# The Wheatstone Bridge

**Week no. – 4**

**Date of experiment –** 12/09/2023

**Group name – Group 6**

**Group members –** Binduthraya Matta (B21203), Saransh Duharia (B21021), Jasnoor Tiwana (B21194), Rawal Ram(B21219), Adarsh Santoria (B21176).

## 1. Experiment layout

Wheatstone bridge is widely used for measuring any electrical resistance accurately. There are three known resistors(P, Q and S) and an unknown resistor (R) bridge form as shown in Fig.1 and Fig. 3.

Wheatstone bridge operates on the principle of null deflection, Which states that when no current flows through the galvanometer, the ratio of their resistances is equal. Under normal conditions, the bridge is in an unbalanced condition where current flows through the galvanometer. The bridge is said to be balanced when no current flows through the galvanometer. This condition can be achieved by adjusting the known resistance and variable resistance.

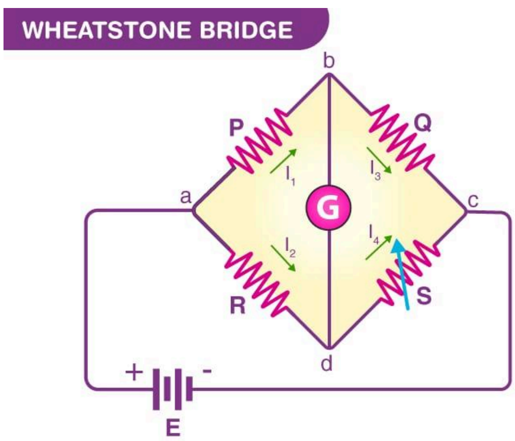



Fig. 1

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

Fig. 2: Condition for balanced wheatstone

For sensor Interrogation, We adopted a different approach. The resistive sensor takes the place of R, and the output voltage Vbd is calibrated with respect to its variation. In other words, a change in resistance is transduced to a voltage reading.

