Thermocouple home experiment

This home experiment is designed to teach you about amplifying signals, introduce you to generating data files for later use. This project and report may be done in teams of two. The report is to be in the standard memo format.

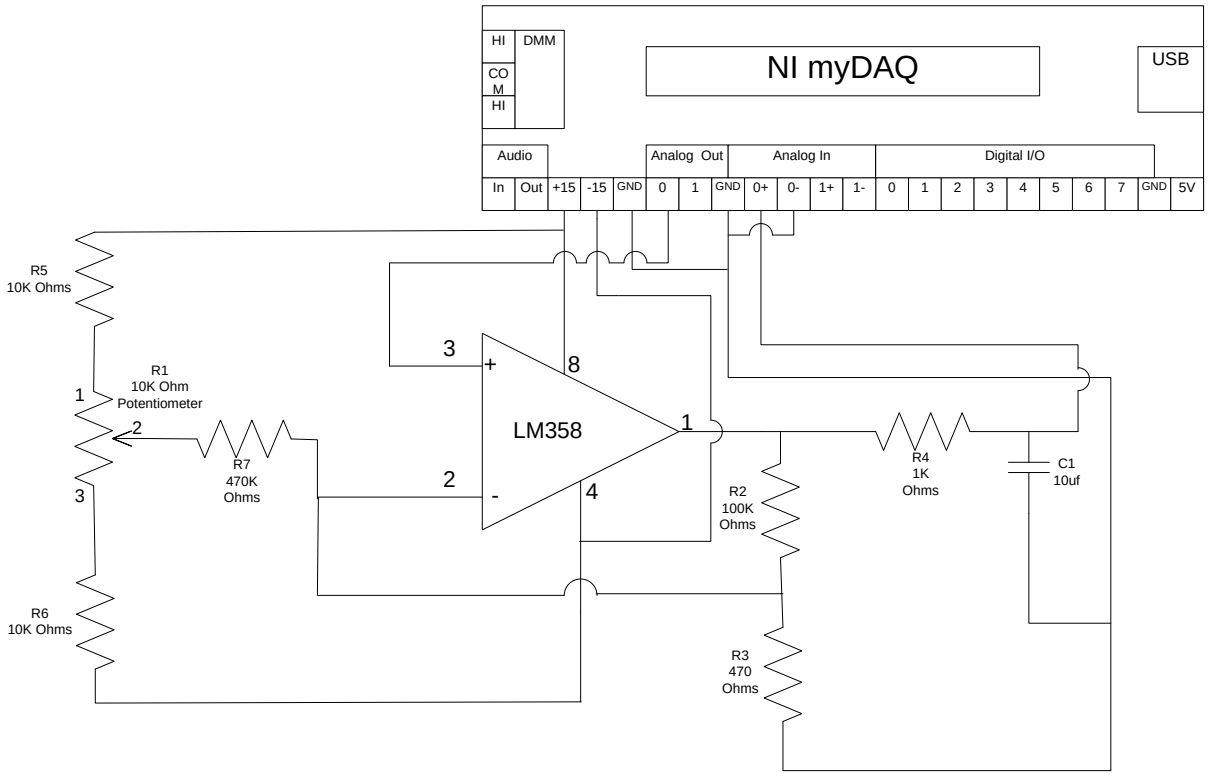
Part 1: Amplifier construction and setup

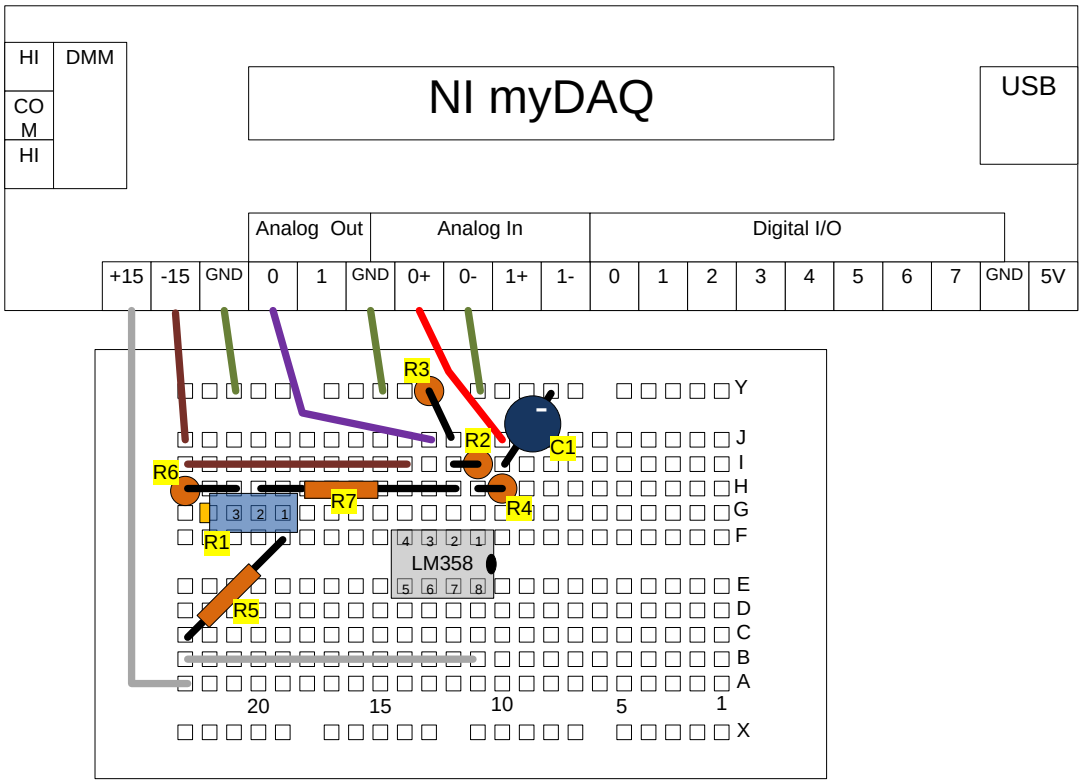
Since the 16 board is not really precise enough to do a good job measuring temperatures directly from a thermocouple you will be constructing an amplifier to increase the incoming signal level to more useable levels.

