TP-1

Wheatstone Bridge in continuous mode

(Resistance Measurement)

1. The aim of the lab

The purpose of the experiment is to:

- Measure the value of two resistors R_1 and R_2, using two assemblies: the AOIP box bridge and the wire bridge.
- To verify the consistency of the results found experimentally.

2. Theoretical reminder :

2.1 Principle:

Consider four resistors R_a, R_b, R_c , and R_x arranged along the four sides of a diamond ABCD (Figure 1). A galvanometer G is placed between points A and C."

Both the experiment and theory demonstrate that it is possible to select the four resistors so that the galvanometer does not deflect when the switch K is closed. At this point, we say that the bridge is balanced. The current I1 flowing through branch AB entirely flows into branch AD. The same holds for current I2. At this moment, we can write that:

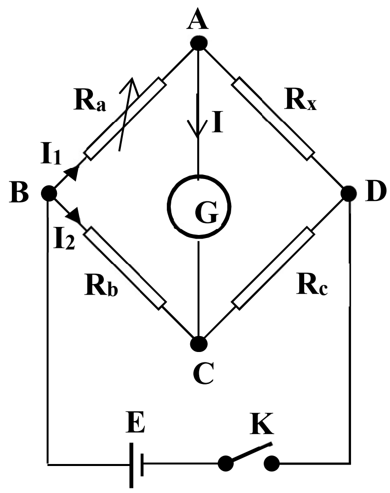


Figure 1

$$V_A - V_C = 0$$

or:

$$V_B - V_A = V_B - V_C \quad \text{(by adding } V_B\text{)}$$

$$V_A - V_D = V_C - V_D \quad \text{(by subtracting } V_D\text{)}$$

According to Ohm's law we can write:

$$R_a I_1 = R_b I_2 \qquad \text{and} \qquad R_x I_1 = I_2 R_c I_2$$

By dividing member by member, when the Wheatstone bridge is balanced, we will have:

$$\frac{R_x}{R_a} = \frac{R_c}{R_b} \qquad (1)$$

At the balance of the bridge, R_x will be given by the relation:

$$R_x = \frac{R_c}{R_b} \times R_a \qquad (2)$$

Error calculation:

$$\frac{\Delta R_x}{R_x} = \frac{\Delta R_c}{R_c} + \frac{\Delta R_b}{R_b} + \frac{\Delta R_a}{R_a} \qquad (3)$$

2.2 Zero method:

In practice, calibrated variable resistors do not vary continuously but discretely.

Let "P" be the step size of the resistance box R_a; Modifying this resistance can cause the galvanometer spot to move to the left and then to the right of zero; interpolation is required in such cases; for the value R_a-P, the spot stops at division h_2 to the left of zero, and for R_a+P; it stops at division h1 to the right of zero (see figure 2).

Assuming that the variations of R_x are proportional to the deviations, we can write:

$$R_x = \left(R_a + P \frac{|h_2| - |h_1|}{|h_1 + h_2|} \right) . \frac{R_b}{R_c} \qquad (4)$$

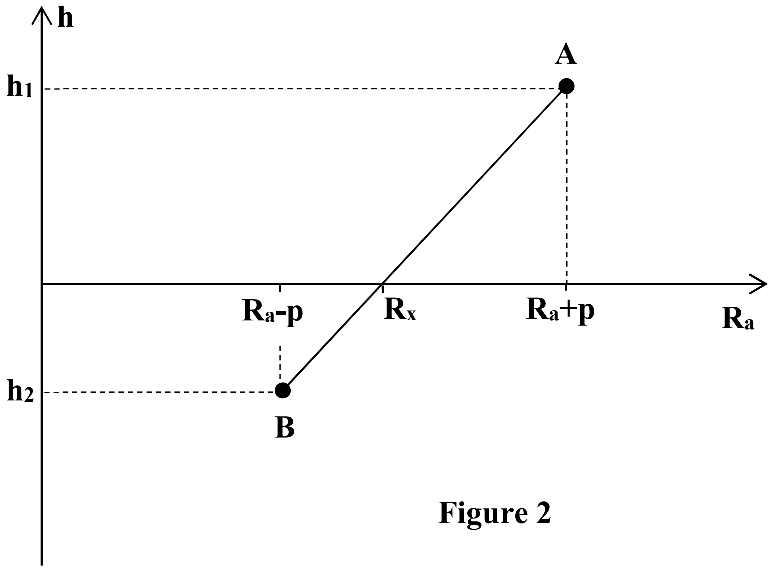


Figure 2

3. Materials Used:

- 01 variable direct current (DC) voltage generator.
- 04 variable decade resistance boxes (X1000; X100; X10; X1).
- 01 unknown resistance R_x to be measured.
- 01 galvanometer.
- 01 switch.
- 01 ohmmeter.

4. Manipulation :

4.1 AOIP box bridge

Build the assembly shown in Figure 1.

- The R_b and R_c resistors will be boxes of AOIP resistors x1000 each.
- Ra will consist of a set of 4 AOIP boxes x1000, x100, x10 and x1 mounted in series.

First of all, set the R_c/R_b ratio which will be taken as equal to 1 ($R_c = R_b$).

The galvanometer is fixed on the largest caliber.

- Take $R_a = 0$, close switch K, and note the direction of deflection of the spot.
- Then, gradually increase the value of R_a while observing the behavior of the galvanometer. At a certain position of the knob, the deflection changes direction, indicating that between this position and the previous one, there exists a position where the deflection of the spot is zero. Return to the previous position and repeat the process with the next AOIP resistance box in the same manner. Continue this procedure with the other boxes that make up resistance R_a.
- As the deflections of the spot become small, gradually increase the sensitivity of the galvanometer to precisely locate the value of R_a that determines the smallest current in branch AC.
- If the deflection direction of the spot remains the same for all values of R_a, you should increase the value of the R_c/R_b ratio.