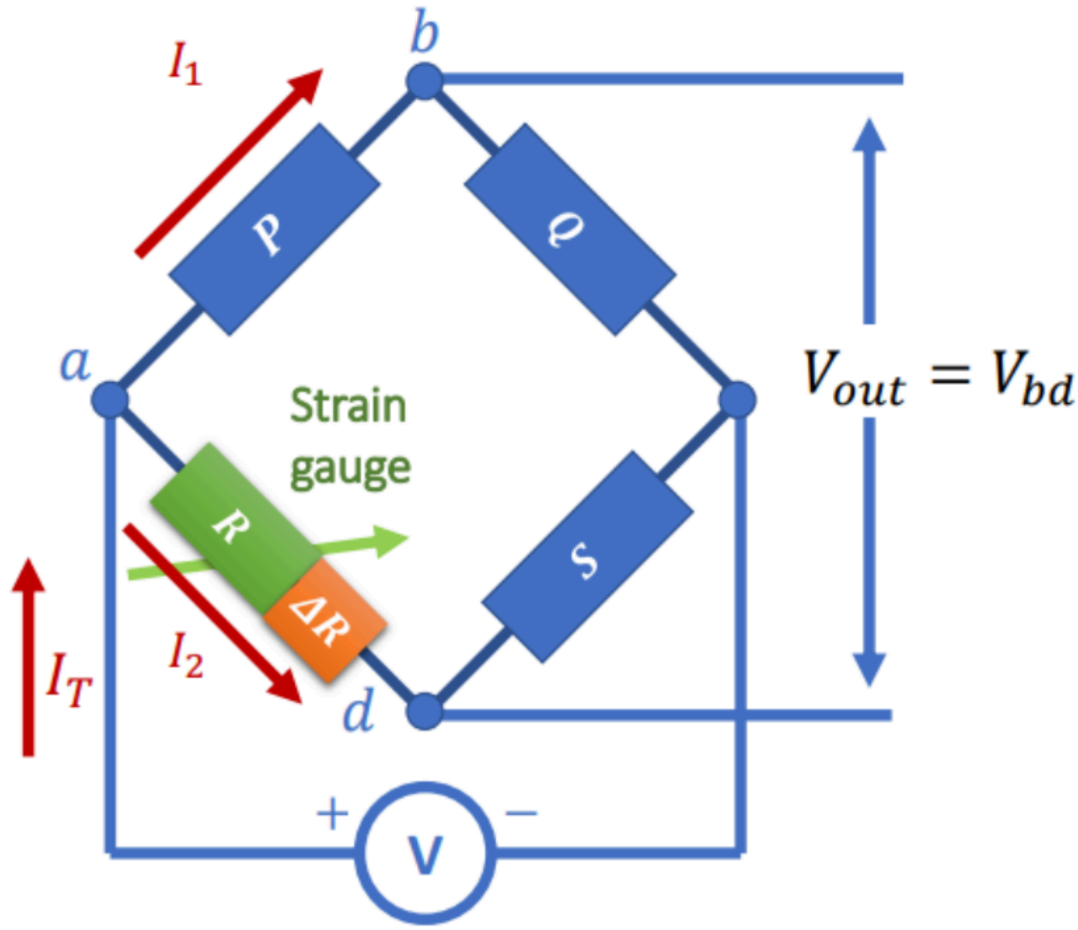



Fig. 3: Sensor with variable resistance output in the place of R

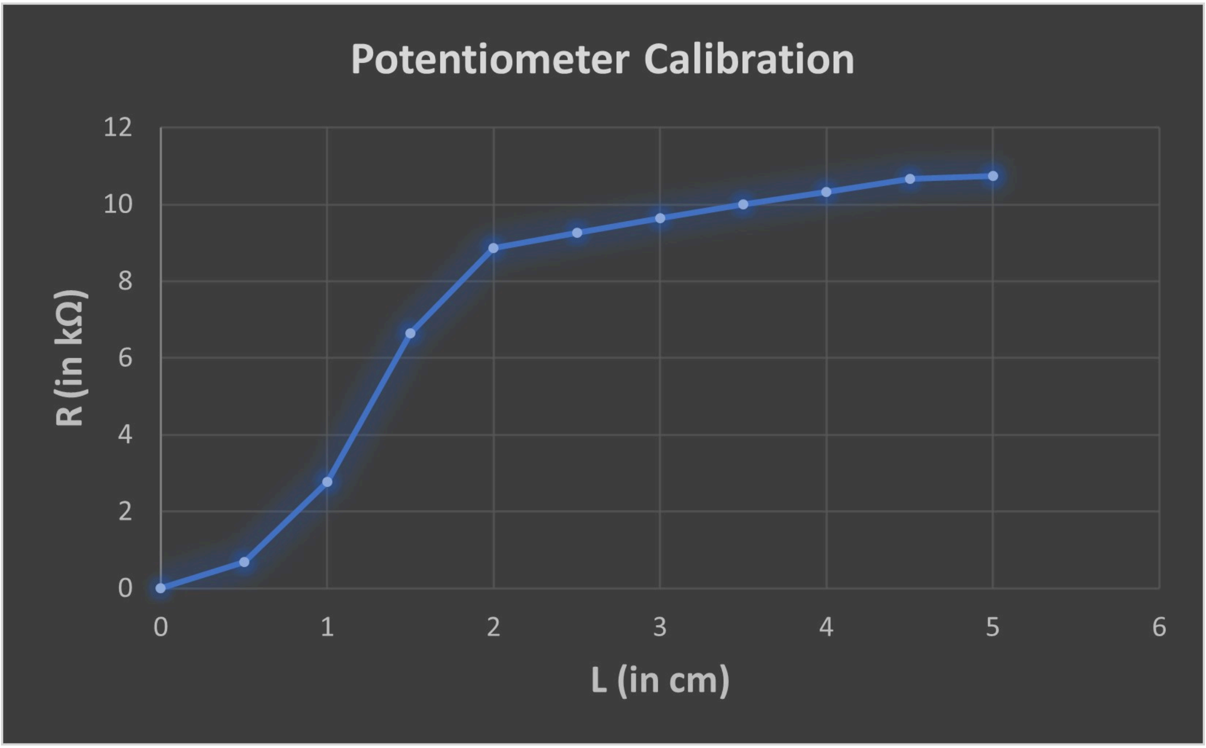
**2. Results**

**Task 1 – Calibrate the slide potentiometer**

In calibration of potentiometer, we make note of how potentiometer resistance is changing when we move its slider.

