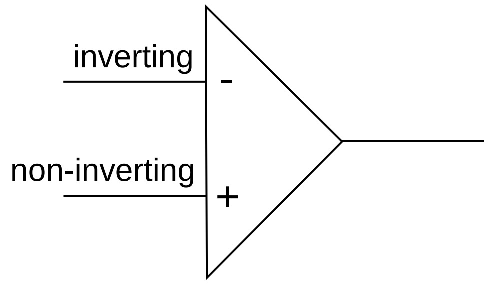
385L / 5585 – Laboratory 5 – Operational Amplifiers 20 MAR 2017 (Due: 10 APR 2017)

Objectives:

1. Determine the open loop gain of a TL082 op-amp
2. Understand the control character of an LM311 comparator
3. Understand inversion and amplification from an op-amp

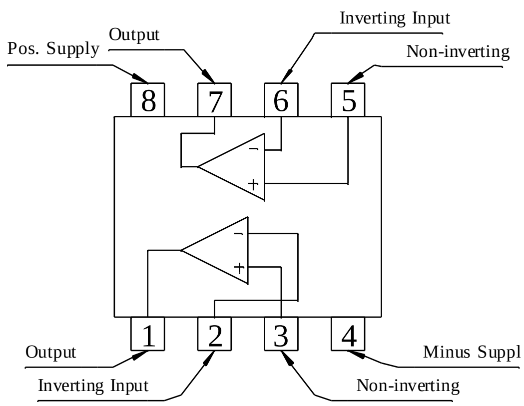


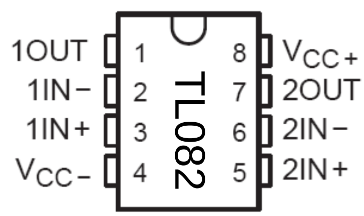
Equipment and Parts:

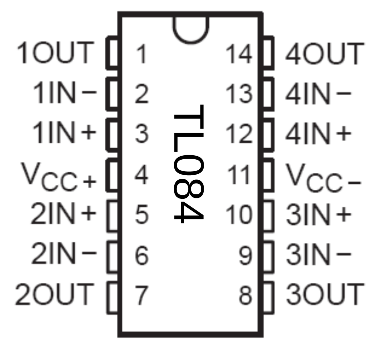
1. Oscilloscope with probes
2. Function generator
3. Op-amps, resistors and capacitors
4. Frequency Meter (Keithley 776)
5. DC voltage sources (ELENCO benchtop kit sources)

5-1 Null Measurements

The first op-amp used is a TL082 (or TL084). This package contains two (four) separate op-amps. The pin diagram(s) is shown in the figure below. Wire the circuit shown below using the adjustable voltage source for the inputs to the op-amp. For the V_{cc} inputs use +12 V and -12 V on pins 8 (4) and 4 (11). Then, connect one side of the + 20 or -20 V variable voltage source to the inverting input or pin 2. Use a multimeter to monitor the op-amp output and adjust the variable voltage source between ±12.5 V (do not exceed ±12.5V!) until the transition from one output voltage limit to the other occurs. Determine the positive and negative voltage limits of the op-amp output. That is, adjust the voltage into the inverting input until: (1) the op-amp output just begins to decrease from its positive limit; (2) it is close to zero output; and, (3) it is not quite to the negative limit. Several trials will be required to set these values. Record the input voltages required to achieve each of these values and comment on the gain and inversion?

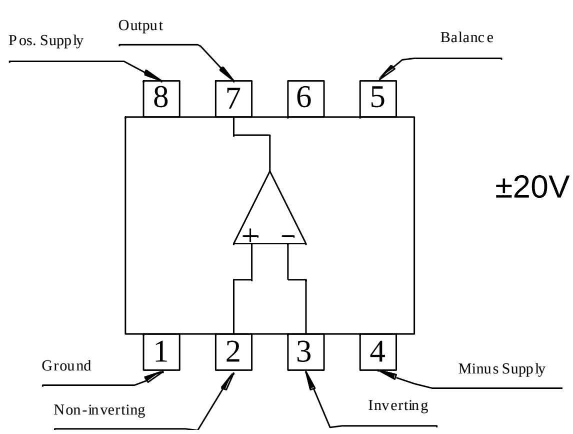


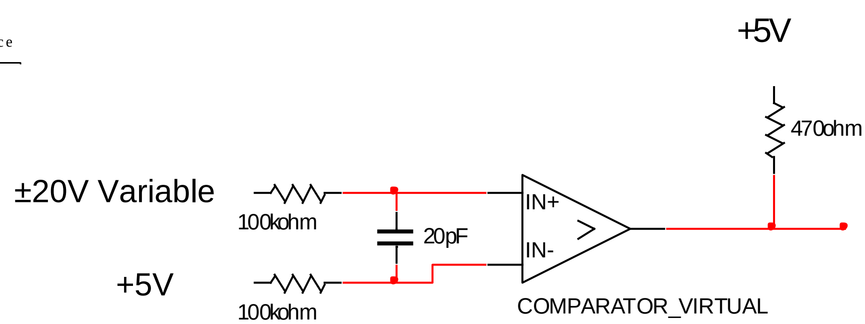




5-2 Voltage Comparator

A specific type of op-amp is a comparator – we'll be studying the LM311. This device is designed to accurately compare two input voltages and adjust the output according to this comparison. Wire the circuit shown below using ± 12V from the ELENCO kit for the supplies.

