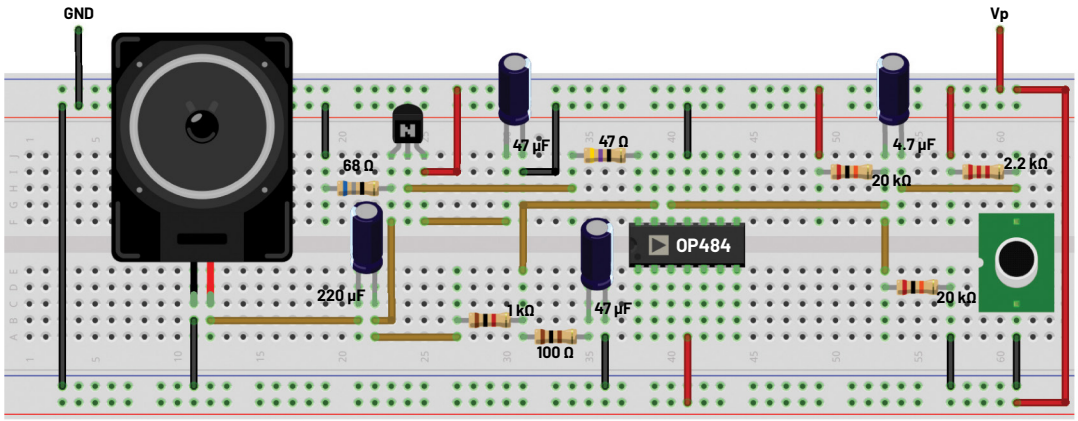

Figure 4. An audio amplifier with electret microphone breadboard connections.

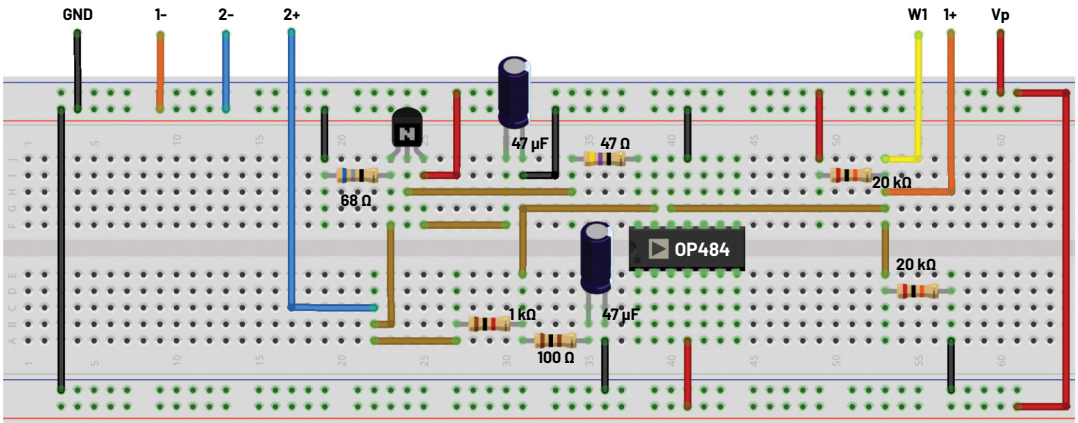

Figure 5. Audio amplifier oscilloscope breadboard connections.

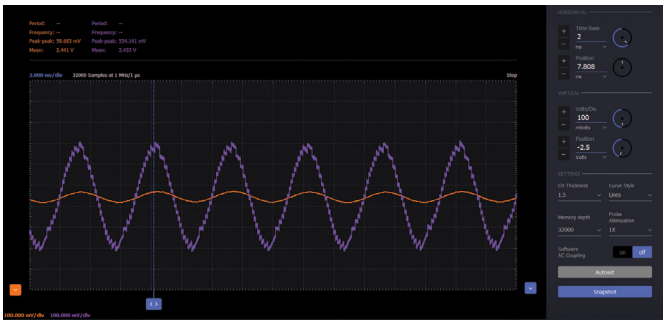

Figure 6. Amplifier input and output waveforms.

Connect the electret microphone and the loudspeaker in the circuit as shown in Figure 4. Move the loudspeaker directly in front of the microphone until audible feedback occurs.

Questions:

1. Why does the clipping occur when the amplitude of the sine wave is increased?

2. Why does audible feedback occur when the loudspeaker and the microphone are close to each other?

You can find the answers at the StudentZone blog.

About the Author

Andreea Pop has been a systems design/architecture engineer at Analog Devices since 2019. She graduated from the integrated circuits and systems master's program and has a B.Eng. in electronics and telecommunications, both from the Technical University of Cluj-Napoca.

About the Author

Antoniu Miclaus is a system applications engineer at Analog Devices, where he works on ADI academic programs, as well as embedded software for Circuits from the Lab®, QA automation, and process management. He started working at ADI in February 2017 in Cluj-Napoca, Romania. He is currently an M.Sc. student in the software engineering master's program at Babes-Bolyai University and he has a B.Eng. in electronics and telecommunications from the Technical University of Cluj-Napoca.