Circuits and Electronics

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Course code: CSE250

Section: 14

Experiment no: 02

Experiment name: Introduction to series and parallel circuits.

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2 (1)

Name of the Experiment:

Introduction to series and parallel circuits.

Objective:

The experiment is to acquaint the students with series-parallel circuits and to give them the idea about how to connect different circuits in bread board.

Apparatus:

(i) DC power supplies

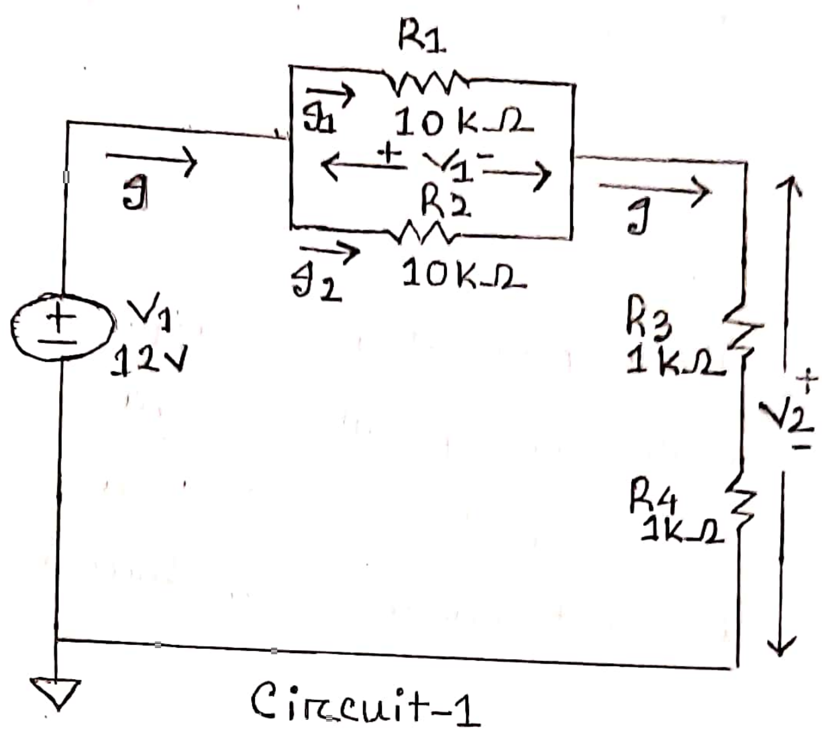
(ii) Resistors

(iii) Bread board / Trainer board

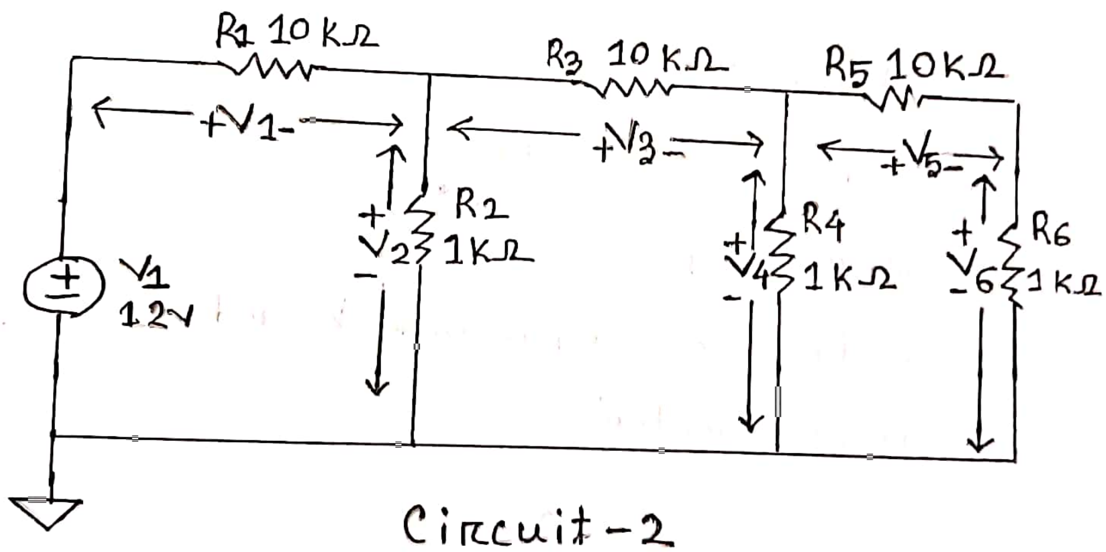
(iv) Multimeter

2(2)

