

### Laboratory Experiment 3 Parallel Circuits, Kirchoff's Current Law, Rheostat

**Parallel Circuits:** Assume we have n resistors connected in parallel (say their resistance values are  $R_1, R_2, R_3, \dots$  and  $R_n$ ). The total resistance value in this parallel connection is calculated using the formula,

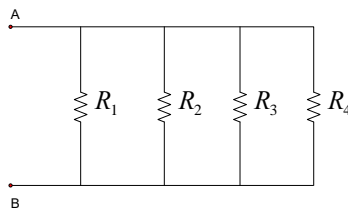
$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \dots + \frac{1}{R_n} \quad (1)$$

1- In this part, we'll use four resistors ( $R_1= 1k\Omega, R_1= 1k\Omega, R_1= 2.7k\Omega, R_1= 10k\Omega$ ). Firstly, measured the resistance values of each resistor and record them on Table 1 (first four rows of Table 1).

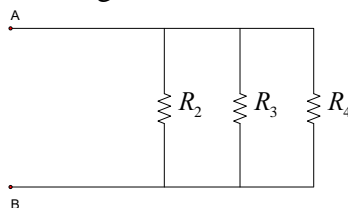
**Table 1:** Resistance measurements and calculations.

	Resistance
1- $R_1$ (measured)	
2- $R_2$ (measured)	
3- $R_3$ (measured)	
4- $R_4$ (measured)	
5- $R_T$ (calculated)	
6- $R_{AB}$ (measured)	
7- $R_{AB}$ ( $R_1$ removed)	
8- $R_{AB}$ ( $R_4$ removed)	

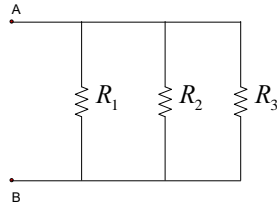
Using the values of  $R_1$  to  $R_4$ , calculate the total resistance value ' $R_T$ ' using the formula shown in (1) when there are four resistors. Record  $R_T$  to Table 1 (row 5). Now construct the circuit in Figure 1 (this circuit is the parallel connection of all of four resistors) and measure the total resistance value using the digital multimeter (set the digital multimeter to resistance measurements and connect the probes of the multimeter to nodes A and B in the circuit). Record your measurement to Table 1 (row 6). Now remove  $R_1$  from the circuit (see Figure 2 for the new circuit), and measure the resistance between nodes A and B and record it to Table 1 (row 7). Lastly remove  $R_4$  from the circuit (see Figure 3 for the new circuit), and measure the resistance between nodes A and B and record it to Table 1 (row 8).



**Figure 1:** Circuit diagram for resistance measurement.



**Figure 2:** Circuit diagram for resistance measurement when  $R_1$  is removed.



**Figure 3:** Circuit diagram for resistance measurement when  $R_4$  is removed.

### Questions

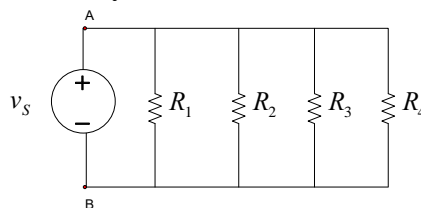
- Are the readings in the fifth and sixth rows of the Table 1 close to each other?
- When  $R_1$  is removed from the circuit, the deviation in the total resistance ( $R_{AB}$ ) is large? Why this happens?
- When  $R_4$  is removed from the circuit, the deviation in the total resistance ( $R_{AB}$ ) is not as large as the case seen in question 2? What is your opinion about this occasion?
- The point in a circuit where more than one circuit element is connected is called as a node. Due to this definition how many nodes are there in this circuit?

Kirchoff's Current Law: Kirchoff's current law states that the summation of incoming currents to a node should be equal to the summation of outgoing currents from the same node.

