EAS 199B: Homework 5   Due 11,12 March 2013

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Group Assignment

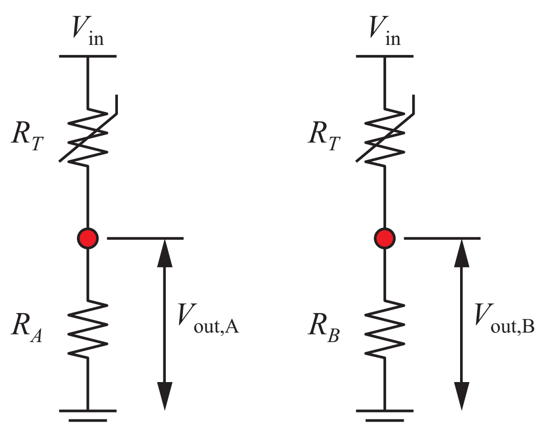
1. Write an Arduino program to control the temperature of the fish tank. Print the code in mono-spaced font on a document with a title page or cover sheet with group members, date, and course title
2. Prepare for validation of simultaneous temperature and salinity control. The checklist will be posted on the homework web page.

Individual Assignment

3. What happens when you replace the resistor in the thermistor voltage divider after you have completed the calibration?

   If we focus on the accuracy of the temperature measurement, we can convert that broadly stated question into a straightforward computation. Let’s rephrase the question as, “How much does the *indicated* temperature change when the thermistor is held at a constant temperature and the fixed resistor in the voltage divider is replaced by another fixed resistor of a slightly different resistance?”

   We can devise a method to answer the more specific question by considering a thought experiment represented by the two circuits sketched below.



The “Before” state shows the thermistor circuit as the thermistor was calibrated. The “After” state shows the circuit after the fixed resistor RA was replaced by another fixed resistor RB. The values of RB and RA differ by an amount allowed by the precision specification on the resistors.

Applying the voltage divider rule to the two circuits gives

$$V_{\text{out},A} = V_{\text{in}} \frac{R_A}{R_A + R_T}$$

$$V_{\text{out},B} = V_{\text{in}} \frac{R_B}{R_B + R_T}$$

Notice that RT is the same in both formulas because in the thought experiment, the temperature of the thermistor is held constant. If we convert these two voltages to temperature, we will find out how much the temperature *appears* to change due to a changed in the fixed alone.

Answer the original question with the following steps

a. Compute $V_{\text{out},A}$ and $V_{\text{out,B}}$ for $V_{\text{in}} = 5$ V, $R_T = 10$ kΩ, $R_A = 10$ kΩ and $R_B = 10.5$ kΩ. How much does V_{out} change? How does the percent change in V_{out} compare to the percent change in the fixed resistance from R_A to R_B?

b. Convert $V_{\text{out},A}$ and $V_{\text{out,B}}$ to temperatures using the calibration equation

$$T = a_1 V^3 + a_2 V^2 + a_3 V + a_4$$

where $a_1 = 1.1877056$, $a_2 = -7.5201946$, $a_3 = 36.113083$, $a_4 = -36.416107$. How large is the apparent temperature change, i.e. what is the value of $T(V_{\text{out},B}) - T(V_{\text{out},A})$? How does the apparent percent change in T compare to the percent change in the fixed resistance from R_A to R_B?

c. Based on the answers to part (a) and part (b), complete the following sentence, "A five percent change in the fixed resistor results in an absolute change of ________ °C."

4. Evaluate the following statements in MATLAB

```
>> x = [1, 2, 3, 4];
>> y = [2.7, 8.2, 6.4, 1.3];
>> c = polyfit(x,y,2)
>> z = polyval(c,3)
```

Plot y versus x and add a '*" at the location of point z to the plot.

Describe in words the meaning of z.

5. Modify the `fit_thermistor_calibration` function so that it computes and prints the R^2 statistic for the fit

$$R^2 = \frac{\sum_{i=1}^{n}(\hat{y}_i - \bar{y})^2}{\sum_{i=1}^{n}(y_i - \bar{y})^2}$$

where $\hat{y}_i$ is the value of the fit function evaluated at x_i and $\bar{y}$ is he average of the y_i. Include a copy of your modified code in your solution. Use your modified code to evaluate R^2 for the sample data in `thermistor_calibration.txt`. The `fit_thermistor_calibration.m` and `thermistor_calibration.txt`. files are can be downloaded from the web page for homework assignments.