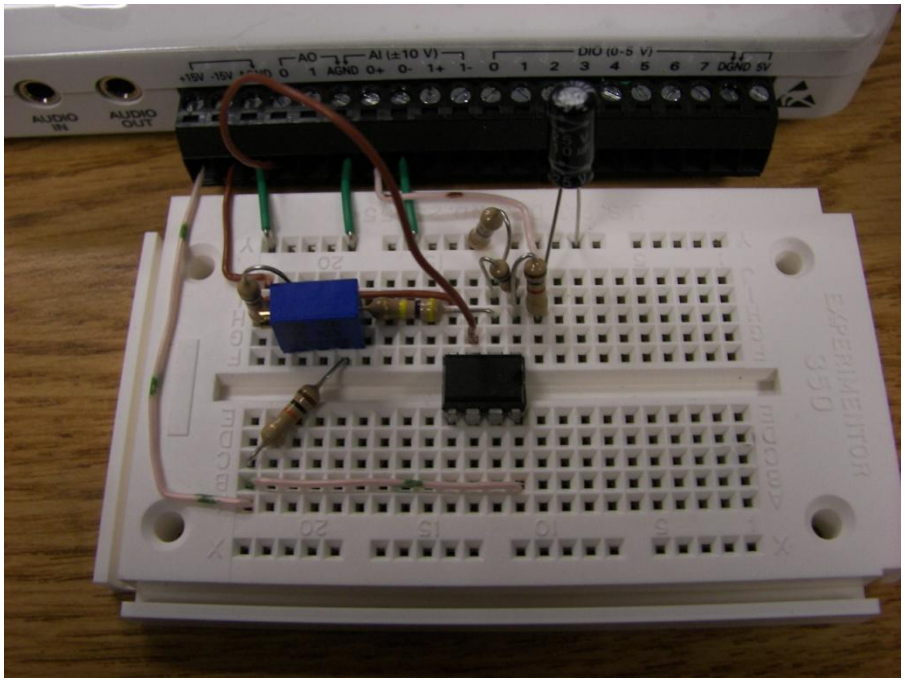
Using the components in your kit, construct the following circuit on your solderless breadboard. The following images show one way to construct the circuit however feel free to make your own layout that follows the schematic.

Construction Notes:

1. All the ground symbols connect to one rail of your solderless board, such as the "Y" terminal row. This is important.
2. Be extremely careful to use the correct resistors or you will be unable to get the circuit to calibrate.
3. Keep all wires as short as possible to reduce the noise in your circuit.
4. Do not stick wires more than 1/4" into the board. Long leads will wind around inside and cause short circuits.







Once the circuit has been constructed, attach your myDAQ to the computer and download and run the "circuit cal.vi" program. This will automatically detect your myDAQ and set the appropriate channels to use.

Using the input selection control on the front panel, select “Zero Volts”. This will set the analog output to 0 volts. Adjust R1 to get the mean voltage as close to 0 as you can.

Select “20 mVolts” on the front panel control. Allow two or three seconds for the system to stabilize, and record the new mean voltage, (somewhere around 4.5 volts) and the approximate p-p voltage value of the noise in your circuit.

Divide the recorded mean voltage value by .02 to determine the gain of your circuit. This value should be somewhere around 200.

Part 2: **Conversion to temperature**.

Now that you have an amplifier and know the gain, you can modify the program to convert the incoming voltage values to temperature. You will be using a type T thermocouple, so you will need to use coefficients for that type thermocouple in a formula node. Since you are new to formula nodes, and C program syntax, the code required in the formula node is provided below.

```
//define coefficients and variables //;

float D1=2.5928000000E+01;
float64 D2=-7.6029610000E-01;
float64 D3=4.6377910000E-02;
float64 D4=-2.1653940000E-03;
float64 D5=6.0481440000E-05;
float64 D6=-7.2934220000E-07;
float V;

float gain=200;   //amplifier gain//

V=Ein/gain;  //adjust input voltage for gain//
V=V*1000;   //convert to millivolts from volts//

//calculate output in degrees C//
DC= (V*D1)+(D2*V**2)+(D3*V**3)+(D4*V**4)+(D5*V**5)+(D6*V**6);
```

The gain value (200 here) will need to be replaced with the exact gain you calculated earlier, and the formula node input and output points are “Ein” and “DC” respectively.

