Op-Amps I

Goals

1. Understand basic op-amp operation.
2. Measure gain of an op-amp circuit.
3. Explore features of op-amp circuits.

Background

An operational amplifier (op-amp) is an integrated circuit that comprises many transistors and other elements in a single package, typically with 8 pins. An op-amp amplifies the difference between its two inputs to produce an output. The gain of the op-amp itself is enormous, but op-amp circuits are designed to use external negative feedback in a way that greatly reduces the gain of the overall circuit. Though the internal workings of an op-amp are complicated, the behavior of an op-amp **with negative feedback** can be modeled using two simple "Golden Rules:"

OP-AMP Golden Rules (with negative feedback):

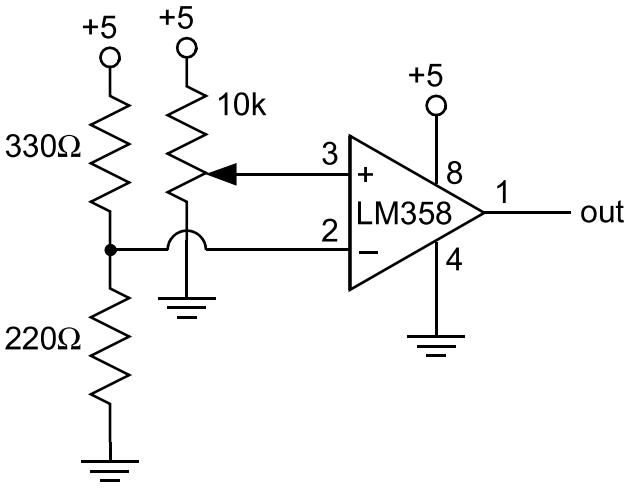
1. **The output does whatever it must to keep the voltage difference between the two inputs zero.**
2. **The inputs draw no current.**

Download a copy of the data sheet for a LM358 op-amp and find the pinout diagrams.

Experimental Instructions

1. Op-amp circuits

a. **Open-loop gain**: Build the circuit shown at right, which has no feedback (also known as open-loop). An op-amp always needs power: + 5 volts and ground in this case. **After this diagram the power leads (4 & 8) and the pin numbers will be assumed and not shown.** Adjust the potentiometer so that the output is near the point where it jumps from a maximum to a minimum.

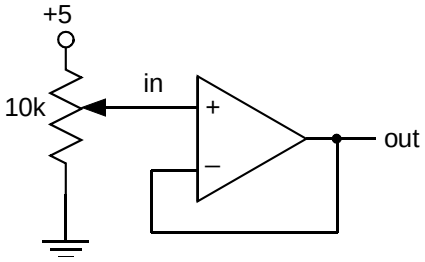


→Record the voltages at pins 1, 2, and 3 (relative to ground) for situations as close as you can to the max-to-min transition on both sides. Are your voltages consistent with the specified open-loop gain in the data sheet?

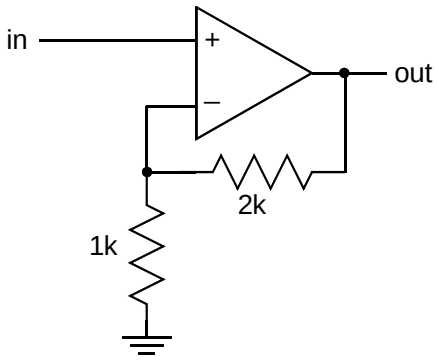
b. **Follower**: Build the circuit shown at right.

→Record the input and output voltages for several values over the full range of the output voltage.

➔ Use your data to determine the circuit gain. Does the measured gain agree with the gain expected from applying the Golden Rules?



c. **Non-inverting amplifier**: Build the circuit shown at right. Input a sine wave and observe the output on an oscilloscope.

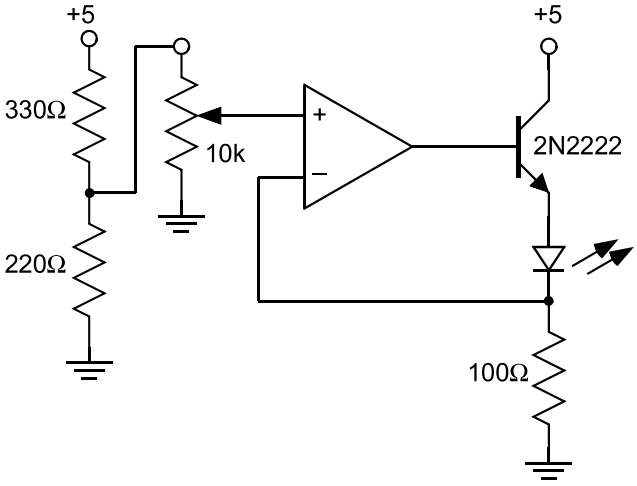


→Record several pairs of input/output traces for a range of parameters of the input wave (e.g. two different frequencies, two different amplitudes).

→Use your data to determine the circuit gain and the maximum output voltage swing. Does the measured gain agree with the gain expected from applying the Golden Rules?

2. Op-amp circuits

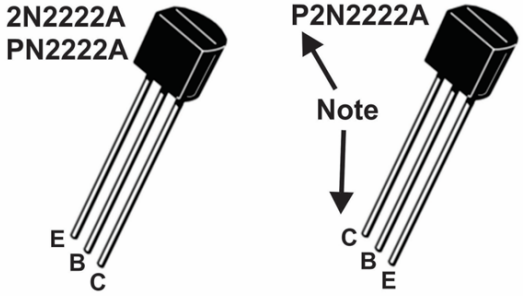
Current source: Build the circuit shown at right. As you adjust the potentiometer, the brightness of the LED (use a red one) will change.



➔ Make measurements of the voltage input to the positive op-amp terminal and the current through the LED.

➔ Explain the function of every element in the circuit, and why it is said to function as good tunable current source.

HINT: Remember from Lab 1 the voltage-drop diode across the diode varies exponentially with current (non-ohmic). So what you've done here is made an non-ohmic circuit element ohmic (I_{diode} now increases LINEARLY with $V_{in}=V_{+}$).



As most circuits are non-ohmic, op-mps are critical to ensure the circuits behave linearly.

Also, it appears this year most of your transistor are in fact P2N2222A models despite being labelled otherwise adjusts accordingly!