Name _____

Lab Section _____

Sensor Interfacing and Instrumentation Amplifiers **Lab 2**

Introduction: In this lab you will design and build a circuit that will convert temperature into a variable DC voltage suitable for interfacing with an analog to digital converter. The circuit will be constructed using a thermistor an instrumentation amplifier as well as various resistors and capacitors.

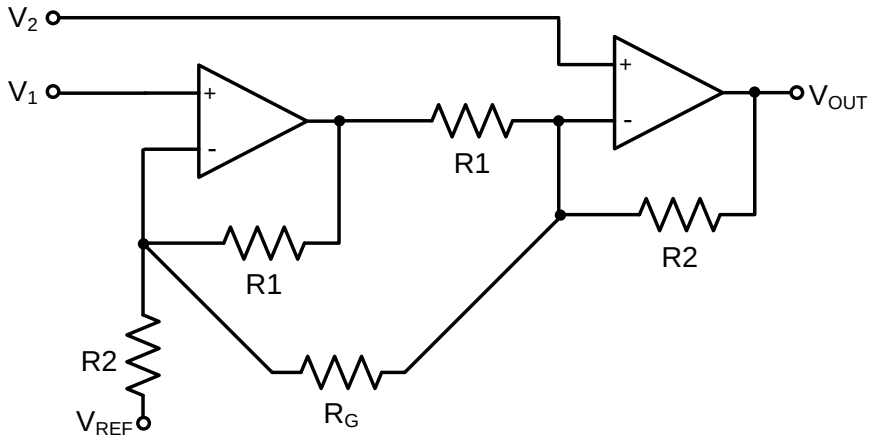
Lab Requirements:

1. Your circuit will operate off of a single ended 5V supply

2. Your circuit must provide a minimum of 3.8V of change (more is better) in output voltage when the thermistor's temperature varies from 80°F to 130°F.

Instrumentation Amplifiers

An instrumentation amplifier (IA) is an operational amplifier (op-amp) circuit topology that provides a differential input, high input impedance, low output impedance, high common-mode rejection ratio and utilizes a single gain setting resistor. An IA amplifier can be built from discrete op-amps or can be purchased as an IC component. For this lab you will be working with the INA122 instrumentation amplifier from Texas Instruments. The INA122 is a low power, rail-to-rail, two op-amp style instrumentation amplifier.



Setting the Gain:
The gain of this amplifier topology can be calculated with the following equation:

$$G = 1 + \frac{R2}{R1} + \frac{2R2}{R_G}$$

And the output voltage can be computed as follows:

$$V_{OUT} = (V_2 - V_1)\left[1 + \frac{R2}{R1} + \frac{2R2}{R_G}\right] + V_{REF}$$

Since the internal resistors in INA122 are 100k for R2 and 25k for R1 the gain will be set by:

$$G = 1 + \frac{100k}{25k} + \frac{2(100k)}{R_G}$$

Which simplifies to:

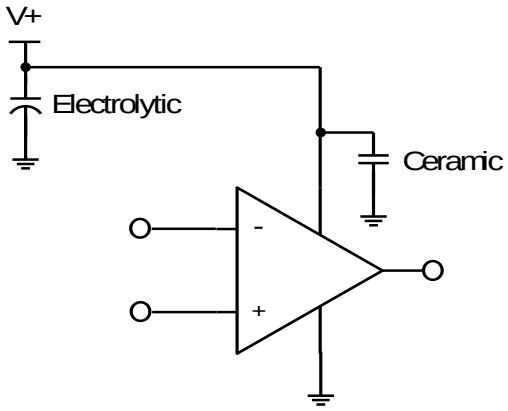
$$G = 5 + \frac{200k}{R_G}$$

And the output voltage as a function of the differential input will be:

$$V_{OUT} = (V_2 - V_1)\left[5 + \frac{200k}{R_G}\right] + V_{REF}$$

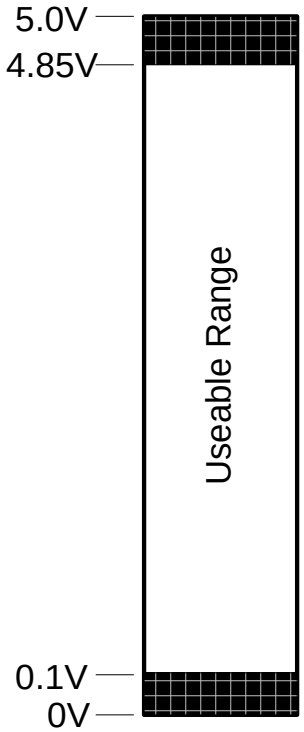
Reference Input:
A useful feature found is most instrumentation amplifiers is the V_{REF} voltage reference input. This input provides a means for offsetting the DC output of the amplifier by applying a stable low impedance DC reference to this pin. If utilized, the output of the amplifier will be DC level shifted by the voltage that is placed on the reference pin. If a DC offset is not required the "V_{REF}" pin will be connected to ground.

