System Level Laboratory

Thermocouple based Temperature Measurement System

Objective

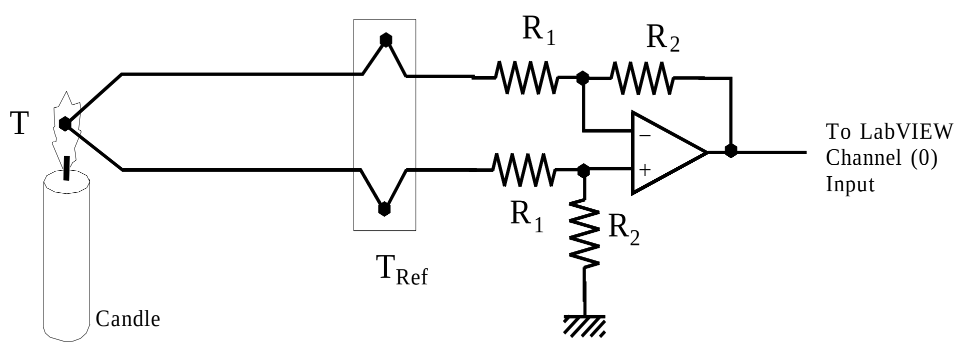
The objective of this experiment is to study the characteristics of thermocouple (TC) for temperature measurement. VI will be built in LabVIEW to collect data and display the time response of the thermocouple when the temperature changes suddenly. You will analyze the data to determine the sensor time constant.

You will use a Type J thermocouple to measure the temperature characteristics of a candle flame and determine the time constant of the TC. The reference junction will be formed where the TC wires are inserted into the breadboard sockets at room temperature.

Exercise 1. Thermocouple and the signal conditioning circuit

(1) Connect the TC to a DMM and note how the voltage increases when the measurement junction is heated by gently placing it between your fingers. Note and mark which lead is more positive in voltage.

(2) Construct a differential amplifier with a gain of *approximately* 200. Find resistors that will provide a gain near 200, say 200 ±10%



NOTES: (1) match the resistor pairs as close as possible
(2) keep leads short to minimize noise
(3) plug the TC directly into the breadboard, this becomes the reference temperature point

What exact values did you use for the resistors (use variables to match them)?

R_1: ___________________________________ R_2: _____________________________________

What is the exact gain of your amplifier: ____

What amplifier output voltage do you expect for 750^{o}C if the reference temperature were 0^{o}C?

(3) Connect your TC to the constructed differential amplifier and gently heat the junction between your fingers. Verify that the amplifier output voltage increases as the junction is heated. Now you know that TC and its signal conditioning differential amplifier are working.

(4) Use a thermometer to measure the temperature near your reference junctions, i.e., where they plug into the circuit breadboard. Ask TA for room temperature:

Record the temperature T1: ____

Determine the voltage for this temperature from the tables and using interpolation. Record the value of the voltage: ________________

This is the correction voltage which will be subtracted from TC voltage.

What amplifier output voltage do you expect for a temperature of 700^{o}C with your reference junction temperature? ____________

Exercise 2: Construction of a VI to measure and display the temperature

(1) Build a VI in LabVIEW to perform following functions:

A. Take a reading of amplified output voltage
B. Use interpolation to determine the temperature in ^{o}C and display this on a meter.
C. Use the conversion equation to calculate the temperature in ^{o}F and display on a meter.
   ºF = ºC * (9/5) + 32

(2) Set the sampling rate as 500 Hz and measure the increased temperature by gently placing the thermocouple between your fingers. This will verify your VI works.

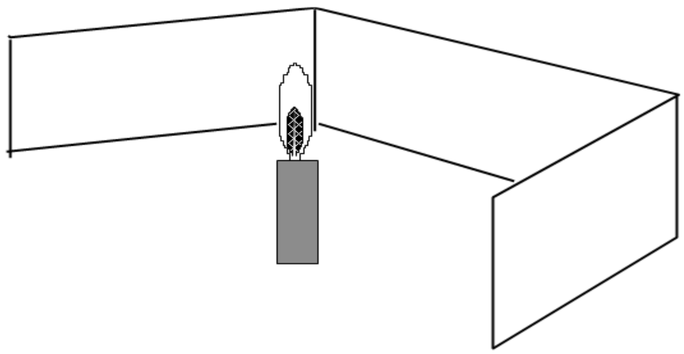
Record the output voltage from your VI and the amplifier, corrected TC output voltage, and temperature in ^{o}C and ^{o}F.

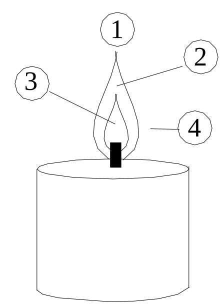
Post Lab Questions

1) Illustrate by a manual calculation how the VI determines the temperature from the input voltage.
2) Suppose the TC output voltage 22.79 mV, what is the corresponding temperature? Assume the reference is 0^{o}C. What is the percentage difference between the corrected temperature and un-corrected temperature?

Exercise 3: Candle Flame Temperature Characteristic

The candle flame is small and flickers with draft so you may have to take several readings in each location. You can also use books to construct a partial shield around the candle so that it will not "flicker".





(1) Get a candle and set it up so the flame will engulf the junction of the TC
(2) With the LabVIEW VI running you will see the analog and digital readout of temperature.
(3) Record the temperature in several parts of the flame for 3 times:

	ºC	ºF	ºC	ºF	ºC	ºF
1						
2						
3						
4						

Post Lab Questions

1) What amplifier output would you actually get for a temperature of 745^{o}C?

2) For each of the four candle flame positions determine the average flame temperature and their standard deviations.

3) Derive the relationship between the computer data (i.e., ADC output) and flame temperature. From this relationship determine what temperature 13FH represents and what computer data would result from a flame temperature of 367 ^{o}C.

4) How much temperature measurement error does the noise contribute?

Exercise 4: Thermocouple GTC and PTC Time Constant Determination

In this experiment, the same setup and VI will be used to study the dynamic behavior of thermocouple – its first order time response. We will determine the time constant of the thermocouple in both the good thermal contact (GTC) (in fire in this case) and poor thermal contact (PTC) (in air for example).

(1) Good Thermal Contact (GTC) Time Response

Continue using the VI you build in step 2, replace **Thermometers** with **Waveform Chart**. Let the thermocouple in the air for 20 seconds, start VI for 3 seconds, then put the thermocouple into the flame for 15 second. Take the screenshot of the time response curve for the amplified TC output voltage in Waveform Chart.

(2) Poor Thermal Contact (GTC) Time Response

Continue using the VI. Let the thermocouple in the flame for 20 seconds, start your VI, after 3 seconds take the thermocouple out of the flame for 20 seconds. Take the screenshot of the time response curve for the amplified TC output voltage in Waveform Chart.

Answer all the questions as a GROUP in your report!