Lab 4 – The Wheatstone Bridge

In this lab you will learn how to use the Wheatstone Bridge circuit for sensor interrogation.

Learning outcomes

In this lab, you will learn

- The relation between output voltage V_{BD} of an unbalanced Wheatstone Bridge circuit and a variable resistor R.
- How the unbalanced configuration of Wheatstone Bridge can be used to measure various sensor signals involving variable resistance indirectly.

Instructions

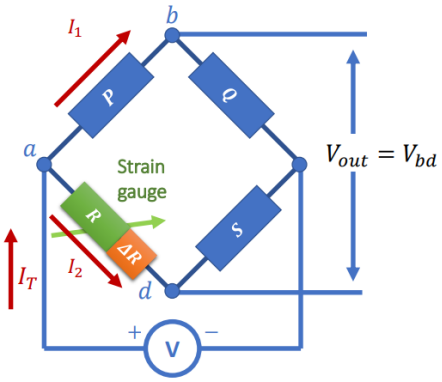
The Wheatstone Bridge is a well-known bridge configuration that is commonly used for measuring resistances. These resistances can take the form of strain gauges, thermistors or other forms of resistive transducers.

The Wheatstone Bridge circuit is nothing more than two simple series-parallel arrangements of resistances connected between a voltage supply terminal and ground producing zero voltage difference between the two parallel branches when balanced.

A Wheatstone bridge circuit has two input terminals and two output terminals consisting of four resistors configured in a familiar diamond-like arrangement as shown. This is typical of how the Wheatstone bridge is drawn.

While typically the Wheatstone bridge is used to measure an unknown resistance ($R + \Delta R$ below) by varying the resistance in another arm (say Q) and obtain a null condition, for sensor interrogation a different approach is adopted.

The resistive sensor takes the place of R, and the output voltage V_{BD} is calibrated with respect to its variation. **In other words, a change in resistance is transduced to a voltage reading**.



Wheatstone bridge circuit diagram. (Source: wikipedia.org)

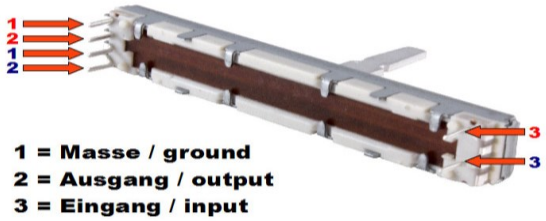
The working equation is thus of the form

$$V_{BD} = \frac{VQ\Delta R}{(P+Q)(R+\Delta R+S)},$$

where

$$\frac{P}{Q} = \frac{R}{S}.$$

For this experiment, you will learn how to calibrate a Wheatstone bridge to use it as a sensor interrogator. You will use a slide potentiometer as the variable resistor, and characterize three different realizations of the Wheatstone bridge (i.e. use different resistance combinations in the other arms). You will then obtain the transfer characteristics of these Wheatstone bridge configurations, i.e. present in tabular form the relation between V_{BD} and $R + \Delta R$, plot these transfer characteristics, and give an estimate of the error encountered in your measurements. In your report, you will then give a justification for the choice of resistances, and the characteristics observed in your experiment.



Pin Layout of given Slide Potentiometer (Source: forum.arduino.cc)

Tasks

- **Task 1** – Calibrate the slide potentiometer.

- **Task 2** – Build the Wheatstone Bridge circuit on the breadboard and get your measurement configuration verified by your Instructor/TA.

- **Task 3** – Tabulate the theoretical and measured output voltage V_{BD} value, and calculate the error in the theoretical and practical values. Then, plot the output voltage V_{BD} vs resistance of slide potentiometer. **You will do this for two different sets of the resistance combinations.**

- **Task 4** – You will be given a few unknown resistances by your TA. You will use your Wheatstone bridge to determine the values of these unknown resistances, validate your result, and give an estimate of the precision and accuracy of your measurements. The provided resistances could be anywhere in the range that is covered by the slide potentiometer.

Task completion criteria

1. You calibrate the slide potentiometer.
2. You build the Wheatstone Bridge circuit with the slide potentiometer R_2 as input parameter.
3. You tabulate the theoretical and practical output voltage V_{BD} value and the percentage error.
4. You plot the output voltage V_{BD} vs resistance of slide potentiometer for the two sets of resistance combinations.
5. You correctly estimate the values of the resistances as provided by your TA using the Wheatstone bridge, and comment on the estimated accuracy and precision of your measurements.