Circuit / Block / System Diagram :



Circuit-1



Circuit-2

3(1)

Result/Analysis:

Circuit-1:

In Circuit-1, there are four resistors and they are R_1, R_2, R_3 and R_4. Here, R_1 and R_2 are connected in Parallel. On the other hand, R_3 and R_4 are connected in parallel. The voltage and current of each resistors are given below:

Here, $V = 12\ V$

$R_1 = R_2 = 10K\Omega$

$R_3 = R_4 = 1\ K\Omega$

$$\therefore \frac{1}{R_{12}} = \frac{1}{R_1} + \frac{1}{R_2}$$

$$\Rightarrow R_{12} = \frac{R_1 \times R_2}{R_2 + R_1} = \left(\frac{10\times10}{10+10}\right) K\Omega$$

$$= \left(\frac{100}{20}\right) K\Omega$$

$$= 5\ K\Omega = 5000\ \Omega$$

Again, $R_{34} = R_3 + R_4$

$$= (1+1)\ K\Omega = 2\ K\Omega = 2000\ \Omega$$

3(c)

Total resistance $R = R_{12} + R_{34}$

$= (5000 + 2000)\,\Omega$

$= 7000\,\Omega$

Total current $I = \frac{V}{R}$

$= \frac{12}{7000}$

$= 1.71428 \times 10^{-3}\,A$

$= 1.714\,mA$

Voltage $V_1 = I R_{12}$

$= (1.714 \times 5000)\,mV$

$= 8570\,mV$

$= 8.57\,V$

Here voltage V_1 for R_1 and R_2 resistors. As they are connected in parallel, their voltage will be same.

4(1)

Voltage $V_2 = I R_{34}$

$= (1.714 \times 2000)$ mV

$= 3428$ mV

$= 3.428$ V

$I_1 = \frac{V_1}{R_1} = \frac{8.57}{10 \times 10^3} = \cancel{0.857}$

$= 8.57 \times 10^{-4}$ A

$= 857$ μA

$I_2 = \frac{V_1}{R_2} = \frac{8.57}{10 \times 10^3}$

$= 8.57 \times 10^{-4}$ A

$= 857$ μA

Here R_3 ~~& R~~ and R_4 are connected in series. In series connection, the current folow will be same. So, there current flow is $I = I_3 = I_4$.

$\therefore I = I_3 = I_4 = 1.714$ mA

4(2)

However, In series connection, voltage will not be same. So, the voltage of R_3 and R_4 are given below:

Voltage of R_3

$$V_3 = I R_3$$
$$= (1.714 \times 1000 \times 10^{-3}) V$$
$$= 1.714 \text{ V}$$

Voltage of R_4

$$V_4 = (1.714 \times 10^{-3} \times 1 \times 10^3) V$$
$$= 1.714 \text{ V}$$
$$V_5 = V_3 = V_4 = 1.714 V$$

The hand calculation and the results using PSpice simulation are given below:

	Theoretical calculation	PSpice Simulation result
V	12V	12V
V_1	8.57V	8.571V
V_2	3.428V	3.429V
$V_5 = V_3 = V_4$	1.714V	1.714V
I	1.714mA	1.714mA
I_1	857 μA	857.14 μA
I_2	857 μA	857.14 μA
$I = I_3 = I_4$	1.714mA	1.714mA

5 (i)

Circuit-2:

In circuit-2, there are 6 resistors and they are R_1, R_2, R_3, R_4, R_5 and R_6. The voltage and current of each resistor are given below:

$V = 12\,V$

$R_1 = R_3 = R_5 = 10\,k\Omega = 10000\,\Omega$

$R_2 = R_4 = R_6 = 1\,k\Omega = 1000\,\Omega$

Here, R_5 and R_6 are connected in series.

$$\therefore R_{56} = R_5 + R_6$$
$$= (10+1)\,k\Omega$$
$$= 11\,k\Omega$$

Here, R_4 and R_{56} are in parallel.

