ECE 281

Electrical Circuits and Instrumentation + Laboratory

Fall 2016/2017

LAB # 6

7**.11.2016**

Objective:

1. **To observe the loading effect of analog voltmeter**
2. **To study wheatstone bridge and its properties**

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1. To observe the loading effect of analog voltmeter (15 Points)

Procedure:

1. Construct the circuit given in Figure 1

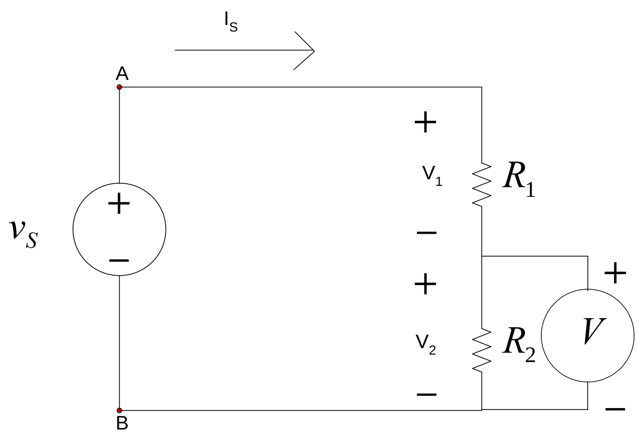

Figure 1

2. First use analog multimeter and measure voltage V_2 for each resistance value, and fill Table 1, Column 3.

3. Use digital multimeter and make the same measurements, and fill Table 1, Column 4.

4. Analyze the circuit to calculate the actual voltage drop V_2 and fill Table 1, Column 5.

R_1	R_2	V_2 (Analog)	V_2 (Digital)	V_2 (Calculated)
1 kΩ	**1 kΩ**			
10 kΩ	**10 kΩ**			
100 kΩ	**100 kΩ**			
1 MΩ	**1 MΩ**			
10 MΩ	**10 MΩ**			
1 kΩ	**10 kΩ**			

Table 1

Questions:

- How can we understand that the digital multimeter has higher internal resistance compared to analog multimeter?
- Which multimeter is more accurate in terms of resistance measurements?

2. To study Wheatstone bridge and its properties (15 Points)

Wheatstone bridge: Wheatstone bridge is a particular circuit which is used to measure unidentified resistance values. In order to figure out the functionality of this particular circuit, let's consider the circuit diagram shown in Figure 4. In this circuit there are five resistors. If no current is observed over the resistor R_5 (I_5=0 A), then this circuit is said to be in **balance condition**. What condition should be satisfied such that the Wheatstone bridge is balance?

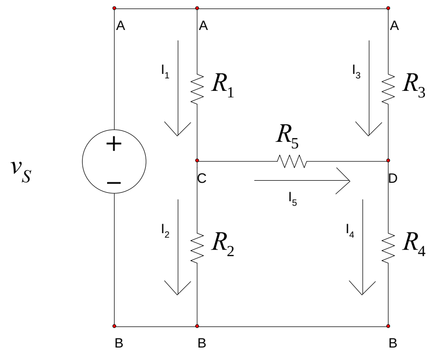

Figure 2: Wheatstone bridge circuit.

It is seen obvious that

$$I_1 = I_2 + I_5 \quad (1)$$

and

$$I_4 = I_3 + I_5 \quad (2)$$

If $I_5 = 0$ A (if the Wheatstone bridge is balanced),

$$I_1 = I_2 \quad (3)$$

and

$$I_4 = I_3 \quad (4)$$

Using (3) and (4) and applying node voltage method, we can write,

$$\frac{A-C}{R_1} = \frac{C-B}{R_2} \quad (5)$$

and

$$\frac{A-D}{R_3} = \frac{C-B}{R_4} \quad (6)$$

Again using node voltage method we can also write,

$$C = D + R_5 I_5 \quad (7)$$

As $I_5 = 0$ A, (7) can be simplified and we can obtain the relation

$$C = D \quad (8)$$

Using (8) inside (6), we can obtain

$$\frac{A-C}{R_3} = \frac{C-B}{R_4} \quad (9)$$

Now using (5) and (9), we can write

$$\frac{R_1}{R_2} = \frac{R_3}{R_4} \quad (10)$$

So the relation shown at (10) should be satisfied for balance condition.

Procedure:

1. Use first R_1, R_2, R_3, and R_4 value combination given in Table 2 and construct the circuit given in Figure 3

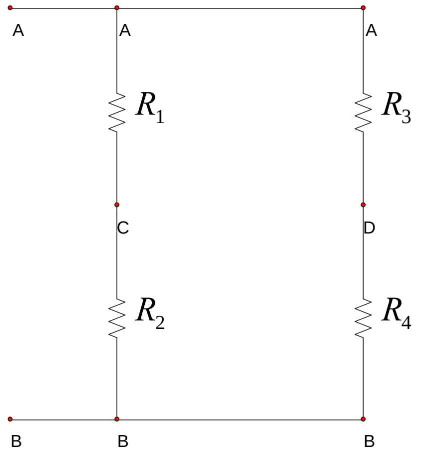

Figure 3

2. Use digital multimeter, measure resistance between A-B without power.
3. Connect 10V between A-B as shown in Figure 4 and measure the voltage drop between C-D.

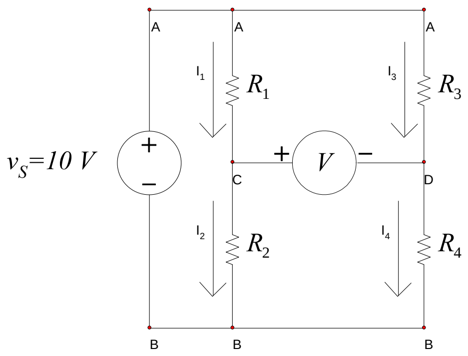

Figure 4

4. Remove power
5. Repeat steps 1-4 for each Resistor combination given in Table 2, and fill the blanks.

R_1	R_2	R_3	R_4	R_t (Between A-B)	V (Between C-D)
1 kΩ	1 kΩ	1 kΩ	1 kΩ		
1 kΩ	10 kΩ	1 kΩ	10 kΩ		
1 kΩ	1 kΩ	10 kΩ	10 kΩ		
1 kΩ	10 kΩ	10 kΩ	1 kΩ		

Table 2

Questions:

- What is the total resistance if all the resistors have same value?
- When is the voltage is zero (or near to zero) between points C-D?