KARADENİZ TECHNICAL UNIVERSITY
Electrical and Electronics Engineering Department
EEE1002 Measurement in Electrical Engineering- Lab

Direct Current Bridges

1.1 Preparation questions (20)

Answer the following questions before coming to the experiment and present them in a report before the experiment.

1. What does moderate resistance mean? In what range should a value be for a resistor to be of medium value?
2. What is a Galvanometer? Where is it used?
3. Why cannot the direct current bridge be fully stabilized in practice? Please explain.
4. Why are small-value resistors manufactured as four-prongs? Please explain.
5. What are the specific resistances of gold, copper, silver, aluminum and iron?
6. Why are aluminum conductors used in transmission lines instead of copper?
7. This question will be solved in Multisim

    a. Build the circuit in Figure 1.
    b. Show the circuit you built in Multisim (Vp-p: 5V 1kHz Square wave (clock), R= 1kΩ, C=0.1µF).
    c. Determine the voltage values in designated points (1 & 2).
    d. Find the time constant of the circuit (τ) and find the voltage on '2' at the time τ and show these values on graph with 'cursors', obtained from Multisim graph.

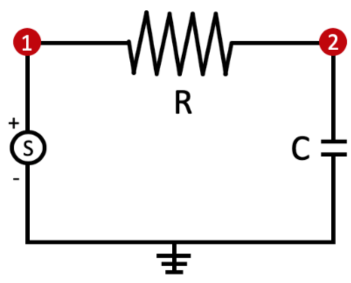

Figure 1 Multisim circuit.

1.2 Wheatstone Bridge

Unknown medium-value resistors are found by comparing to known resistors. The construction of the Wheatstone bridge is displayed in Figure 2 as follows:

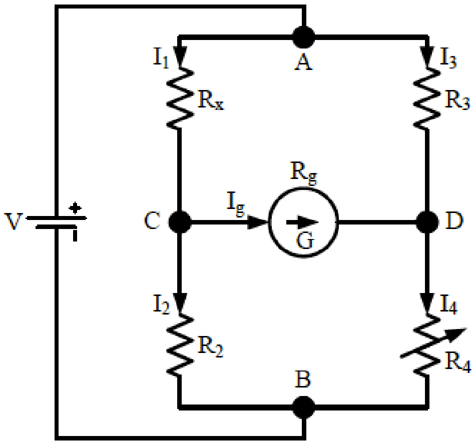

Figure 2 Wheatstone bridge.

- R_X is the resistance to be measured.
- R_2 and R_3 resistors are of constant value.
- The bridge is brought into balance with R_4 variable resistance. When the bridge is in balance, the potential of C and D nodes is the same compared to A and B nodes.
- While the bridge is in balance, no current flows through the galvanometer with internal resistance R_g. In this case, the currents passing through resistors are as in equations (1, 2).

$$I_1 = I_2 \tag{1}$$

$$I_3 = I_4 \tag{2}$$

- R_X can be calculate by using equations (3-8):

$$V_1 = V_3 \tag{3}$$

$$V_2 = V_4 \tag{4}$$

$$I_1 R_x = I_3 R_3 \tag{5}$$

$$I_2 R_2 = I_4 R_4 \tag{6}$$

$$\frac{I_2 R_x}{I_2 R_2} = \frac{I_4 R_3}{I_4 R_4} \tag{7}$$

$$R_x = \frac{R_2 R_3}{R_4} \tag{8}$$

During measurements equation (8) may not be satisfied completely. There are number of reasons for that:

- If the current passing through the galvanometer falls below the lower measuring limits of the galvanometer, the galvanometer does not show this current. The fact that the galvanometer does not deflect while balancing the bridge indicates that the current passing through it is smaller than the measuring limit. It is very difficult to measure the full equilibrium condition of the circuit since every meter will have an uncertainty.
- The bridge is balanced with the help of variable resistance (R_4). When the equilibrium condition is very close, the current passing through the galvanometer changes direction by changing the value of the R4 resistance by one step (1 Ω or 0.1 Ω). In Figure 3, this indicates that the resistance change required for the equilibrium condition is between the two stages. The bridge cannot be stabilized due to the small value resistances in the laboratory. In this case, the resistance value that will balance the bridge is calculated with (9):

