MODULE 10

WHEATSTONE BRIDGE

1. GOALS

1.1. Understand the working principle of the Wheatstone bridge circuit,
1.2. Determine the value of the unknown resistance using the Wheatstone bridge principle,
1.3. Understand the Wheatstone bridge application.

2. TOOLS AND MATERIALS

2.1. Resistance decade box (1 unit),
2.2. Unknown resistor (1 unit),
2.3. Conductor wire holder (1 unit),
2.4. Galvanometer (1 set),
2.5. Battery (1 unit),
2.6. Rheostat (1 unit),
2.7. Connector cable (1 set).

3. BASIC THEORY

The Wheatstone bridge is a circuit consisting of four resistors as shown in Figure 10.1. The Wheatstone bridge can be used to determine the resistance of an unknown resistor with one of the resistances in the circuit having a known value.

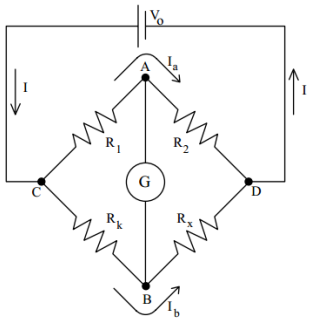

Figure 10.1. Wheatstone Bridge circuit.

When the Wheatstone bridge circuit is supplied with a voltage source V_0, then a certain amount of current will flow into the circuit. Point C is a branching point that causes a current I to be divided into currents I_a and I_b. Point A is the connecting point of resistance R_1 and R_2 which can be replaced with a long wire. Point B is the connecting point for a resistor whose value is unknown R_x and a resistor whose

value is known R_k. Point D is the connecting point between R_x and R_2 as well as connecting the negative pole on the DC source.

Next, points A and B are connected with a galvanometer to measure the potential difference at that two points. In the Wheatstone bridge circuit, the assumption is that no current flows through the galvanometer so that the galvanometer will always show a deviation of 0 because the voltage at point A is the same as the voltage at point B. In this condition, the relationship is obtained:

$$I_a R_1 = I_b R_k \quad (10.1)$$

$$I_a R_2 = I_b R_x \quad (10.2)$$

Divide equation 10.1 with equation 10.2 so we get the relationship as shown below:

$$\frac{I_a R_1}{I_a R_2} = \frac{I_b R_k}{I_b R_x} \quad (10.3)$$

$$R_x = R_k \frac{R_2}{R_1} \quad (10.4)$$

The resistances R_1 and R_2 can be replaced by a long wire. The relationship of resistance to the length of the wire can be written as in equation 10.5.

$$R = \rho \frac{L}{A} \quad (10.5)$$

R : Resistance (Ω)

ρ : Resistivity (Ωm)

L : Lenght of wire (m)

A : Cross-sectional area of wire (m^2)

By substituting equation 10.5 into equation 10.4, the following equation will be obtained:

$$R_k = R_x \frac{L_1}{L_2} \quad (10.6)$$

Through equation 10.6, it can be determined the resistance of an unknown resistor.

4. PRACTICE MATERIALS

4.1. Explain how the Wheatstone bridge circuit works!,

4.2. Look for applications of the Wheatstone bridge circuit!

5. EXPERIMENTAL PROCEDURES

5.1. **Determine the unknown resistance R_x**

1. Arrange the circuit as shown in Figure 10.1.,
2. Set the value of R_k,
3. Set the positions of L_1 and L_2 so that the galvanometer shows zero current,

4. When the galvanometer has shown zero current, write the value of R_k, L_1 and L_2,
5. Repeat steps 2 – 4 for 5 variations of R_k,
6. Tabulate the data in the table 10.1.,
7. Perform linear regression for the data of L_1/L_2 against R_k and get the gradient value,
8. Determine the value of unknown resistance R_x,
9. Measure the actual value of resistance R_x using a multimeter,
10. Compare the value of R_x obtained from the experiment with the actual value measured by the multimeter,

Table 10.1. Wheatstone bridge measurement results without a rheostat.

No	R_k (Ohm)	L_1 (m)	L_2 (m)	L_1/L_2
1				
2				
3				
4				
5				

11. Rearrange the Wheatstone Bridge circuit by adding a rheostat set in maximum resistance mode as given in Figure 10.2.

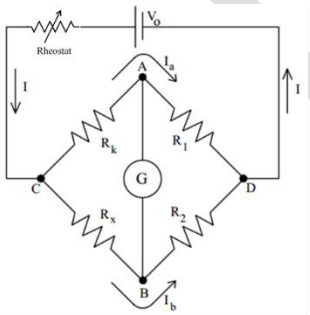

Figure 10.2. Wheatstone Bridge circuit with a rheostat.

12. Repeat steps 2 – 10 for that circuit,

Tabel 10.2. Wheatstone bridge measurement results with a rheostat.

No	R_k (Ohm)	L_1 (m)	L_2 (m)	L_1/L_2
1				
2				
3				
4				
5				

6. ANALYSIS TASK

6.1 Compare the measurement results of the Rx using a multimeter and the Wheatstone bridge, is there any difference? Explain!

6.2 What is the function of rheostat in this experiment? Explain!

6.3 Why does the Wheatstone bridge principle value the voltage difference between points A and B must be zero? Explain!

7. REFERENCES

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