| **L** (in cm) | **R** (in kΩ) |
|---|---|
| 0 | 0.006 |
| 0.5 | 0.68 |
| 1 | 2.77 |

| | |
|---|---|
| 1.5 | 6.64 |
| 2 | 8.86 |
| 2.5 | 9.26 |
| 3 | 9.64 |
| 3.5 | 10.01 |
| 4 | 10.33 |
| 4.5 | 10.67 |
| 5 | 10.74 |




From this graph, it can be observed that the resistance of the potentiometer doesn't vary linearly with the L (the distance of the slider from the point of the minimum resistance). At first, the resistance increases with an increasing slope, but then the slope gradually starts reducing, as resistance approaches its maximum value.

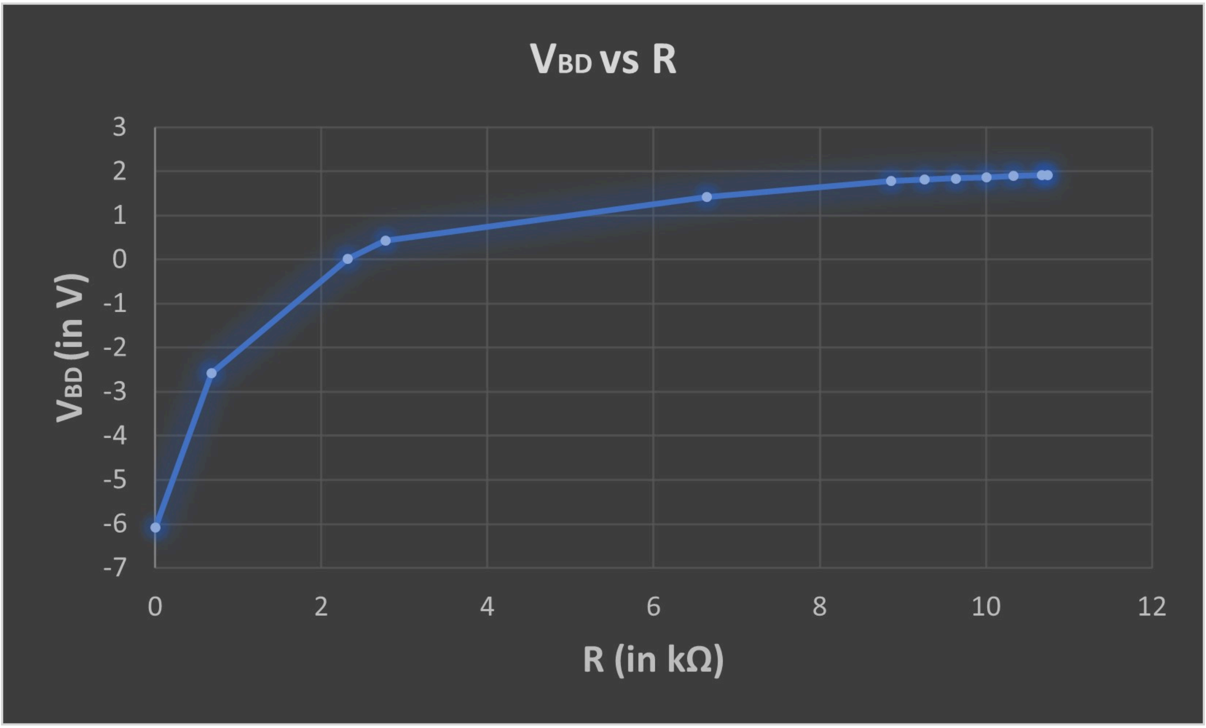
**Task 2 – Build the Wheatstone Bridge circuit on the breadboard and get your measurement configuration verified by your Instructor/TA.**

