MAE 3340 *INSTRUMENTATION SYSTEMS*

Laboratory Exercise 5, Spring 2015

Wheatstone Bridges/Statistics/Error Analysis

Hand in This Completed Document as the Laboratory Report

NAME: ______________________________________

SECTION/Team Name ______________________________________

(Complete) Executive Summary:

Once you have completed the Lab..... Explain the objectives of this exercise and comment on the manufacturer's claim as to the accuracy of these resistors.

Introduction: We showed in class that a Wheatstone bridge may be used to make accurate resistance measurements. Read through the section on Wheatstone bridges in your book. This week, you will build a bridge and use it to measure the resistance of a randomly selected group of resistors that have a nominal resistance and a standard deviation of 5% of the nominal value (according to the manufacturer). You will use your results to investigate this claim.

Equipment:

MyDAQ and Attached Breadboard
Variable Decade Resistor and/or Elenco Resistor Replacement Box
Red and Black Test Cables
Breadboard Jumper Wires
100 Ohm Precision Resistors
Assorted Test Resistors
Provided Labview VI's and Spreadsheet Template

Lab Procedure

a) Power Dissipation

The resisters you will be using are operable at up to 1/4 watts. However, you do not want them to get warm, so we will want to keep the power closer to 1/16 watt -- a safety factor of 4. **Verify that the +5 VDC output from the MyDAQ breadboard will dissipate 1/16th watt in R_1, R_2.** One leg of the bridge will be made of two precision *100 Ohm resisters*, and this leg will have the lowest resistance in the circuit. Do the analysis before lab, and show it to the lab instructor before lab, staple it to this report. The information you need listed in the Lab 5 Summary Notes. The resistance of the Meter we are using is *10 MΩ. **(Hint: don't make this calculation harder than it needs to be!) (See Lab 5 Lecture Notes)***

Current and Power Dissipated through each 100 Ohm resistor (R_1, R_2) = _______________

b) Build Wheatstone Bridge

To build your bridge, use the breadboard provided. Two legs of the bridge (R_1 and R_2) will be formed with fixed "known" precision resistors, and they will both carry a value of 100 Ohms. For the 4th leg (R_4), you will test 20 randomly selected resistors -- half from a low resistance pool, and half from a high resistance pool. The third leg of the bridge (R_3) will be formed with one of the decade resistance boxes provided. The decade resistor boxes are marked *"High Resistance"* or *"Low Resistance."* The *"Low Resistance"* boxes can create a resistance anywhere between 0.01 and 900 ohms in 0.01-ohm increments. The "High Resistance" Boxes allow a range from 1 to 99,000 Ohms in 1-Ohm increments. **Use the *"High Resistance"* boxes for 1/2 of the resistors you test in this lab.**

You will also be using Elenco Resistor Replacement Boxes for the other half of your resistors. See Lab 5 Notes for details on operation. As you learned in the lecture for this lab, the value of a resistor is indicated by a series of painted stripes. Before testing you will read the resistance code and tolerance and record the nominal value and tolerance on Table 2. Even though there is a nominal resistance value, because of tolerance uncertainty … these units will actually have unknown resistances.

c) Resistance Measurements

Add power to your system using the MyDAQ +5 V DC output from the interconnected Breadboard. Monitor the bridge balance by connecting to the MyDAQ Voltmeter using the NI_Elvis Voltmeter VI (from lab 3) in voltage measuring mode. Your circuit should look like the Figure on Slide 9 in the Lab 5 lecture notes. Draw your circuit on another piece of paper and label each component. Include this figure with your lab write up.

Write down a relation for the unknown resistance as a function of the three known resistances for a balanced condition. Put one of the unknown resistors in the bridge and balance the bridge by adjusting the decade resistor until the voltage goes (close to) zero. This gives you a measurement for that resistor. Put in on the table on the following page. Repeat with 19 more resistors. *Also Populate the **.xlsx** spreadsheet that you can download from the MAE 3340 webpage.* Save the results as *text.csv format* so that these files can be read by the *Histogram VI.*

Table I: Resistance Values

Resistor Number	Nominal Resistance (Ohms) (color code)	Measured resistance (Ohms)	Spec Accuracy (%) (color code)	R_i/R_{nom}

When you are finished, get together with the other 4 groups in your section and make a spreadsheet file containing all 80 samples. …. save this file as a CSV (*comma separated values*) text file. As described in the lab 5 lecture notes, you will read this CSV-delimited file into your histogram VI.

d) Precision Uncertainty Confidence Interval

Using only your group's 20 resistors, estimate the normalized sample mean ($\bar{x}$), sample standard deviation (S_x), and the confidence interval of the precision uncertainty of the mean to 95% confidence. *Assume a student-t distribution with the appropriate degrees of freedom in calculating the confidence intervals.*

Perform the same calculations, but now using all 80 resistors. *Assume a Gaussian distribution in calculating your results.* Compare the results.

Show and Explain your calculations ....

e) Data Histogram

Make a histogram of the data based on all 80 resistors and attach it to this lab (Labview makes this easy, see Lab 5 lecture notes). You can read your CSV-delimited spreadsheet file directly into this VI. Attach a screen shot of the histogram to your report.

f) Error Analysis

Given the relationship between the known resistors and the unknown resistors, find the uncertainty in your measurement that is due to the uncertainty in the values of R_1 and R_2 (1%). Assume that the decade resistor (or Elenco resistor substitution box) is exact.

• Complete the end to end error analysis (See Lab 4 lecture notes) ..... Be sure to account for the resolution of the MyDAQ voltmeter vi.

Compare this calculated uncertainty value to the standard deviation and precision uncertainty you computed

--- based on your 20 resistors *(student-t)*
--- based on all 80 resistors for the class section *(Gauss)*

Show and Explain your calculations ....