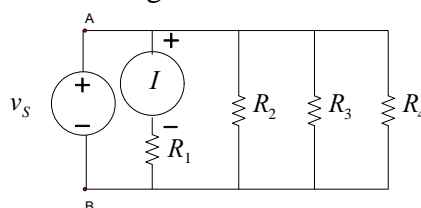
2- In this part we'll try to validate Kirchoff's current law with a simple circuit setting. See the circuit in Figure 4 (Circuit parameters are  $R_1= 1k\Omega$ ,  $R_1= 1k\Omega$ ,  $R_1= 2.7k\Omega$ ,  $R_1= 10k\Omega$  and  $V_S=10$  Volt DC). Construct the circuit to the breadboard and measure the current values passing over each resistor. In order to manage these measurements, the multimeter (acting as an Ampermeter at each case) should be connected properly to the circuit. For example one can refer to Figure 5 for measuring the current value over  $R_1$ . Using this example, the students are encouraged to connect the multimeter suitably to the circuit on the breadboard in order to also measure the currents over  $R_2$ ,  $R_3$  and  $R_4$ . Record your measurements on Table 2 (first four rows of Table 2). Now also measure the total current value flowing from this circuit. For this reason construct the circuit shown on Figure 6 and note your current measurement to fifth row of Table 2 ( $I_{Total}$ ). Now using your current measurements for each resistor (see Table 2, rows 1 to 4) calculate the total current  $I_T$  once again using Kirchoff's Current Law, which is given by the formula,

$$I_T = I_1 + I_2 + I_3 + I_4 \quad (2)$$

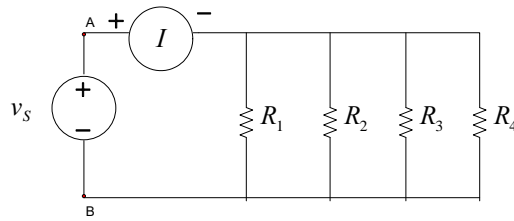
for the circuit in Figure 4. Now record your calculation to Table 2 (row 6).



**Figure 4:** Circuit diagram for current measurements.



**Figure 5:** Circuit diagram for current measurement over  $R_1$ .



**Figure 6:** Circuit diagram for current measurement for total current.

**Table2:** Current measurements and calculations.

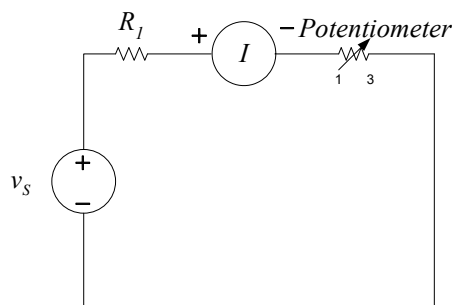
Current measurements	Current Value (mAmper)
Current over $R_1$ (measured): $I_1$	
Current over $R_2$ (measured): $I_2$	
Current over $R_3$ (measured): $I_3$	
Current over $R_4$ (measured): $I_4$	
Total current (measured): $I_{Total}$	
Total current (calculated): $I_T$	

**Questions:**

- Is the value of  $I_T$  and  $I_{Total}$  close to each other?
- Which resistor has the highest current and why?

**Rheostat:** Any device that regulates (controls) current flow is called as a rheostat. A potentiometer can be used as a rheostat if it is connected properly in a circuit.

**3-** Use of a rheostat: Construct the circuit shown in Figure 7 (In this circuit, we take  $R_1 = 1k\Omega$  and  $V_s = 10V$  DC. We also use a potentiometer whose nominal value is  $10k\Omega$ ). Connect only one of the constant terminal (terminal 1) and the variable terminal (terminal 3) of the potentiometer to the circuit while leaving the other constant terminal (terminal 2) open (don't connect this terminal to anywhere). By rotating the shaft of the potentiometer in clockwise and anti-clockwise directions fill up Table 3 according to your reading over the ampermeter.



**Figure 7:** Circuit diagram for current measurement over rheostat

**Table 3:** Current measurements

Turning direction	Clockwise	Anti-clockwise	Mid-point
Current value (I)			

**Questions:**

- What should be the limit values (the maximum and the minimum) of the current  $I$  when  $R_1 = 1k\Omega$  and the potentiometer is adjusted to its maximum value ( $10k\Omega$ ) and minimum value ( $1k\Omega$ ).