Measurements to be conducted:

Measure the two resistances provided on the lab table using the described method. For each measurement, determine R_x and ΔR_x, and present the result in the format: ($R_x \pm \Delta R_x$). Organize the results in the following table:

	R_a (Ω)	R_b (Ω)	R_c (Ω)	R_x (Ω)	ΔRx (Ω)	$R_{Ohmmeter}$ ( )	$R_{Color\ Code}$ ( )
R_x (Ω)							

Find the value of resistance R_x using the zero method:

a- graphically

b- analytically (using formula (4)).

- Determine the value of R_x using the Ohmmeter.

-compare and interpret the results.

4.2 Wire bridge:

Instead of resistor boxes in branches BC and CD (Figure 1), a wire is stretched on which a slider connected to point C can slide. The following setup is obtained:

If we denote the resistances of branches BC and CD as R_b and R_c, we can derive the relation (2) presented above. Since the wire in the BD segment is homogeneous and of constant cross-section, we can write, if l_1 and l_2 are the lengths of branches CD and BC, respectively:

$$R_x = \frac{R_c}{R_b} \times R_a = \frac{l_1}{l_2} \times R_a \qquad (4)$$

The lengths l_1 and l_2 can be read from the graduated scale. The balance of the bridge will be achieved by moving the slider C, and the values of l1 and l2 will be noted.

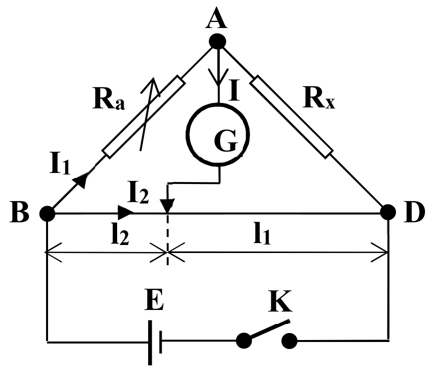


Figure 3

Measurements to be conducted:

Repeat the same measurements previously performed for the two supplied resistors.
We achieve balance in the bridge with good precision when the slider is towards the middle of the BD scale. We modify R_a.

Error calculation: in this case, we have:

$$\frac{\Delta R_x}{R_x} = \frac{\Delta R_a}{R_a} + \frac{\Delta l_1}{l_1} + \frac{\Delta l_2}{l_2} \qquad (5)$$

On l_1 and l_2, there is a reading error and a zero-point error for the current passing through the galvanometer. If Δl is the length of the wire range over which we can consider that the current intensity remains equal to zero, we can write:

$$\Delta l_1 = \Delta l_2 = \frac{\Delta l}{2} \qquad (6)$$

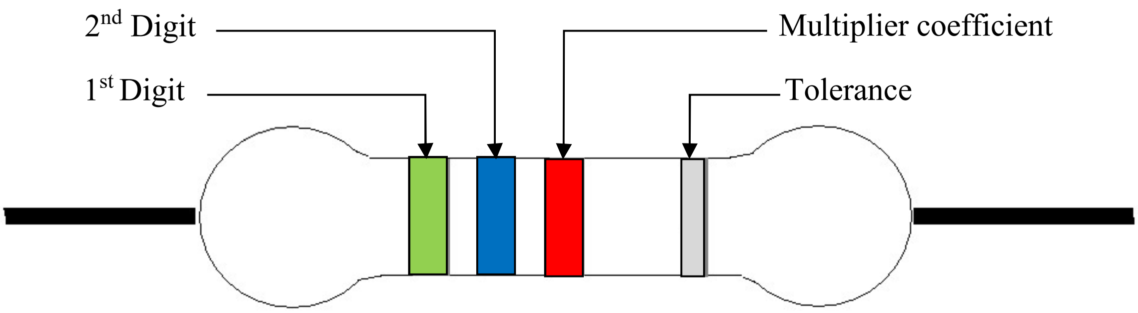
Calculate R_x and ΔR_x each time. Gather the results in the following table:

	R_a (Ω)	l_1 (m)	l_2 (m)	R_x (Ω)	Δl (m)	ΔRx (Ω)	$R_{Ohmmeter}$ (Ω)	$R_{Color\ Code}$ (Ω)
R_x (Ω)								

Interpretation of the results.

5. Conclusion

Color code for resistors



$$R = 56 * 10^2$$
$$R = 5600 \pm 10\% \ \Omega$$

Color	*1st et 2nd Digit*	*Multiplier Coefficient*	*Tolerance*
Black (**N**oir)	0	1	/
Brown (**M**arron)	1	10	± 1 %
Red (**R**ouge)	2	10^2	± 2 %
Orange (**O**range)	3	10^3	/
Yellow (**J**aune)	4	10^4	/
Green (**V**ert)	5	10^5	/
Blue (**B**leu)	6	10^6	/
Violet (**V**iolet)	7	10^7	/
Gray (**G**ris)	8	10^8	/
White (**B**lanc)	9	10^9	/
Gold (Or)	/	0.1	± 5 %
Silver (Argent)	/	0.01	± 10 %

Astuce

Un moyen mnémotechnique pour se rappeler du code des couleurs est de retenir l'une des deux phrases suivantes:

Ne **M**anger **R**ien **O**u **J**e **V**ous **B**rûle **V**otre **G**rande **B**arbe

ou

Ne **M**angez **R**ien **O**u **J**eûnez **V**oilà **B**ien **V**otre **G**rande **B**êtise

L'ordre des mots dans la phrase indique le chiffre correspondant à la couleur de l'anneau.