IC231 Spring 2022 – Lab 5 – The Wheatstone Bridge

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In this lab you will obtain the response curve of a Wheatstone Bridge, and use it to measure unknown resistance values.

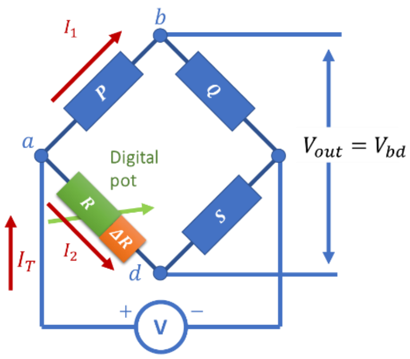
Learning outcomes

In this lab, you will learn

- How to measure resistances using a Wheatstone Bridge configuration.
- How to adjust the sensitivity of the Wheatstone Bridge.

Instructions

The Wheatstone Bridge is a well-known bridge configuration that is commonly used for measuring resistances. These resistances can take the form of strain gauges, thermistors or other forms of resistive transducers. From an academic standpoint, the unknown resistance in one of the arms of a Wheatstone Bridge is ascertained by obtaining a balance condition of a galvanometer connected between the junctions i and *d*. However, when used in sensing applications, the unknown resistance can change continuously, and as such the magnitude of the voltage V_{bd} is calibrated against the value of the unknown resistance.



In this lab activity, you will build a Wheatstone bridge where the digital potentiometer takes the place of the unknown resistance. Known values of resistances are used in the other arms. The digital potentiometer is then swept across its whole range, while the voltage V_{bd} is measured using an oscilloscope. You will do this for at least four different sensitivities of the Wheatstone bridge (see Lecture 3.x for more details).

But first you will simulate the output of the Wheatstone bridge using Python/MATLAB/Excel or any other software of your choice. to get an estimate of the output voltage ranges, and the current draw from the Raspberry Pi. You will use the results of these simulations to compare it with your experimental results.

Tasks

- **Task 1** – Write a routine to simulate the value of V_{bd} for different values of the unknown resistance, with the ratio and standard arm resistances taken as parameters. You will use the graphs generated in this step to compare it with the experimental results. You will also ascertain the total amount of current draw using this simulation. Remember that your current draw should not exceed the limits of the Raspberry Pi.

- **Task 2** – You will decide on four sets of values of the resistances P, Q and S and get it okayed by the TA and instructor.

- **Task 3** – You will build the Wheatstone bridge circuit and measure its transfer/response curves for the different values of P, Q and S. To measure the transfer curve, you will need to sweep the digital potentiometer over its full range of values. You will then plot the four curves you obtain on the same plot, where on the x-axis you will have the value of either the resistance R, or the fractional change in resistance $\Delta R/R$ (see Lecture 3.x), and on the y-axis you will have the voltage V_{bd}. In another plot (or set of plots), you will show the extent of agreement of your experimental results with the numerical simulations from Task 1.

  IMPORTANT – to know how to use the digital potentiometer as a variable resistance, you will have to refer to the datasheet of the potentiometer.

- **Task 4** – You will be given three unknown resistances by your Instructor/TA. You will use your calibrated Wheatstone Bridge to find the value of these unknown resistances.

General Instructions

1. After connecting the potentiometer to the RPi, call your TA to verify the signal connection.
2. Use the 3.3 V pins for both powering the potentiometer, and for the voltage source for the Wheatstone Bridge (VH).
3. If you run into any issues, ask your TA/Instructor.

Task completion criteria

1. You simulate the transfer curves for the Wheatstone bridge with the ratio and standard arm resistances as parameters.
2. You measure the transfer curves for the Wheatstone Bridge.
3. You demonstrate control of the sensitivity of the Wheatstone Bridge.
4. You are able to measure unknown resistance values using your calibrated Wheatstone Bridge within limits of acceptable error.
5. Answering the MCQs.