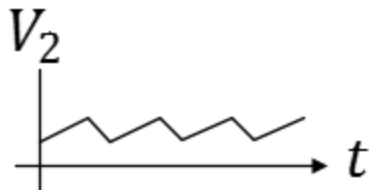


# Module 9D: The Amplifier: Gain and Offset Control

## Laboratory Outline

Very often you will find yourself in need of a way to provide gain (amplify) to a voltage signal. Often, this is part of a process called “signal conditioning” where the signal is conditioned to properly drive the next device within a system. This module will guide you through the procedure of using an LM358 operational amplifier to provide gain (and even a voltage offset) to a small voltage signal.



**Figure 1:** An amplifier with gain and offset controls will allow the designer to optimize the lowest and highest voltage of a periodic signal. For example, the waveform  $V_2$  can be modified through an amplifier to resemble  $V_3$ .

## Prerequisites

- Laboratory Exercise #5

## Parts Needed

- (1) LM358 Operational Amplifier (2 per IC)
- Two trim pots and a  $0.1 \mu F$  capacitor from your kit.
- Regulated 5-volt source and ground from the Arduino.

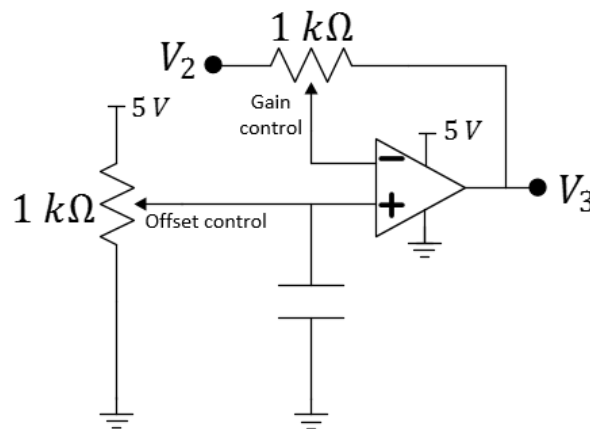
## At Home: Construction

- ✓ Obtain the datasheet for the LM358 operational amplifier.

**Question 1:** Record below the pinout for the LM358 chip and label the pin numbers on the Op Amp circuit schematic in Figure 2 as well.

**Question 2:** Draw circuit-schematic parts to the LM358 chip above to show how to construct the gain-and-offset amplifier shown in Figure 2.

- ✓ Build the circuit shown in Figure 2. Use any small capacitor ( $0.1 \mu F$  is a good choice). The potentiometers may also be substituted with others up to  $10 k\Omega$  in value. Set the potentiometers to **half their value** using an Ohmmeter as your starting point for adjusting.



*Figure 2: An (inverting) amplifier with gain and offset control.*

## In the Laboratory: Analysis

- ✓ Configure the function generator to provide a sinusoid with an amplitude of 2 volts and an offset of +2 volts.

**Question 3:** Sketch by hand the signal generated by the function generator as viewed on the oscilloscope.

- ✓ Use the function generator as input to the operational amplifier you build. Adjust the gain using the potentiometer while simultaneously monitoring both the input and output of the amplifier on the scope.

**Question 4:** Describe what you see as the gain potentiometer is adjusted.

- ✓ While simultaneously monitoring both the input and output of the amplifier on the scope, adjust the gain and offset of the amplifier using the two pots until you have a large sinusoidal signal that goes (as nearly as possible) between 0 and 5 volts.

**Question 5:** Sketch the signal you obtained here and comment on its appearance. Is there any distortion with the settings fixed to these “optimal” values?

**Question 6:** What happens with small changes in either potentiometer?

## Back at Home: Drawing Conclusions

**Question 7:** Provide any recommended procedures for tuning your gain and offset in the future when trying to obtain a “full-scale” waveform.

## Learning Objectives

- To interpret critical information from the LM358 datasheet.
- To build a gain-and-offset amplifier based on the LM358 operational amplifier.
- To adjust trimpots to gain a full-scale waveform while using the oscilloscope for making informed choices.

## Learn More!

**Note:** By applying this circuit to the triangular waveform from *Explore More!: The Voltage-Follower Buffer*, the waveform can be made to span the entire range of possible reference voltages from an active sensor. In *Explore More! Module: PWM Control via an Active Sensor*, you can apply the gain-and-offset amplifier to the triangular waveform of the simple oscillator (after the voltage-follower buffer) in order to create a more *robust* scheme for active sensor control of a PWM waveform’s duty cycle. In *Explore More!: Simple Microphone Usage*, this circuit can be used as an amplifier for the microphone in your kit.

**Note:** *Robust* is a term often used very loosely in engineering. It most often refers to a system that is insensitive to deviations in parameters or outside forces.