

StudentZone— ADALM2000 Activity: Variable Gain Amplifiers

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Objective

In this laboratory, we continue our discussion on operational amplifiers (see the previous lab “ADALM2000 Simple Op Amps”), focusing on variable gain/voltage controlled amplifiers.

Most operational amplifier (op amp) circuits have a fixed level of gain. However, it is often advantageous to vary the gain. This can be done simply by using a potentiometer on the output of a fixed-gain op amp circuit, but sometimes it may be more useful to vary the gain of the amplifier circuit itself.

A variable gain or voltage controlled amplifier is an electronic amplifier that varies its gain depending on a control voltage. This type of circuit has many applications, including audio level compression, synthesizers, and amplitude modulation. It can be realized by first creating a voltage controlled resistor, which is used to set the amplifier gain. The voltage controlled resistor is one of the numerous circuit elements that can be produced by using a transistor with simple biasing. Another approach is to use potentiometers to vary the value of the resistors that set the gain of the amplifier.

Materials

- ▶ ADALM2000 Active Learning Module
- ▶ Solderless breadboard and jumper wire kit
- ▶ Two 1 kΩ resistors
- ▶ One 4.7 kΩ resistor
- ▶ Three 10 kΩ resistors
- ▶ One 10 kΩ potentiometer
- ▶ One OP97 operational amplifier
- ▶ One 2N3904 NPN transistor

Voltage Controlled Amplifier Using a Transistor

Background

Consider the circuit schematic presented in Figure 1.

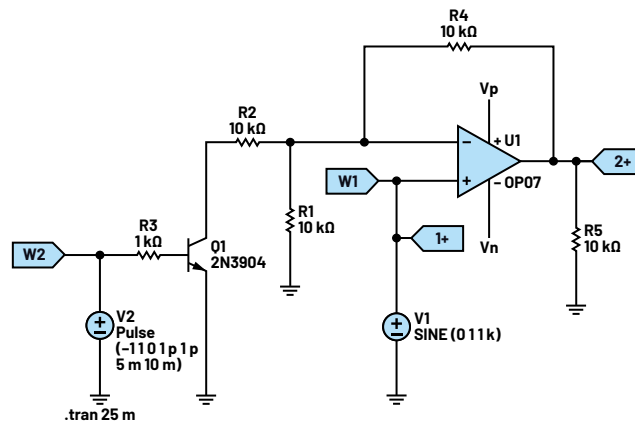


Figure 1. Voltage control using a transistor.

The configuration of the circuit is similar to a basic non-inverting amplifier. The only addition consists of a transistor and a resistor in parallel with resistor R2. The transistor works as a switch that allows two gain settings, based on its current state (on/off).

Hardware Setup

Build the following breadboard circuit for the voltage controlled amplifier using transistors (Figure 2).

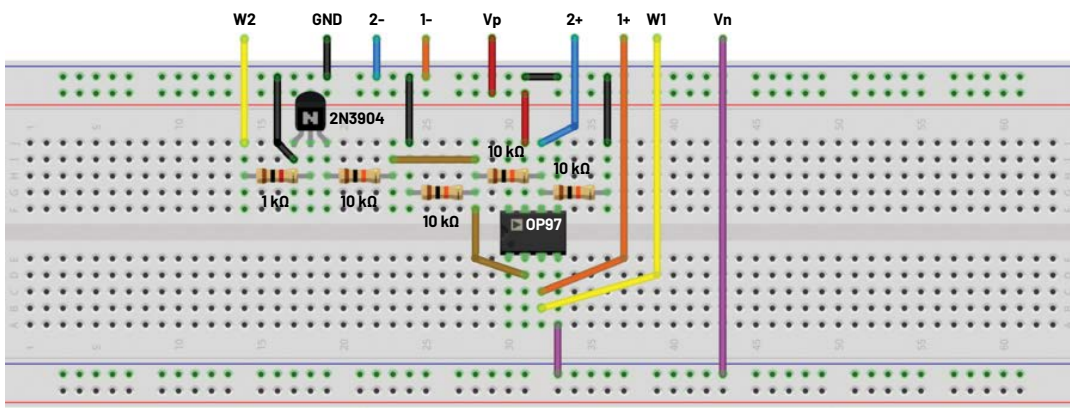


Figure 2. Breadboard circuit of voltage control using a transistor.