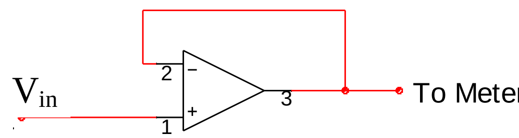




Adjust the ±20 V source output to determine the minimum change in input (comparator) voltage required to complete the transition from one output (comparator) state to the other (do not exceed ±12.5V). Approach the transition region from both above and below. Replace the ±20 V to the non-inverting input with the output of the function generator. The function generator should be set on a triangular wave with amplitude of ±5 V. Monitor both the input signal and the output signal on the scope and connect the output to the frequency meter. Beginning with a frequency of l00 kHz reduce the frequency until the frequency meter indicates an erratic or higher than expected frequency. Inspect the oscilloscope trace at which the transition first becomes unstable. Reset the function generator to l00 kHz and to a larger amplitude. Repeat the measurement of the frequency at which the output becomes unstable. What is the slowest rate of change of the input voltage that will produce a single output transition with the LM311?

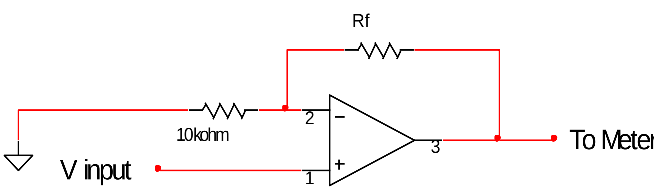
5-3 Voltage Follower

Again, using the TL082, wire the circuit shown right. Using the variable voltage source for V_{in}, compare the output voltage to the input voltage. Calculate the gain, using $G=V_{out} / V_{in}$.



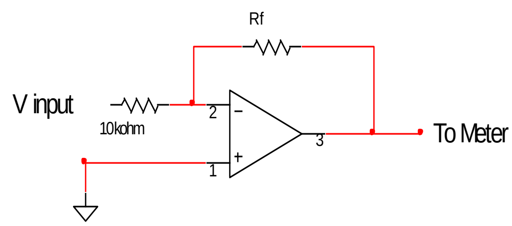
5-4 Follower With Gain

Using the TL082, wire the follower with gain circuit shown right with R_f = 10 kΩ. Use the variable voltage source as V_{in} and adjust the input voltage to approximately 0.2 V and measure V_{out}. Repeat for values of V_{in} of 0.4 V, 0.5 V, 1.0 V, 2.0V, and 5.0V. Calculate the gain from the measured values and compare it to the theoretical gain. What limits the gain for large values of V_{in}? Repeat the above measurements but with feedback resistors of 100kΩ, 1MΩ, and 10 MΩ. Compare the measured gains to those expected and explain any deviations. Disconnect the variable voltage source and connect the non-inverting input to ground, providing a zero voltage input. With feedback resistors of 100 kΩ, l MΩ , and 10 MΩ measure the output voltage. This is called the offset voltage and introduces error in the output of the op-amp. What percent error did the offset voltage cause for the gain of 100 on the previous experiment?



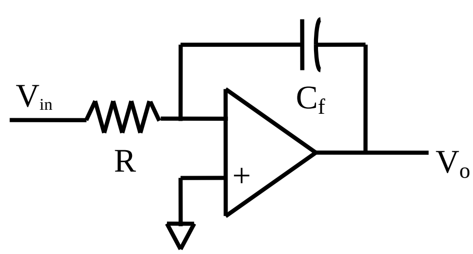
5-5 Inverting amplifier

Using the TL082, construct the inverting amplifier shown right with R_f = 100 kΩ. Measure V_{in} and V_{out} for five or more values ranging from -0.7 to +0.7 Volts. Compare the expected output to the measured. What error is observed? Repeat the above experiment with R_f = 10MΩ and R_{in} = 100 kΩ.



5-6 Integrator

Wire the circuit shown right. The capacitor is in the feedback of the op-amp. Select the resistor and capacitor such that the time constant is in the millisecond range. Using the function generator examine the output of the op-amp and compare it to the input if the input is a sine, triangle, or a square wave. For each wave qualitatively examine the frequency dependence of the circuit.



5-7 Differentiator

Switch the positions of the capacitor and resistor in the previous circuit. Again compare the output of the op-amp to the respective inputs. Also examine the frequency dependence of the output.

5-8 Logarithmic Amplifier

Replace the capacitor in the circuit above with a diode. Using the DC adjustable voltage source, measure the output voltage for several input voltages. Plot ln(V_{in}) versus V_{out} and determine the slope and intercept.