We used 3 known resistors,a  potentiometer, a 9V DC battery, a multimeter, a breadboard and jumper wires to build the Wheatstone Bridge as shown in Fig. 1. The resistance R was replaced by the potentiometer and the multimeter was connected in between the terminals b and d to measure the voltage across them. We proceeded with the experiment after the circuit was verified by the 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 VBD vs resistance of the slide potentiometer. You will do this for two different sets of the resistance combinations.**

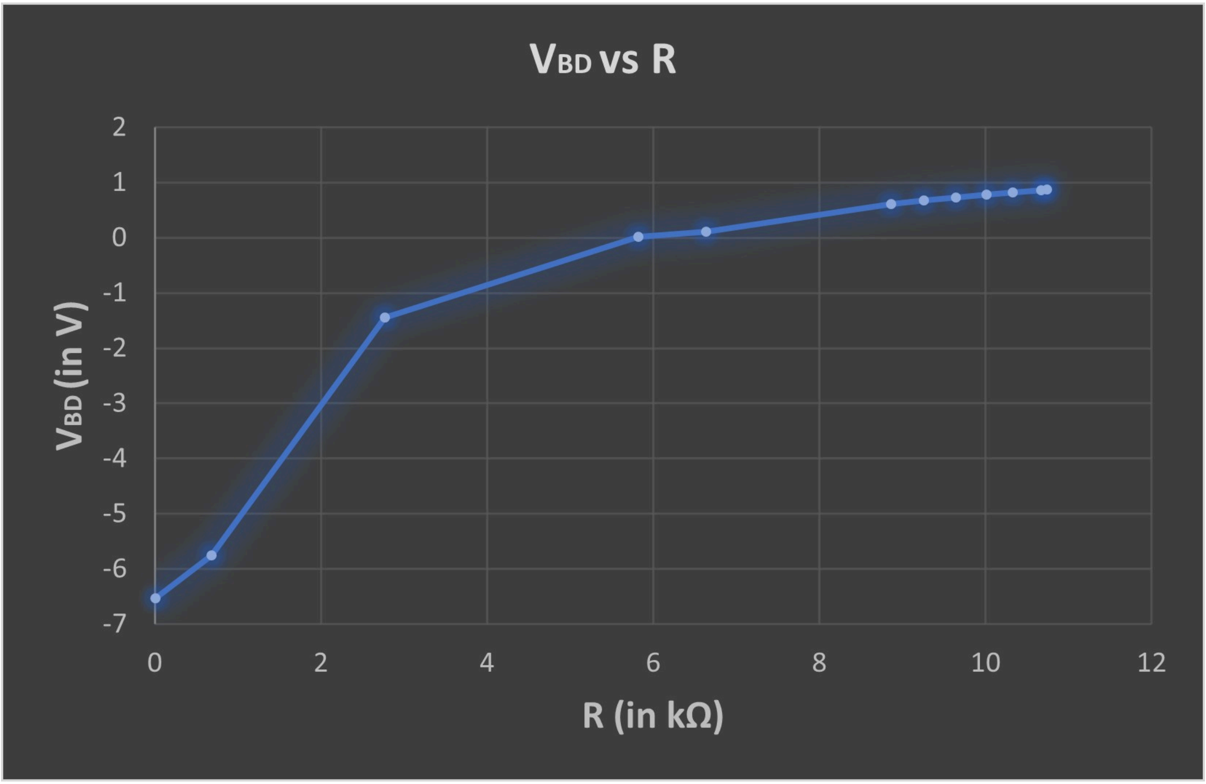
**P = 4.65kΩ, Q = 2kΩ, S = 0.995kΩ, V = 9V**