Using the above code, insert a formula node to convert the data from the analog read to temperature. Since this particular code only calculates a single point, and the data is coming in as an array, you will need to embed it into an auto-indexed FOR loop.

Once you have the program modified, you should get an output of around 385 deg C with the 20mVolt selection and 0 degrees at 0 mVolts.

In your report, discuss how the program converts the array into temperatures and displays it.

Part 3: saving the data.

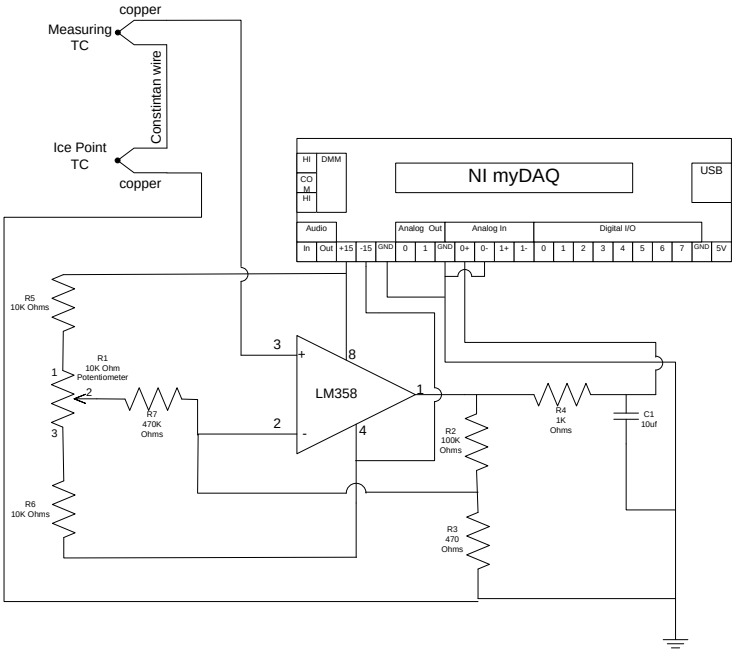
Modify the code to build a 2D array of data that contains time since the start of the program (in seconds) in one column and the mean value of the temperature in the second column. The program should initialize the array to an empty array so you only get the data from this run, and should add one sample to each column with each iteration of the loop. DO NOT store the entire sample stream of 5000 points each loop! The loop executes at 100ms / iteration.

Have the program write the data to a spreadsheet file when the stop button is pressed.

Test your program by setting the input selection control to "setpoint" and entering voltage values corresponding to a 0, 100, 200, 300 and 400 deg C. Stop the program so it logs the data to a file and plot this file in excel for inclusion in your report.

Part 4: connecting the TC

Now that the circuit has been set up and verified, its time to connect the real TC's to the system. Remove the wire from analog out 0 of the myDAQ to pin 3 of the amplifier and insert the two thermocouples provided in your kit as shown in the following diagram.



Use the short thermocouple for the ice point and the long one for the measurement TC.

Create an Ice bath and insert both TC's into the bath. Adjust R1 for 0 volts (0 Deg).

Your circuit is now ready to measure temperature!

Part 5: Measure the temperature:

Place a pan of ice and water mixture on a stove or hotplate. Using the program developed above, record the temperature of the water as it heats to boiling, recording the values in your file. Do not forget to keep the reference TC in a good pan of ice water, or your results will be skewed.

Graph this file in excel to include in your report. Also include one page of your data file with your graph.

For your final version of the program:

Include the VI ***documentation Front Panel, Block diagram*** with ***hidden frames, list of subvi's and express vi's***

In your report discuss the results as well as any limitations you noted for this method of amplification.

Consider the following in your report:

- Show the calculation of the gain of your circuit. Explain how you can use the standard TC calibration curves with the amplified circuit.
- Using the p-p noise value you recorded earlier in the experiment, determine either from lookup tables or calculation what the approximate amount of noise is in degrees C.
- If the program were to crash in the middle of your experiment, what would happen to the data you collected to this point and why?

Attach the grade sheet as the **last page** in your report.

Extra Credit:

Modify the program and hardware to utilize the AD592 for cold junction compensation instead of using the ice bath for the TC. Do this in ADDITION to the above work for extra credit. Include enough data and description in your report to show that your technique works.

Thermocouple home experiment Grade Sheet

Part 1:	Basic circuit created as defined and returned proper results.	____ /10 pts
Part 2:	Formula Node added and functions	____ /5 pts
Part 3:	Data storage functioned properly	____ /5 pts
Part 4:	Data from heating experiment Data acquired properly and looks good. Graph is complete and follows proper formats	____ /10 pts
Discussion of assignment and data		____ /20 pts
Total		____ / 50 pts