Bypass Capacitors:
It is important that you always remember to include power supply bypass capacitors on the supply rails. The bypass capacitors stiffen the voltage rails and provide a low impedance path to ground in order to shunt high frequency noise.



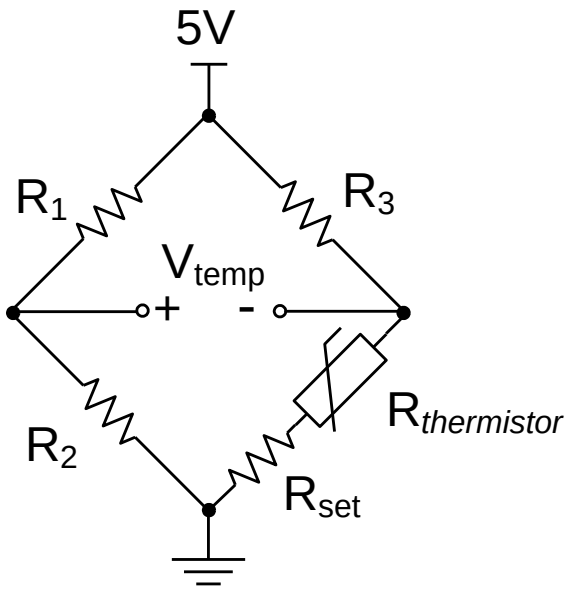
Typically, a single 0.1uf ceramic capacitor placed in close proximity to the Instrumentation Amplifier should be sufficient for this lab.

Output Swing:
The output of the INA122 can swing to within a minimum of 0.15V to the positive rail and within 0.10V of the negative rail. When using a single ended 5V supply, you should expect a maximum output of no more than 4.85V and a minimum output of 0.10V.

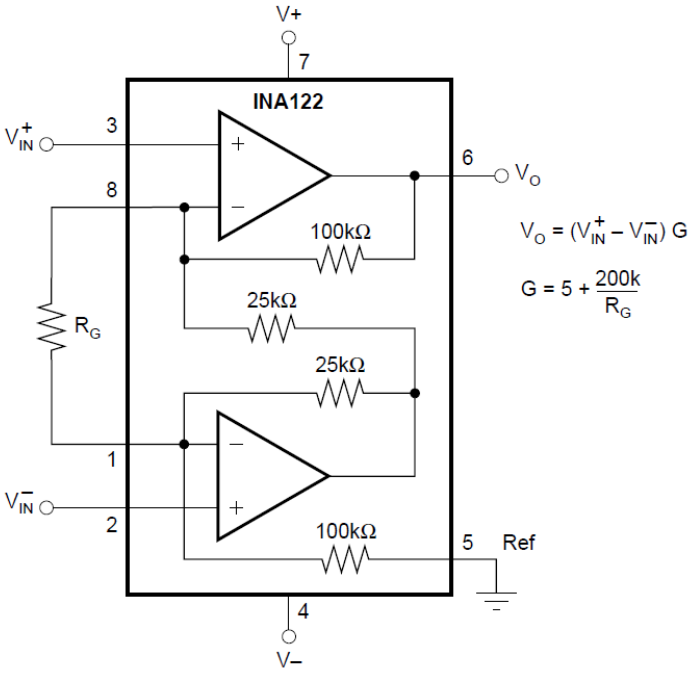


Wheatstone bridge:

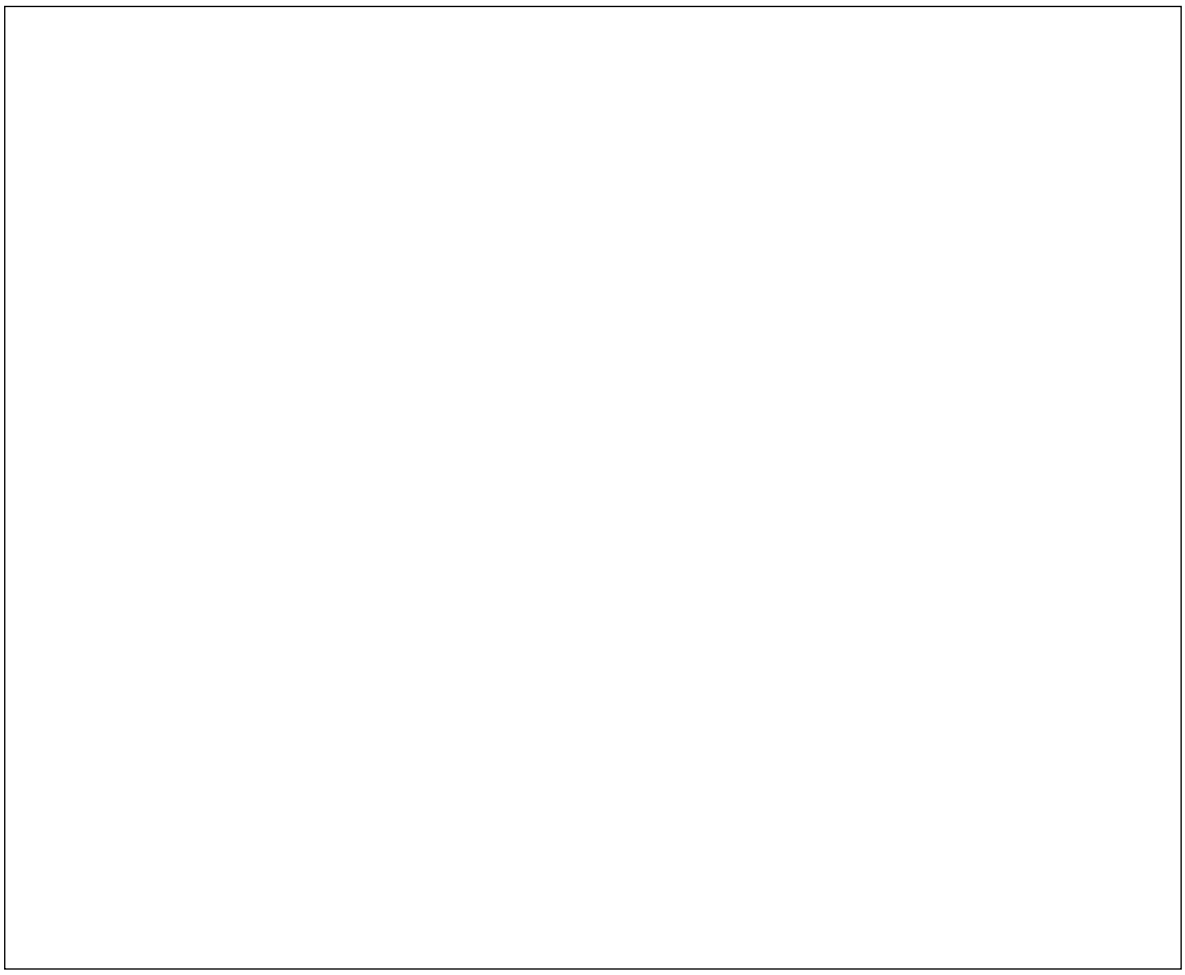
Often, Wheatstone bridge circuits will use a potentiometer placed in one of the legs in order to null the output of the bridge. For simplicity and cost savings you will use a single fixed value resistor R_{set} to perform this function. Choose a value for R_{set} that will result in a small positive voltage at the output of the bridge when the thermistor is heated to 80°F. Determine the bridge output over the 80°-130°F temperature range and select a value R_G. Many different combinations of R_G and R_{set} will work to meet the performance requirements. Alternatively, you may tune the bridge by adjusting the value of R_3 in which case you may choose to omit the R_{set} resistor.



INA122 Pinout:



Draw the schematic of your complete circuit in the box below (include component values and supply voltages):



What values did you select for the following resistors?

R_1 _____

R_2 _____

R_3 _____

R_{set} _____

R_G _____

What is the gain of your circuit?

_____ V/V

Thermistor Temperature vs. IA Output Voltage	
Temperature	Voltage
Room Temp. _____° F	_____V
80° F	_____V
85° F	_____V
90° F	_____V
95° F	_____V
100° F	_____V
105° F	_____V
110° F	_____V
115° F	_____V
120° F	_____V
125° F	_____V
130° F	_____V

Does your circuit provide 3.8V of output swing between 80°F and 130°F?

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