ELECTRONICS LAB #2

A – Testing the Regulated Power Supplies

Attach DC power supplies to the two jacks on the breadboard and plug them in. Use a multimeter to ensure that you have ~+5V at one power supply and -5V at the other.

## B – Wiring a Variable Voltage Source

For many applications (including the study of operational amplifiers), it is useful to have an adjustable voltage source. A potentiometer such as that shown in the picture below, often called a "pot," is a variable resistor that can be used for this purpose. Turning the screw on the end of the pot changes the resistance between the "wiper" and the end contacts.

Potentiometer
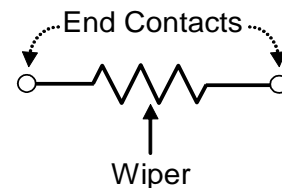
Typically, pots are used to generate a variable potential by connecting the end contacts to a voltage source and the wiper to a voltage output. In this configuration, the pot acts as a voltage divider, supplying an output voltage that depends on the position of the wiper. Calculate the expected range of voltages (V_{out}) for the following potentiometer arrangement which incorporates a 10 kΩ pot.
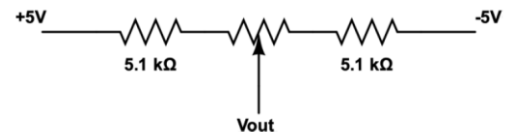
Now, wire this circuit near the top of the breadboard and measure the voltage range. ***Leave this circuit in place for later use.***
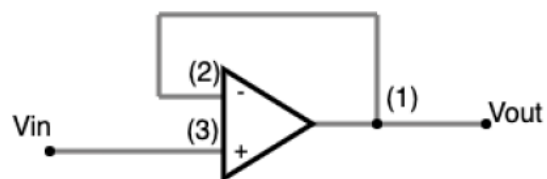
C – The Voltage Follower

The 082 op amp shown below will be used in the remainder of the experiment.

The pin diagram for this IC is on the last page of this lab. Locate and install the 082 across the center of the board as shown. Supply power to the IC by connecting +5 V to the V_{+PS} input of the op amp (pin 8) and -5 V to the V_{-PS} input. Wire the following circuit using your variable voltage source as V_{in} and have the instructor check your circuit.
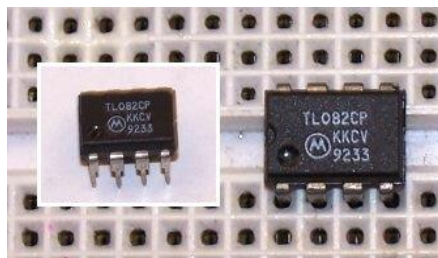
Op-Amp

Voltage Follower Circuit

Use the variable voltage source and the DMM to measure V_{out} and V_{in} for several settings of V_{in} in the -2V to +2V range. What is the gain of this circuit? Measure the difference in V_{in} and V_{out} directly. This small difference is caused by an "offset voltage" that appears as an error in voltage amplification applications. What is the practical value of the voltage follower?

D – The Voltage Comparator

Recall that the output voltage of an op amp is given by the equation below, where A is the open loop gain, which it typically large at low frequencies.

$$V_{out} = A(V_+ - V_-)$$

Thus, the polarity of the output voltage (sign) mimics the sign of the difference between two input voltages (V_- and V_+). That is, if V_+ is more positive than V_-, V_{out} should be positive and large (typically corresponding to the +power supply voltage). Conversely, if V_+ is less positive than V_-, V_{out} will have a large negative value. As a result, an op amp can be used as a *comparator* to ask the question "Is V_+ greater than V_-?", with the sign of V_{out} revealing the answer. In this portion of the experiment, we will build and use a comparator to compare an "unknown input voltage" and a reference input voltage.

Connect the variable voltage source to the inverting input of the op amp. This serves as an adjustable reference voltage (V_{ref}). Now construct a voltage divider using 10 kΩ and 39 kΩ resistors (connected in series between the +5 V supply and common) that will provide an approximately 1 V output relative to common. This ca. 1 V output serves as the "unknown voltage," V_{in}. Connect this voltage to the non-inverting input of the 082.

Observe the comparator output voltage. Adjust the variable voltage source – what occurs at the output? Record the positive and negative limits for V_{out}. Find the value of V_{ref} that just causes the comparator to change states. Compare this to V_{unk}.
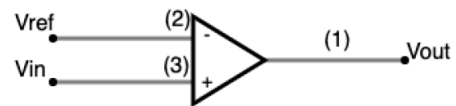

A simple circuit containing two light emitting diodes (LEDs) can be used to observe the polarity of the comparator output. An LED only freely passes current in one direction (when it is forward biased) and can therefore be used to indicate relative voltages at its inputs.

n LED   **LED Symbol**   **Forward-biased LED**
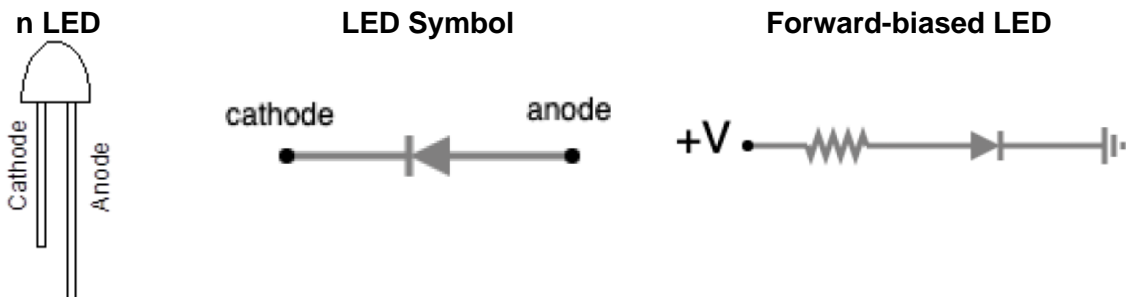
Wire the circuit to the right to the comparator output being careful to connect the LEDs in the correct direction.

