Name ___________________________________

Lab Day _____________Lab Time_____________

Sensor Interfacing and Operational Amplifiers — Lab 3

Introduction: In this lab you will design and build a circuit that will convert the temperature indicated by a thermistor's resistance into a voltage suitable for interfacing to an analog to digital converter "ADC". The circuit will be constructed using a thermistor, an operational amplifier, as well as several resistors and capacitors.

Lab Requirements:

1. Your circuit will operate off of a single ended 5V supply and must consume less than 1mA of current.

2. Your circuit should provide a minimum of 4V of change in output signal when the thermistor's temperature varies from 80°F to 150°F. The output signal must remain within the linear region of the op amp (0.100V to 4.900V) over the temperature range of interest.

Notes from Last Week: Copy the resistance and voltage values for 80F° and 150F° in the space below. Calculate the difference between the 80F° and 150F° results and write it into the $\Delta R_{Thermistor}$ and $\Delta V_{Thermistor}$ lines.

$R_{Thermistor}$ 80° F ________ $R_{Thermistor}$ 150° F ________ $\Delta R_{Thermistor}$ ________

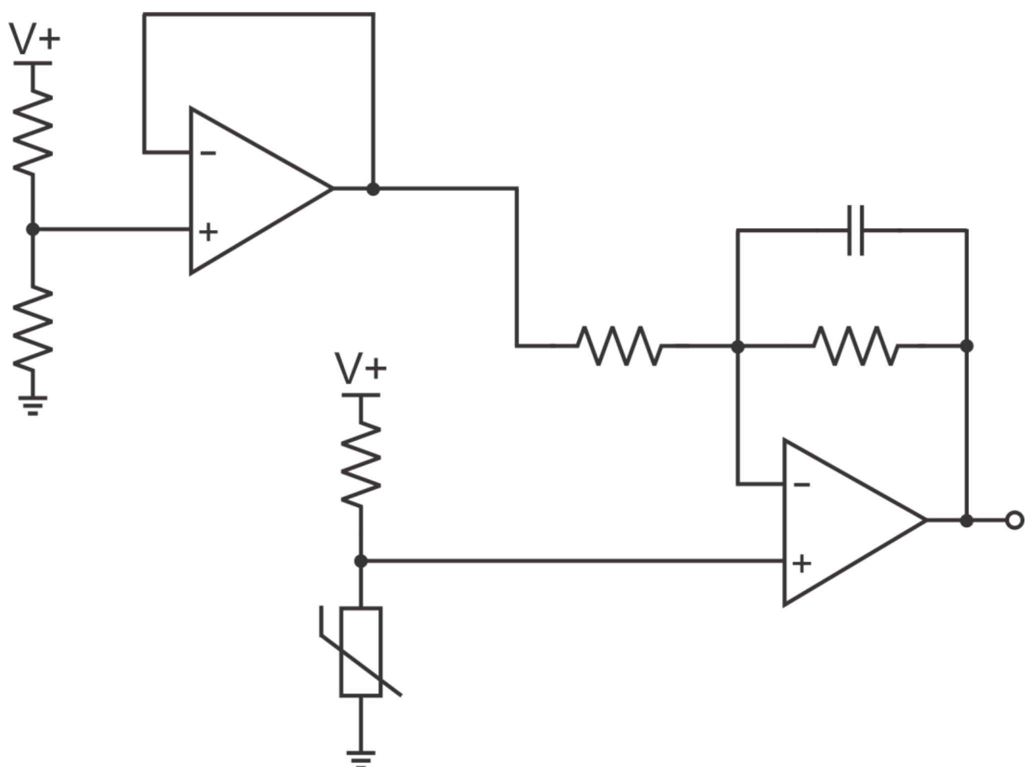
$V_{Thermistor}$ 80° F ________ $V_{Thermistor}$ 150° F ________ $\Delta V_{Thermistor}$ ________

Sensor Amplifier: The sensor amplifier will be capable of improving your sensor's signal in a number of ways. First, the sensor amplifier will be useful in increasing the size of the sensor signal to match the full scale range of the analog to digital converter "ADC" that we will use in a later lab. Second, the amplifier will provide a DC offset so the temperature range of interest falls within the available voltage rails. Third, the amplifier will transform the high impedance of the sensor into a low impedance signal capable of feeding the sample-and-hold circuit on the ADC. Finally, we can easily configure the amplifier as a low-pass filter to reject noise.

There are several different ways to design a sensor amplifier for a thermistor using operational amplifiers. Feel free to experiment with different circuit topologies and design concepts. In the end, all that matters is that you meet the performance specification stated above.

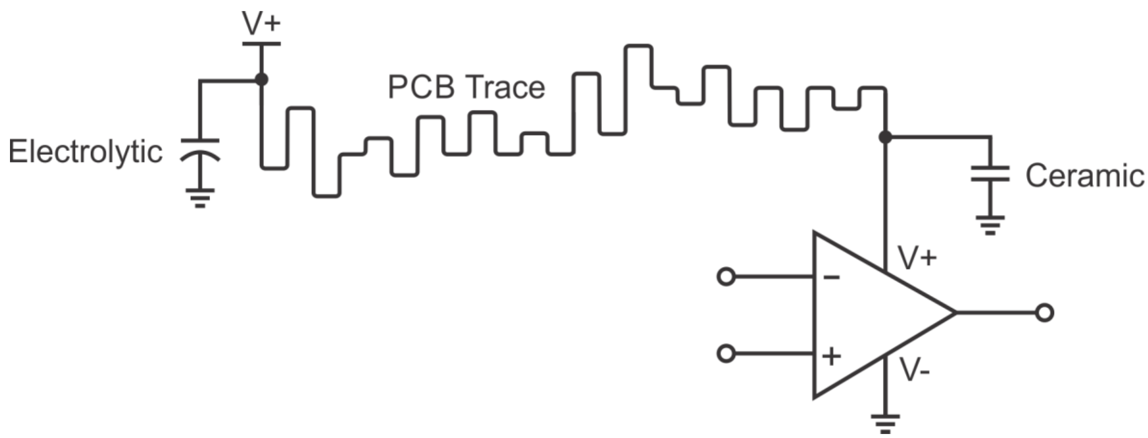
Getting Started: The first step in designing the sensor amplifier is to look at the span of the sensor's output over the temperature range of interest. The span of the sensor's signal will indicate the minimum gain needed in order to meet the design requirement of at least 4V of change at the amplifier output. For instance, if you have a $\Delta V_{Thermistor}$ of 1.6V then you will need a gain of 2.5V/V or more to meet the specification. The second parameter to look at is the DC offset. You will need to apply some DC correction to your circuit in order to fit the 4V span within the 5V power rails.