| **L** (in cm) | **R** (in kΩ) | $V_{BD}$(measured) (in V) | $V_{BD}$(calculated) (in V) | **Absolute Error** (in V) |
|---|---|---|---|---|
| 0 | 0.0061 | -6.08 | -6.24 | 0.12 |
| 0.5 | 0.68 | -2.58 | -2.64 | 0.06 |
| 0.9 | 2.32 | 0.02 | 0.005 | 0.015 |
| 1 | 2.77 | 0.42 | 0.33 | 0.09 |
| 1.5 | 6.64 | 1.42 | 1.53 | 0.09 |
| 2 | 8.86 | 1.78 | 1.80 | 0.02 |
| 2.5 | 9.26 | 1.81 | 1.83 | 0.02 |
| 3 | 9.64 | 1.84 | 1.86 | 0.02 |
| 3.5 | 10.01 | 1.86 | 1.89 | 0.03 |
| 4 | 10.33 | 1.89 | 1.92 | 0.03 |
| 4.5 | 10.67 | 1.91 | 1.94 | 0.03 |
| 5 | 10.74 | 1.92 | 1.95 | 0.03 |



**P = 295.9kΩ, Q = 100.7kΩ, S = 1.983kΩ, V = 9V**

| **L** (in cm) | **R** (in kΩ) | **$V_{BD}$**(measured) (in V) | **$V_{BD}$**(calculated) (in V) | **Absolute Error** (in V) |
|---|---|---|---|---|
| 0 | 0.0061 | -6.53 | -6.69 | 0.16 |
| 0.5 | 0.68 | -5.75 | -4.41 | 1.33 |
| 1 | 2.77 | -1.45 | -1.46 | 0.01 |
| 1.4 | 5.82 | 0.02 | -0.002 | 0.022 |
| 1.5 | 6.64 | 0.11 | 0.22 | 0.11 |
| 2 | 8.86 | 0.61 | 0.64 | 0.03 |
| 2.5 | 9.26 | 0.68 | 0.70 | 0.02 |
| 3 | 9.64 | 0.73 | 0.75 | 0.02 |
| 3.5 | 10.01 | 0.78 | 0.80 | 0.02 |
| 4 | 10.33 | 0.82 | 0.84 | 0.02 |
| 4.5 | 10.67 | 0.86 | 0.87 | 0.01 |
| 5 | 10.74 | 0.87 | 0.88 | 0.01 |




**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.**

The first resistance given to us was measured as 3.12kΩ through the wheatstone bridge. Its actual value as measured by multimeter came out to be 3.28kΩ. The error in the measurement came out to be 0.16kΩ.

Then we were given a second resistance, whose value came out to be 6.97kΩ through the wheatstone bridge. The measured resistance by the multimeter was 6.71kΩ. The error in the measurement was 0.26kΩ.

**3. Conclusion**

1. **What in your opinion is the most important thing you learnt from the experiment?**
   The most important thing we learned is how the output voltage $V_{BD}$ behaves and changes as we vary one of the resistors, keeping the other three constant. We came to know that we can replace this particular resistor with any sensor which involves an output signal in the form of variable resistance directly or indirectly.
2. **What was interesting about the experiment?**
   One of the most interesting things we observed was we can find unknown resistance values without using a multimeter. Besides that, it was the first time we had seen a potentiometer whose resistance doesn't linearly depend with the slider.

3. **What was challenging about the experiment?**
   The experiment was really easy to set up and perform. We ensured that the connections were tight and there were no short circuits. The only part which posed some challenges was measuring the distance of the slider from the point of minimum resistance at various instances of the experiment. We tried our best to take these readings as accurately as possible.
4. **Were there any drawbacks of the way the experiment was done? How would you do it better?**
   The experiment was carried out in the best manner possible, without any possible drawbacks.

5. **Contribution statement:** Adarsh took on the task of calculating actual values and tabulating observed readings. Saransh and Jasnoor worked on making the circuits for the tasks and observed and relayed the readings to Adarsh. Binduthraya and Rawal did the calculations of error and plotted the graphs. As for the report, everyone contributed towards its making.