$$\therefore R_{456} = \frac{R_{56} \times R_4}{R_4 + R_{56}}$$
$$= \left(\frac{1 \times 11}{1+11}\right) k\Omega$$
$$= \frac{11}{12}\,k\Omega$$

5(c)

Now, R_3 and R_{456} are in series.

$$\therefore \; R_{3456} = R_3 + R_{456}$$
$$= \left(10 + \frac{11}{12}\right) k\Omega$$
$$= \left(\frac{131}{12}\right) k\Omega$$

Here, R_2 and R_{3456} are in parallel.

$$\therefore \; R_{23456} = \frac{R_2 \times R_{3456}}{R_{3456} + R_2}$$
$$= \left(\frac{1 \times \frac{131}{12}}{\frac{131}{12} + 1}\right) k\Omega$$
$$= \frac{131}{143} k\Omega$$

Now, R_1 and R_{23456} are connecte in series.

$$\therefore \; R_{123456} = R_1 + R_{23456}$$
$$= \left(10 + \frac{131}{143}\right) k\Omega$$
$$= \left(\frac{1561}{143}\right) k\Omega$$
$$= 10916.084\,\Omega$$

6 (i)

Total current $I = \frac{V}{R_{123456}}$

$= \frac{12}{10916.089}$

$= 1.099295315 \times 10^{-3} A$

$= 1.099 mA$

Voltage $V_{23456} = I R_{23456}$

$= 1.099 \times 10^{-3} \times \frac{131}{143} \times 1000$

$= 1.007 V$

Current $I_2 = \frac{V_{23456}}{R_2}$

$= \frac{1.007}{1 \times 10^3} = 1.007 \times 10^{-3} A$

$= 1.007 mA$

Current $I_{3456} = \frac{V_{23456}}{R_{3456}}$

$= \frac{1.007}{\frac{131}{12} \times 1000}$

$= (9.22442 \times 10^{-5}) A$

$= 92.24 \mu A$

d2)

Voltage $V_{456} = I_{3456} \times R_{456}$

$= 92.24 \times 10^{-6} \times \frac{11}{12} \times 1000$

$= 0.084553\ V$

$= 84.56\ mV$

Current $I_4 = \frac{V_{456}}{R_4}$

$= \frac{84.56 \times 10^{-3}}{1 \times 10^3}$

$= 8.456 \times 10^{-5}\ A$

$= 84.56\ \mu A$

$I_{5} = \frac{V_{456}}{R_{56}}$

$= \frac{84.56 \times 10^{-3}}{(1+10) \times 10^3}$

$= 7.6872 \times 10^{-6}\ A$

$= 7.687\ \mu A$

$I_5 = I_6$ as they are in series connection.

$\therefore\ V_6 = I_6 \times R_6$

$= 7.687 \times 10^{-6} \times 1 \times 10^3$

$= 7.687 \times 10^{-3}\ V = 7.687\ mV$

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7 (i)

The hand calculation and the results using PSpice simulation are given below:

	Theoretical Calculation	PSpice Simulation result
V	12 V	12 V
I	1.099 mA	1.099 mA
V_{23456}	1.007 V	1.007 V
I_2	1.007 mA	1.007 mA
I_{3456}	92.24 μA	92.25 μA
V_{456}	84.56 mV	84.56 mV
I_5	7.687 μA	7.687 μA
I_6	7.687 μA	7.687 μA
V_6	7.687 mV	7.687 mV

Questions and Answers:

1. Using the recorded value of resistors, calculate the value of the currents and check if there is any discrepancies.

→ By using the recorded value of resistors, there is a small amout of

7(2)

discrepancies. The amout is very much little. The amout is less than 0.01%.