Procedure

Use the first waveform generator as source V_{IN} to provide a 2 V amplitude peak-to-peak, 1 kHz sine wave excitation to the circuit. Use the second waveform generator for controlling the transistor, providing a 2 V amplitude, 1 Hz square wave excitation. Supply the op amp to ± 5 V from the power supply. Configure the scope so that the input signal is displayed on Channel 1 and the output signal is displayed on Channel 2. See Figure 3.

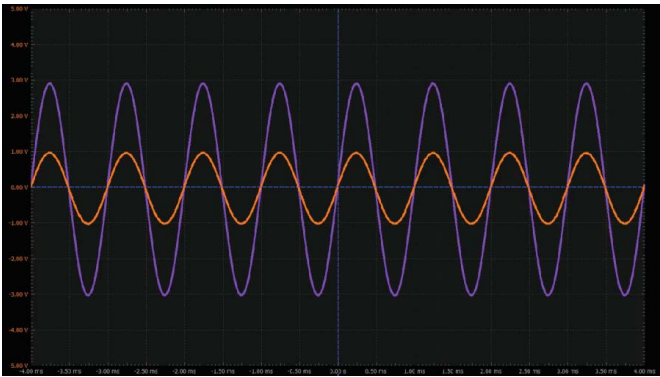


Figure 3. Waveforms of voltage control using a transistor.

The output signal varies between two values, determined by the two gain settings, based on the state of the controlled transistor.

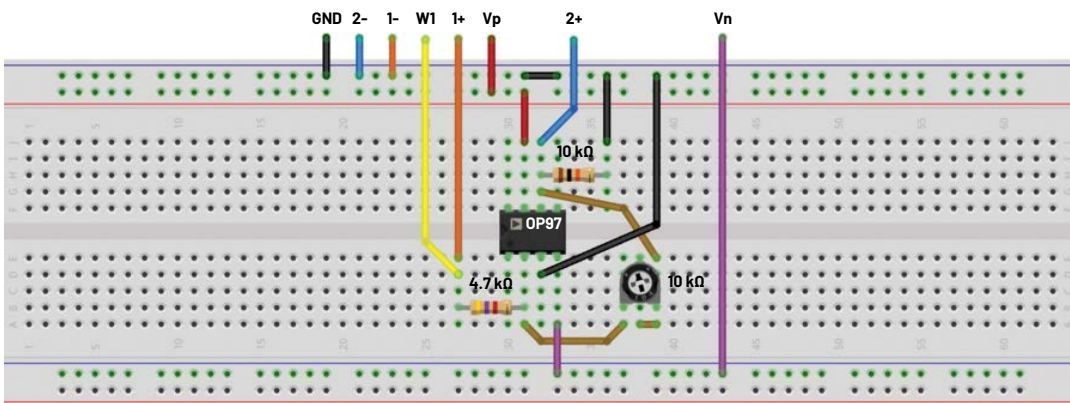


Figure 5. Breadboard circuit of a variable gain inverting amplifier using a potentiometer.

Variable Gain Inverting Amplifier Using a Potentiometer

Background

Consider the circuit schematic presented in Figure 4.

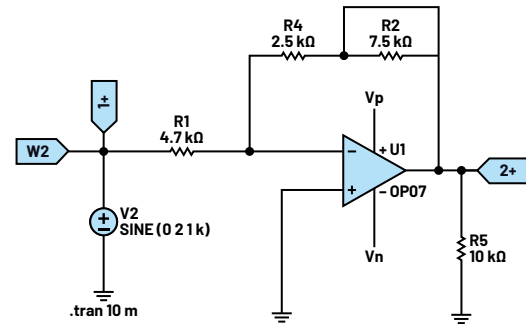


Figure 4. A variable gain inverting amplifier using a potentiometer.

On the inverting amplifier, a potentiometer is used to manually control the output voltage, replacing the standard feedback resistor.

Hardware Setup

Build the following breadboard circuit for the voltage controlled amplifier using transistors (Figure 5).

Procedure

Use the first waveform generator as source V_{IN} to provide a 2 V amplitude peak-to-peak, 1 kHz sine wave excitation to the circuit. Supply the op amp to ± 5 V from the power supply. Configure the scope so that the input signal is displayed on Channel 1 and the output signal is displayed on Channel 2. See Figure 6.



Figure 6. Waveforms of a variable gain inverting amplifier using a potentiometer.

Using this type of configuration, the output is inverted and amplified based on the feedback resistance value.

Variable Gain Inverting/Non-Inverting Amplifier Using a Potentiometer

Background

Consider the circuit schematic presented in Figure 7.

