Lab 2: KCL, Current Divider Rule with Parallel and Ladder Circuit

Objectives

- Learn how to connect a parallel circuit on a breadboard.
- Validate the current divider rules.
- Verify Kirchhoff's current law.
- Verify KCL and KVL in ladder circuit.

List of Components:

- Trainer board
- Resistors (1K, 3.3 KΩ, 4.7 KΩ, 5.6K, 10K)
- Digital Multimeter (DMM)
- Connecting Wire

Theory:

Kirchhoff's Current Law: Kirchhoff's current law (KCL) states that the algebraic sum of currents entering a node (or a closed boundary) is zero.

Mathematically, KCL implies that $\sum_{n=1}^{N} i_n = 0$

Where, N is the number of branches connected to the node and i_n is the nth current entering (or leaving) the node.

An alternative form of KCL: The sum of the currents entering a node is equal to the sum of the currents leaving the node.

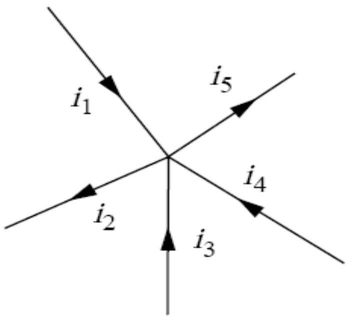


Figure.1 Currents at a node illustrating KCL

From the above figure we see that, currents $\mathbf{i_1}$, $\mathbf{i_3}$, and $\mathbf{i_4}$ are entering the node, while currents $\mathbf{i_2}$ and $\mathbf{i_5}$ are leaving it. By applying KCL we get,

$$\mathbf{i_1 + i_3 + i_4 = i_2 + i_5}$$

Current Division Rule: The total current i is shared by the resistors in inverse proportion to their resistances. This is known as the principle of current division, and the circuit in Figure. 2 is known as a current divider.

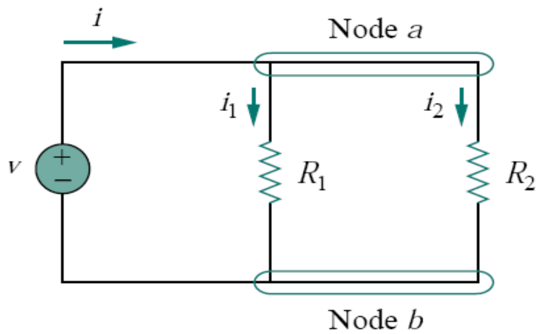


Figure.2 Two resistors in parallel

$$i_1 = \frac{R_2\, i}{R_1 + R_2}, \qquad i_2 = \frac{R_1\, i}{R_1 + R_2}$$

For three resistors in parallel:

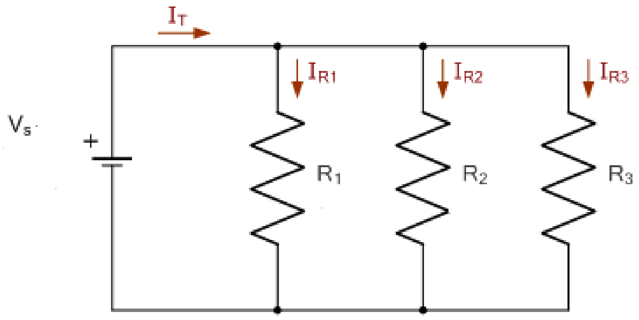


Figure.3 Three resistors in parallel

$$\boldsymbol{R_{eq}} = \left[\frac{\mathbf{1}}{\frac{\mathbf{1}}{\boldsymbol{R_1}}+\frac{\mathbf{1}}{\boldsymbol{R_2}}+\frac{\mathbf{1}}{\boldsymbol{R_3}}}\right]$$

$$\boldsymbol{I_{R1}} = \frac{\boldsymbol{R_{eq}}}{\boldsymbol{R_1}} \times \boldsymbol{I_T}$$

$$\boldsymbol{I_{R2}} = \frac{\boldsymbol{R_{eq}}}{\boldsymbol{R_2}} \times \boldsymbol{I_T}$$

$$\boldsymbol{I_{R3}} = \frac{\boldsymbol{R_{eq}}}{\boldsymbol{R_3}} \times \boldsymbol{I_T}$$

Ladder Circuit: The ladder circuit represents a commonly used circuit style that is configured purely on the basis of series and parallel connections.