With your LED circuit and the DMM connected to the comparator output, vary V_{ref} to verify the proper action of the indicator. Explain your observations.
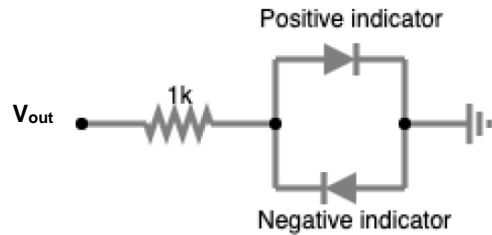
F – Current Follower (aka Current to Voltage Converter)

In this part of the experiment, you will construct a current follower whose output voltage is proportional to the input current. You will use this circuit to amplify a small current to produce a measurable voltage.

Wire the following circuit, with R1 = 10 MΩ, leaving the I_{in} unconnected at this point (however, the 10 MΩ feedback resistor should be connected). Measure V_{out} with no connection to I_{in} (not even a wire). While ideally the output potential should be zero in I_{in} is unconnected, you will probably observe a small potential. This input voltage offset is caused by the unbalanced components in the first differential amplifier of the op amp. More importantly, this offset can present real problems in some applications since any output errors it causes are equal to the input voltage offset multiplied by the gain. Fortunately, it is possible to minimize this offset by applying an opposite voltage at the non-inverting input. For this purpose, an adjustable +20mV source will be constructed by dividing the variable voltage source.
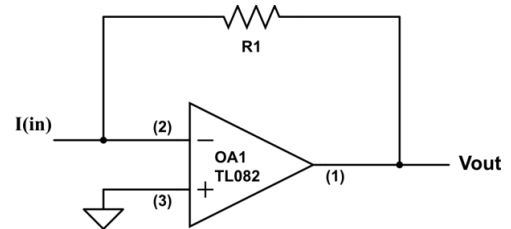
Remove the wire connecting the non-inverting input to circuit common. Wire the following circuit with R1 = 10 MΩ, R2 = 1 kΩ and R3 = 100 kΩ and verify that you have an adjustable ca. +20 mV source.
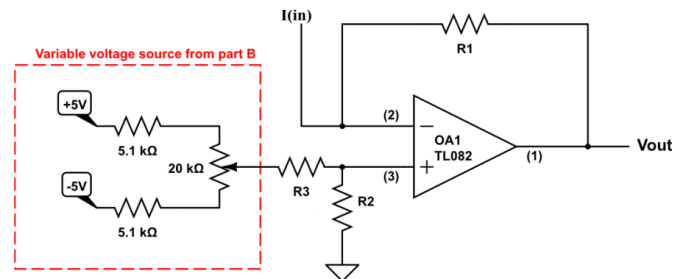
Now, connect the +20 mV source to the non-inverting input and adjust the variable voltage source until $V_{out}=0$. Leave this circuit connected and adjusted for zero offset.

You are now ready to supply and measure a current to the inverting input. For a current source, you will use a signal diode in the reversed bias position. Remember, while diodes are conductive when forward biased, they resist current when reverse biased. They do not, however, become perfect insulators, but instead allow a small current to "leak" through the diode junction. You will use your current follower circuit to determine this leakage current for your diode.

Connect a signal diode, such as those shown at the right (not an LED), between the +5 V supply and current input with the cathode (banded end) toward the +5 V supply. Measure V_{out} and calculate the diode current.
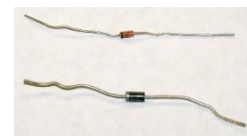
Congratulations, you have completed Electronics Lab #2!

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Pin Connections for the National Instruments
082 Dual Operational Amplifier DIP package
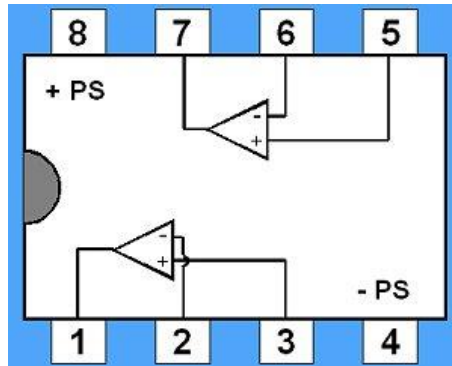
Pin	ID
1	Output, OpAmp #1
2	Inverting Input, OpAmp #1
3	Non-Inverting Input, OpAmp #1
4	Negative Power Supply Voltage
5	Non-Inverting Input, OpAmp #2
6	Inverting Input, OpAmp #2
7	Output, OpAmp #2
8	Positive Power Supply Voltage