$$R_4 = \frac{R_{41}\alpha_2 + R_{42}\alpha_1}{\alpha_1 + \alpha_2} \quad (9)$$

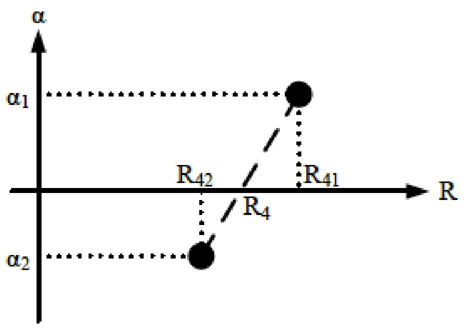

Figure 3. Change of Resistance

1.3 Experiment procedure (40pts)

1. Use 10V DC as a voltage source.
2. Take 1000 Ω as resistance for R_2 ve R_3.
3. Put the Galvanometer (Ammeter will be used in Multisim) to the most insensitive position. Pay attention to the direction of deviation of the galvanometer by giving a value to the variable resistance ($R_4 = \infty$). Give the variable resistance a small value ($R_4 = 0$) to make it deviate in the other direction. The value sought is between these two values. Likewise, by giving the variable resistance one big and one small, narrow the region where the value that creates the balance condition. Note the resistance values and deflection angles when giving each value. Increase the sensitivity of the galvanometer as you approach the equilibrium.
4. While doing this operation on Multisim, Ammeter will be used instead of Galvanometer. However, the method in '3' will be a guidence for the solution.
5. R_4 Determine the value of R_x by taking the resistance R_4 as 1kΩ. Then, record the current values you see in the Ammeter in below table for R_4 values between 0.25 kΩ and 2 kΩ with 0.25 kΩ increment. (This step will be done in Multisim.)

Table.1 Distribution of current for changing R_4 values

R_4 (*k*Ω)	**I (mA)**

1.4 Thomson bridge

When measuring small resistances with the Wheatstone bridge, the resistances of the connection wires affect the result. Therefore, small value resistors (below 1Ω) are measured by the Thomson bridge shown in Figure 4. With this bridge, micro-ohm sized resistors can be measured. As is known, small-value resistors are manufactured with four ends to eliminate the effect of uncertain transition resistances at the attachment points.

In balance equations (10-13) below are valid.

$$I_1 R_x + I_2 R_1 = I_3 R_3 \tag{10}$$

$$I_1 R_N + I_2 R_2 = I_3 R_4 \tag{11}$$

$$I_1 R_x = I_3 R_3 - I_2 R_1 \tag{12}$$

$$I_1 R_N = I_3 R_4 - I_2 R_2 \tag{13}$$

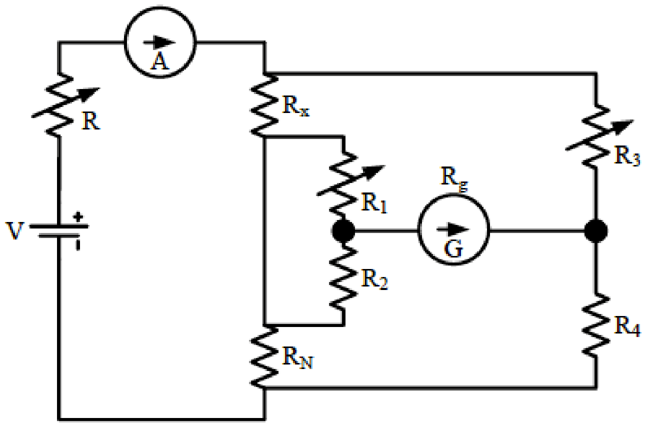

Figure 4. Thomson bridge.

Taking the ratio by using Eqn. (12) ve (13), $\frac{R_1}{R_3} = \frac{R_2}{R_4}$ is obtained and yield Eqn. (14). To satisfy $\frac{R_1}{R_3} = \frac{R_2}{R_4}$, following conditions should be met $R_1 = R_3$ ve $R_2 = R_4$.

$$\frac{R_x}{R_N} = \frac{R_3}{R_4} = \frac{R_1}{R_2} \tag{14}$$

1.5 Experiment procedure (40pts)

In this experiment, the specific resistance of a conductor line will be measured. The conductor is attached between the two points. These two points form the current ends of the four-pin resistor. Two points located between the current ends and has the lenght of *L*. The resistance R_x of the conductor to be measured is the resistance between these two points. Take the distance between the two tension ends as *L* = 5cm and the diameter of the wire as *d* = 0.5m.

1. Take the DC voltage source as 10V.
2. Setup the circuit shown in Figure 4.Take $R_2 = R_4 = 100$ Ω and for R_1 & R_3, *take 100* Ω.
3. Set the galvanometer to insensitive position and select a large value for the R pre-resistance and limit the current passing through the circuit. After activating the voltage source, make the R resistance shrink about 500 mA from the circuit by reducing it. Balance the bridge by changing the values of the resistors R1 and R3 to remain the same.
4. After balancing the circuit, find the conductivity of the wire with the equation (15).

$$R_x = \frac{\rho L}{A} \tag{15}$$