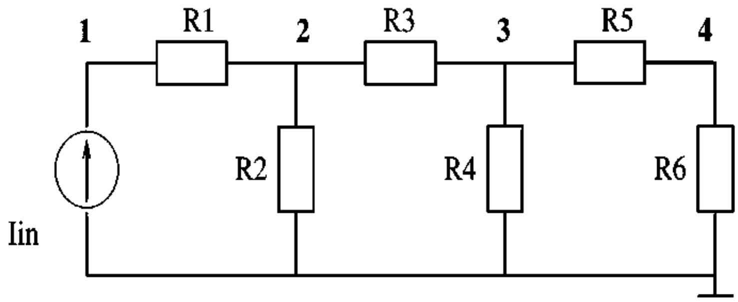
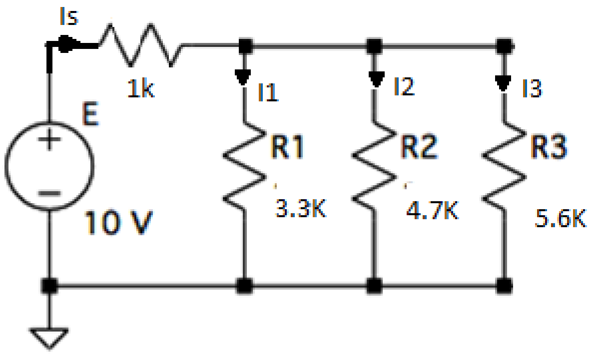
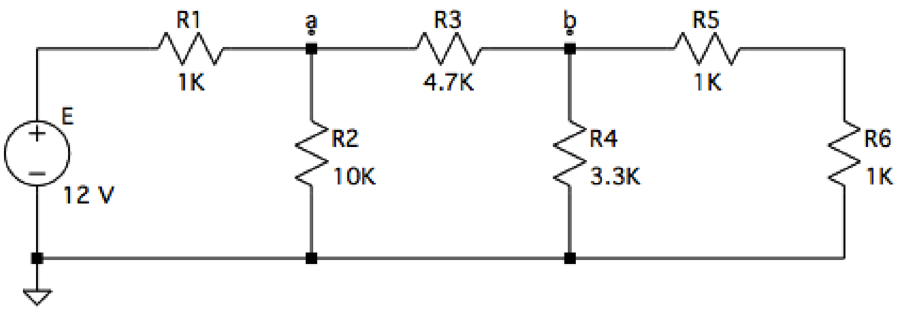


Figure.4 A three section ladder circuit

Circuit Diagram:



Circuit 1



Circuit 2

Procedure:

1. Identify all the given resistors using color coding and fill in the required columns in Table 1.
2. Measure the resistances of the resistors using the DMM and fill in the required column in Table 1.
3. Calculate the percentage error of the resistance values.
4. Percentage Error = |(Practical value – Theoretical value)| / Theoretical value
5. Build the circuit 1
6. Using the DMM, measure the currents $I_{s,}$ $I_{1,}$ $I_{2,\ \text{and}}$ I_3. Record the readings in Table 2.
7. Fill in Table 3.
8. Now, disconnect the voltage source from the circuit and measure the total load resistance, Req of the circuit using DMM. Note down values in Table 4.
9. Construct Circuit 2.
10. Using a DMM, measure the potential differences across all the resistors in circuit 2. Record all the readings in Table 5
11. Using a DMM, measure the current through all the resistors and record in Table 5.

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EEE41L/ETE141L

Data Collection

Lab 2

Group No. ________

Table 1:

Resistance using colour coding					Resistance using DMM	% Error
Band 1	**Band 2**	**Band 3**	**Band 4**	**Resistance ± tol**		

Table 2:

Experimental readings				Theoretical values			
I_S	I_{R1}	I_{R2}	I_{R3}	I_S	I_{R1}	I_{R2}	I_{R3}
% Error							
I_S		I_{R1}		I_{R2}		I_{R3}	

Table 3:

I_S		**Is Total Current equal to sum individual current?**
Sum of individual Current ($I_{R1} + I_{R1} + I_{R3}$)		

Table 4:

Experimental Req	Theoretical Req	% Error

Table 5:

Component	Voltage	Current
E		
R1		
R2		
R3		
R4		
R5		
R6		

Questions:

1. State the current division rule.
2. State the Kirchhoff's current law (KCL).
3. With the experimental data, verify Kirchhoff's voltage law within each independent closed loop of the circuit.
4. With the experimental data, verify Kirchhoff's current law at nodes *a* and *b* of the circuit.
5. Showing all steps, calculate the theoretical values in Table 2. Compare theoretical values to your experimental values and explain whether your circuit follows KCL or not.
6. Showing all the steps, theoretically calculate Req. Compare with the experimental value.
7. Calculate all the theoretical values for Table 5. Show all steps.

Useful Formula:

% Error = (Theoretical value – Experimental Value) / Theoretical Value