Circuit Topology: There are several different circuit topologies that could be used to create your thermistor amplifier. The stage that is directly connected to your sensor should have a high input impedance so the non-inverting configuration would be a good choice. The second op amp in the package could be used as a unity gain follower to buffer a voltage divider to make the necessary dc offset. Be mindful to select components that will not put you over the 1mA max current consumption specification. One fairly straightforward topology is shown below:

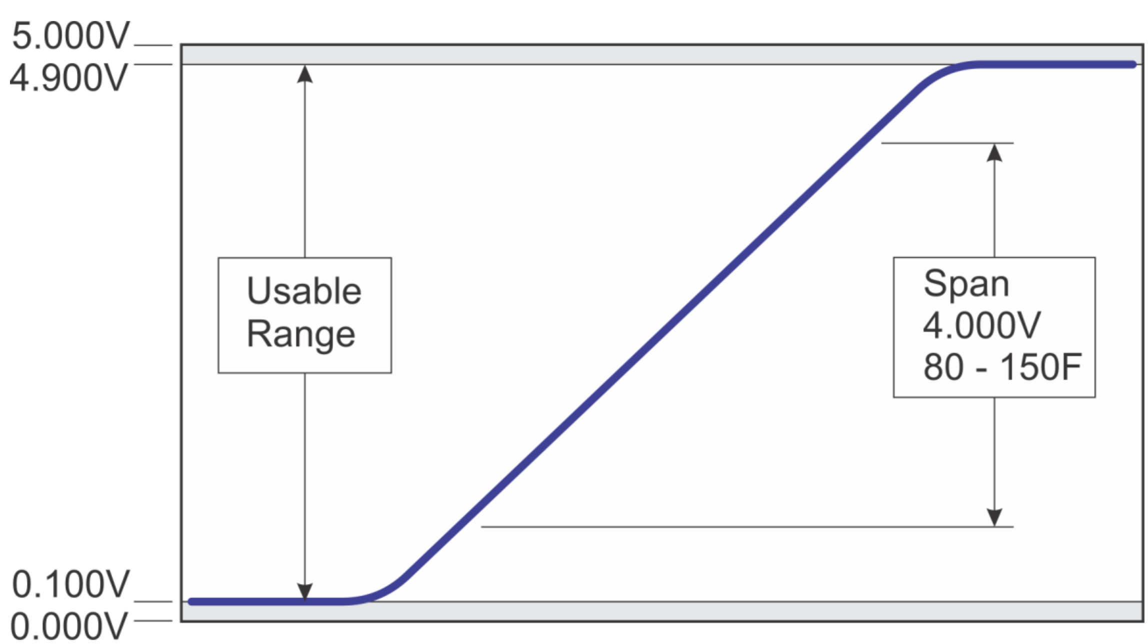


The capacitor in parallel with the feedback resistor will form a 1st order low pass filter. This is not needed for the lab but is often used to reduce out of band noise and for stability.

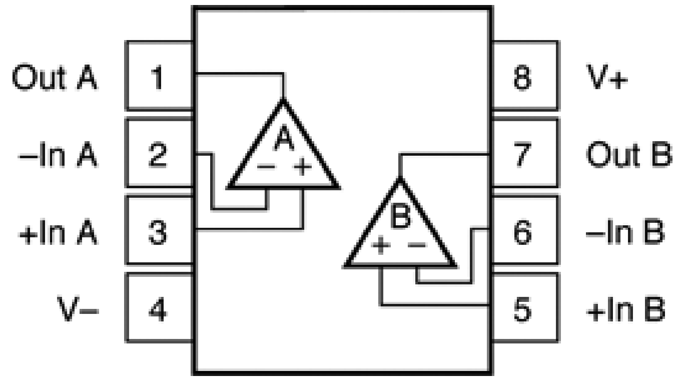
Bypass Capacitors: It is important that you remember to include power supply bypass capacitors on the supply rails. The bypass capacitors stiffen the voltage rails and provide a low impedance path to ground in order to shunt high frequency noise. A single 0.1uf ceramic capacitor placed in close proximity to the Op Amp should be sufficient.



Output Swing: The output of the MCP602 can swing to within 100mV of the positive and negative supply rails. Once you encroach within 100mV of the rail the output of the amplifier will no longer be linear so the output will no longer correlate to temperature. It is critical that you design your circuit to operate within the linear range.



Dual Op Amp Pinout: The MCP602 uses the standard dual op amp pinout as shown below.



Neatly draw the schematic of your complete circuit in the box below. Be sure to include component values, pin numbers and supply voltages.

Thermistor Temperature vs. Amplifier Output Voltage	
Temperature	Voltage
Start 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
135° F	________V
140° F	________V
145° F	________V
150° F	________V

What is the gain of your circuit? ___________ V/V

What is the current consumption of your entire circuit? ____________ uA