2. You are given six 100 ohm resistors. Arrange these resistors as to provide an effective resistance value of 300 ohm.

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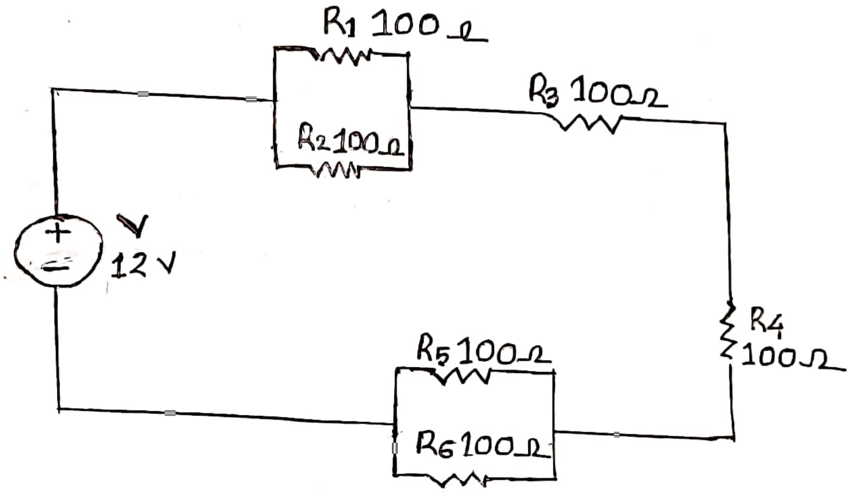

Here, R_1 and R_2 are in Parallel:

$$\therefore \quad R_{12} = \frac{R_1 \times R_2}{R_1 + R_2} = \frac{100 \times 100}{100 + 100} = 50\Omega$$

R_3 and R_4 are in series connection

$$R_{34} = R_3 + R_4 = 100 + 100 = 200\Omega$$

R_5 and R_6 are in parallel connection.

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(i)

Here, R_1 and R_2 are in parallel connection

$$\therefore R_{12} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1} = \left(\frac{1}{100} + \frac{1}{100}\right)^{-1} \Omega$$

$$= 50 \Omega$$

R_5 and R_6 are also in parallel connetion.

$$\therefore R_{56} = \left(\frac{1}{R_5} + \frac{1}{R_6}\right)^{-1} = \left(\frac{1}{100} + \frac{1}{100}\right)^{-1} \Omega$$

$$= 50 \Omega$$

R_{12}, R_3, R_4 and R_{56} are in series connection.

$$\therefore \text{Total } R = (R_{12} + R_3 + R_4 + R_{56}) \Omega$$

$$= (50 + 100 + 100 + 50) \Omega$$

$$= 300 \Omega$$

3. You are given two 1.5 Kohm resistors and six 15 Kohm resistors. Arrange these resistors as to provide an effective resistance value of 3.25 KOhm.

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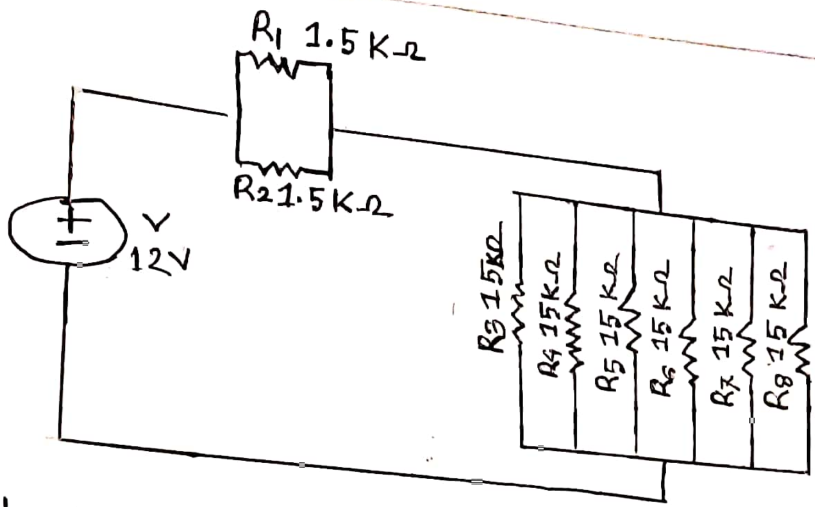


Here, R_1 and R_2 are in paralle connection:

$$\therefore R_{12} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1} = \left(\frac{1}{1.5} + \frac{1}{1.5}\right)^{-1} K\Omega$$

$$= 0.75 \ K\Omega$$

Here, R_3, R_4, R_5, R_6, R_7 and R_8 are in parallel connection:

$$\therefore R_{345678} = \left(\frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5} + \frac{1}{R_6} + \frac{1}{R_7} + \frac{1}{R_8}\right)^{-1}$$

$$= \left(\frac{1}{15} + \frac{1}{15} + \frac{1}{15} + \frac{1}{15} + \frac{1}{15} + \frac{1}{15}\right)^{-1} K\Omega$$

