LAB 3: DC Circuit Analysis (Nodal and Loop Theorem)

A. Objective

The objective of this experiment aims to determine voltage and current using KCL, and KVL, respectively. At the end of this experiment, the student will be able to construct and know how to analyze electric circuit.

B. Instruments and Materials

The required instruments and components are:

- Adjustable DC power supply
- Breadboard
- DMM (Digital Multi-meter)
- Connecting wire (jumper wire 1 set)
- The ½ watt resistors

C. Theory

- **Nodal analysis:** In this method, one of the node is taken as the reference node and the other as an independent node. The voltage at the different independent nodes are assumed and the equations are written for each node as per KCL. After solving these equations, the node voltages are determined. Then, the branches currents are determined. This node is often the one to which the largest number of branches are connected. It is commonly called ground because it is said to be at ground-zero potential, and it sometimes represents ground line in a practical circuit.
- **Loop analysis:** In this method, mesh or loop currents are taken instead of branches currents (as in Kirchhoff's law). The following step are taken while solving a network by this method.

- The whole network is divided into several meshes. Each mesh is assigned a current having a continuous path (current is not split at a junction). These mesh currents are preferably drawn in the clockwise direction. The common branch carries the algebraic sum of the mesh currents flowing through it.
- Write the KVL equation for each mesh using the same sign applied to Kirchhoff's laws.
- Number of equations must be equal to number of unknown quantities. Solve the equations and determine the mesh currents.

D. Circuit Testing

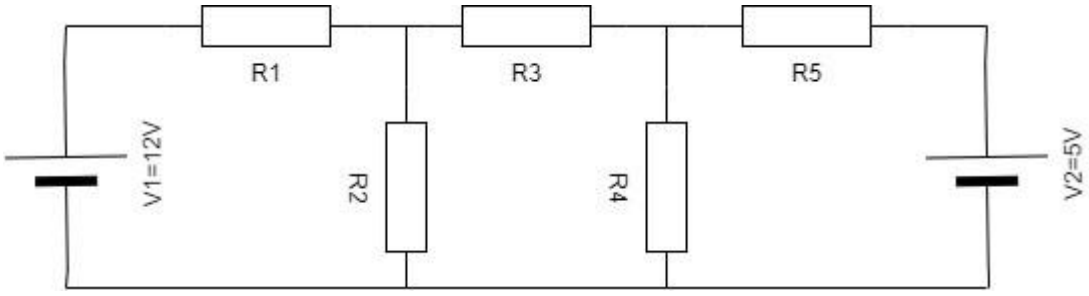

Figure 1

$R_1 = 560\Omega; R_2 = 220\Omega; R_3 = 470\Omega; R_4 = 200\Omega; R_5 = 680\Omega$

E. Experimental Procedure

1. Connect the circuit in **Fig.1** with the given values;
2. Turn on DC power supply and use DMM to measure the applied voltage **(V_1)** and **(V_2)**. Note the voltmeter readings;
3. Turn off the power supply and connect the circuit in **Fig.1** with the DC power supply;
4. Turn on the power supply and measure the voltage on a node by using DMM. Record the result to **Table 1**;
5. Measure the value of current by using the ammeter. Note the reading of Ammeters and record the results to **Table 1;**
6. Now, use the measured value of node voltage and use the measured value of current to verify nodal and loop analysis.
7. Verify the nodal and loop analysis with measured current and voltage.

   $V_A = 12v$; $V_E = 0v$; $V_D = 5v$

   • For node B

   $12 - V_B / 560 = V_B/220 + V_B - V_C / 470$

   • For node C

   $V_B - V_C / 470 = V_C / 200 + V_C - 5/680$

   $\Rightarrow V_B = 2.93v$

   $\Rightarrow V_C = 1.58v$

   • Find current

   $I_{R2} = V_B / R_2$, $I_{R3} = I_{R4} + I_{R5}$, $I_{R1} = I_{R2} + I_{R3}$

   $I_{R5} = V_C / R_5$, $I_{R4} = Vc/R_4$

   Loop analysis:

   • Loop1: $V_1 + R_1 \times I_1 + (I_1 - I_2) = 0$

   $\rightarrow 780\, I_1 - 220 I_2 = 12$

   • Loop2: $(I_2 - I_1) \times R_2 + R_3 \times I_2 + (I_2 - I_3) \times R_4 = 0$

   $\rightarrow 890 I_2 - 220\, I_1 - 200 I_3 = 0$

   • Loop3: $(I_2 - I_3) \times R_4 + R_5 \times I_3 - V_2 = 0$

   $\rightarrow 880 I_3 - 200 I_2 = 5$

   So, $I_3 = 0.007A$, $I_2 = 0.005A$, $I_1 = 0.017A$

   Thus, $V_A = 12v$; $V_D = 5v$; $V_E = 0v$

   $V_B = V_A - R_1 \times I_1 = 2.93v$;

   $Vc = V_B - (I_2 - I_1) \times R_2 - R_3 \times I_2 = 1.55$V

Table 1

	V_A	V_B	V_C	V_D	V_E	I_{R1}	I_{R2}	I_{R3}	I_{R4}	I_{R5}
Theoretical value (V, mA)	12	2.93	1.55	5	0	17m	13mA	12.5mA	75mA	5mA
Measured value (V, mA)	11.9	2.7	0.83	5.02	0.004	16.42m	12.24mm	13.10mm	78.5m	5.03m