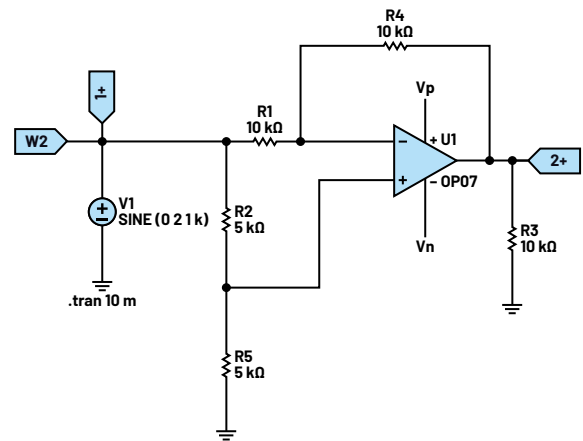


Figure 7. Variable gain inverting/non-inverting amplifier using a potentiometer.

In this amplifier configuration, a potentiometer is used to manually control the output voltage, inverting the input by properly adjusting the potentiometer.

Hardware Setup

Build the following breadboard circuit for the voltage controlled amplifier using transistors (Figure 8).

Procedure

Use the first waveform generator as source V_{IN} to provide a 2 V amplitude peak-to-peak, 1 kHz sine wave excitation to the circuit. Supply the op amp to ± 5 V from the power supply. Configure the scope so that the input signal is displayed on Channel 1 and the output signal is displayed on Channel 2. See Figure 9.

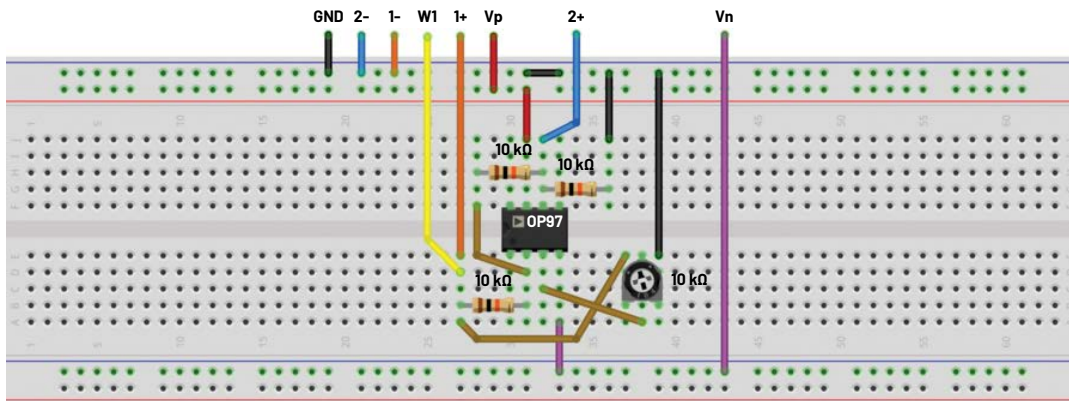


Figure 8. Breadboard circuit of a variable gain inverting/non-inverting amplifier using a potentiometer.

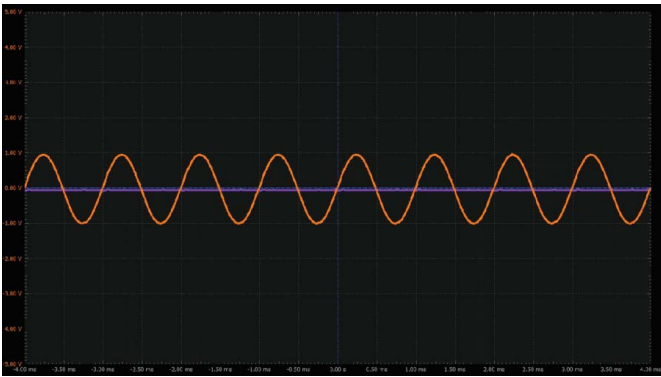


Figure 9. Waveforms of a variable gain inverting/non-inverting amplifier using a potentiometer.

Using this configuration, the output is amplified varying between $\pm V_{in}$.

Question

Can you briefly name several real-life applications in which variable gain amplifiers are useful?

You can find the answer at the [StudentZone blog](#).



About the Author

[Antoniu Miclaus](#) is a software engineer at Analog Devices, where he works on embedded software for Linux and no-OS drivers, as well as ADI academic programs, QA automation, and process management. He started working at ADI in February 2017 in Cluj-Napoca, Romania. He holds an M.Sc. degree in software engineering from the Babes-Bolyai University and a B.Eng. degree in electronics and telecommunications from the Technical University of Cluj-Napoca.