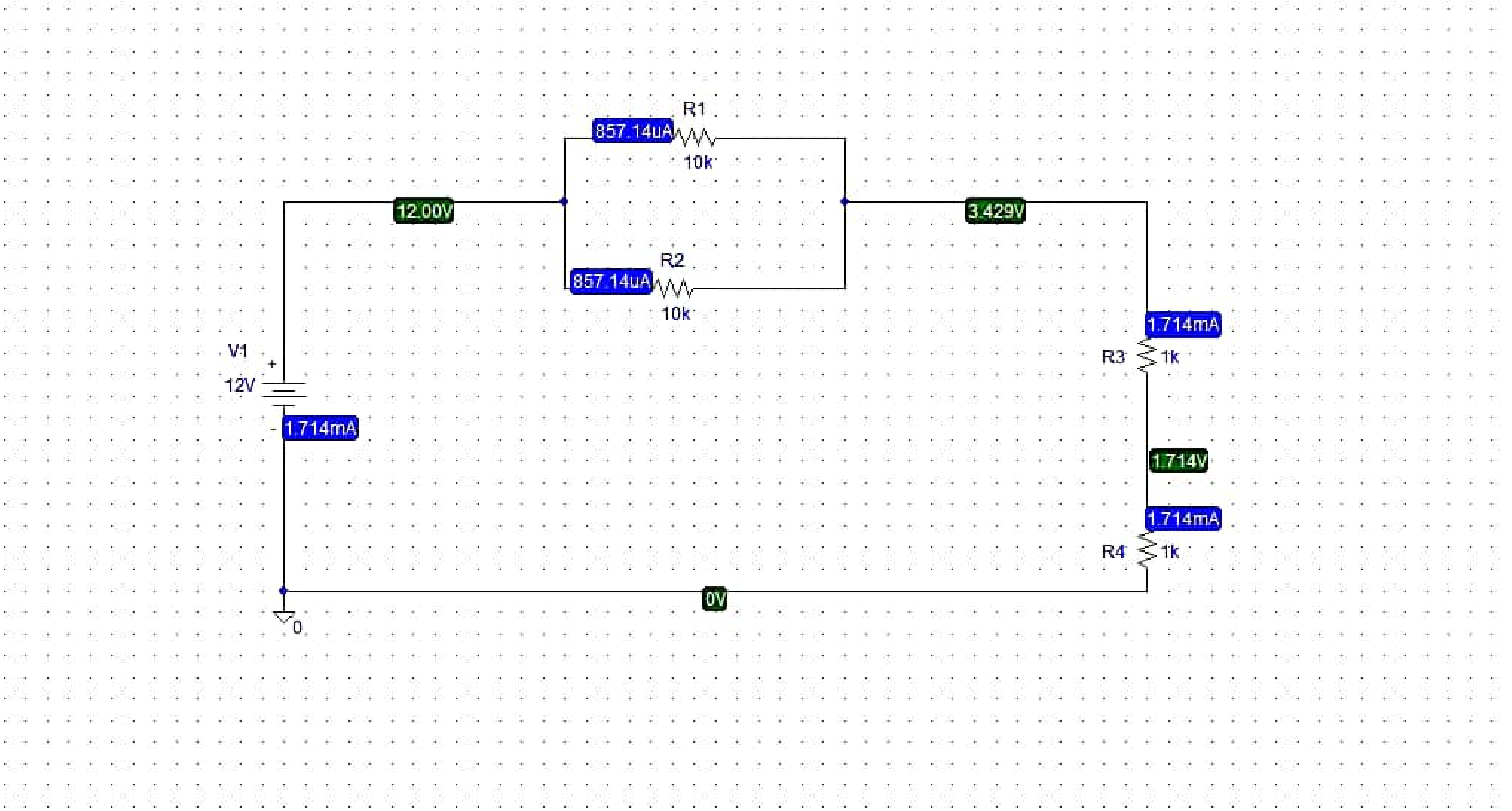
$$= 2.5 \ K\Omega$$

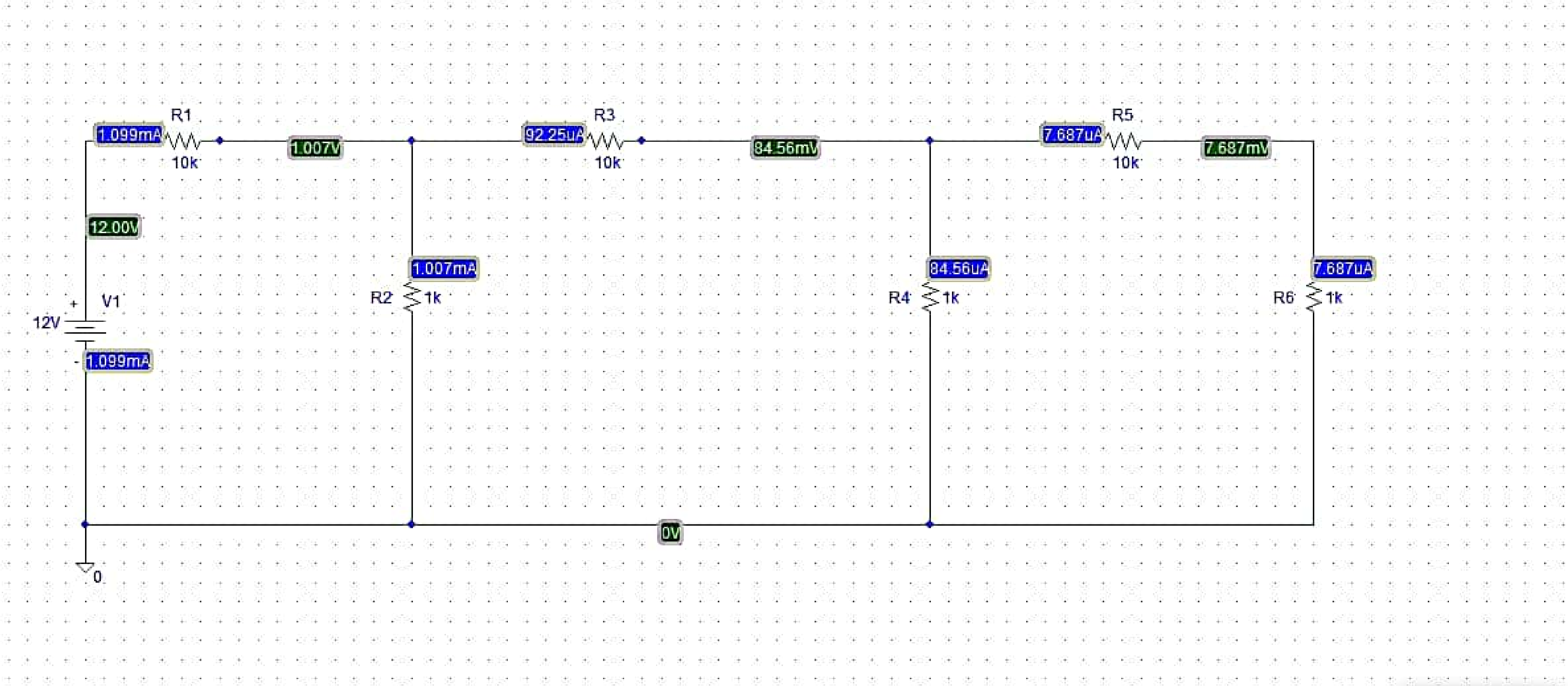
$\therefore$ R_{12} and R_{345678} are in series connection.

$$\therefore \text{Total } R = R_{12} + R_{345678}$$

$$= (0.75 + 2.5) \ K\Omega$$

$$= 3.25 \ K\Omega$$


R1
857.14uA
10k
12.00V
3.429V
R2
857.14uA
10k
1.714mA
R3
1k
V1
+
12V
-
1.714mA
1.714V
1.714mA
R4
1k
0V
0


R1
1.099mA
10k
1.007V
R3
92.25uA
10k
84.56mV
R5
7.687uA
10k
7.687mV
12.00V
1.007mA
R2
1k
84.56uA
R4
1k
7.687uA
R6
1k
+
V1
12V
-
1.099mA
0V
0