EE281 EXPERIMENT 1

REPORT SHEET

Name & Surname : Mustafa Sezgin

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1. **Experimental Work: Theoretical solutions**

Your theoretical solutions must be here in order like experiment sheet. You must use a text based program such as word, LaTeX, Overleaf etc.

1.
Circuit 1:

By KCL
- At the node n001: V(n001) = **5V = V_1**

$I_1 = 5V/R_1 = 5V/1k\Omega =$ **5mA = I_1** --- by Ohm's Law

Circuit 2:

By KCL
- At the node n001: V(n001) = 5V
- At the node n002: $0 = (V(n002) - 5V)/R_1 + V(n002)/R_2$

(1.10mS)V(n002) = 5V-mS
V(n002) = **4.55V = V_3**
5V – 4.55V = **0.45V = V_2**

$I_2 = 4.55V/R_2 = 4.55V/10k\Omega =$ **0.45mA = I_2** --- by Ohm's Law

Circuit 3:

By KCL
- At the node n001: V(n001) = **5V = V_4 = V_5**

$I_3 = 5V/R_1 = 5V/1k\Omega =$ **5mA = I_3** --- by Ohm's Law
$I_4 = 5V/R_2 = 5V/10k\Omega =$ **0.5mA = I_4** --- by Ohm's Law

Circuit 4:

By KCL
- At the node n001: V(n001) = 5V
- At the node n002: $0 = (V(n002) - 5V)/R_1 + V(n002)/R_2 + V(n002)/R_2$

(1.20mS)V(n002) = 5V-mS
V(n002) = **4.17V = V_7 = V_8**
5V – 4.17V = **0.83V = V_6**

$I_5 = 0.83V/R_1 = 0.83V/1k\Omega =$ **$0.83mA = I_5$** --- by Ohm's Law
$I_6 = 4.17V/R_2 = 4.17V/10k\Omega =$ **$0.42mA = I_6$** --- by Ohm's Law
$I_7 = 4.17V/R_2 = 4.17V/10k\Omega =$ **$0.42mA = I_7$** --- by Ohm's Law

Circuit 5:

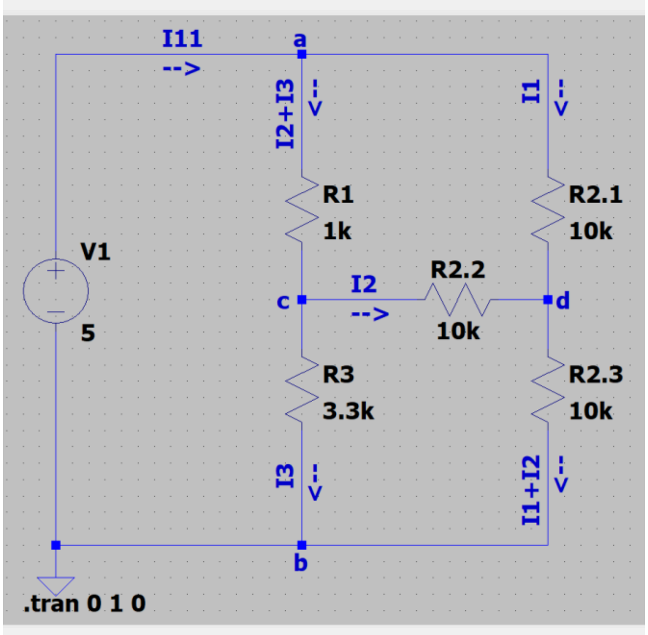
By KCL
- At the node n001: V(n001) = 25V
- At the node n002: $0 = (V(n002) - 25V)/R_1 + V(n002)/R_2 + (V(n002) - V(n003))/R_3$
- At the node n003: $0 = (V(n003) - V(n002))/R_3 + V(n003)/R_2$

(1.40mS)V(n002) - (0.30mS)V(n003) = 25V-mS
(-0.30mS)V(n002) + (0.40mS)V(n003) = 0

Solving the system, we get
V(n002) = **$21.27V = V_{11}$**
V(n003) = **$15.99V = V_{12}$**
25V – 21.27V = **$3.73V = V_9$**
21.27V - 15.99 = **$5.28V = V_{10}$**

$I_8 = 3.73V/R_1 = 3.73V/1k\Omega =$ **$3.73mA = I_8$** --- by Ohm's Law
$I_9 = 15.99V/R_2 = 15.99V/10k\Omega =$ **$1.60mA = I_9$** --- by Ohm's Law
$I_{10} = 21.27V/R_2 = 21.27V/10k\Omega =$ **$2.13mA = I_{10}$** --- by Ohm's Law

2.
Circuit 6:



By KCL
- At the node a: $V_a = 5V$
- At the node c: $0 = (V_c - 5V)/R_1 + (V_c - V_d)/R_2 + V_c/R_3$
- At the node d: $0 = (V_d - 5V)/R_2 + (V_d - V_c)/R_2 + V_d/R_2$

$(1.40mS)V_c - (0.10mS)V_d = 5V\text{-}mS$
$(-0.10mS)V_c + (0.30mS)V_d = 0.5V\text{-}mS$

Solving the system, we get
$V_c = 3.77V$
$V_d = 2.92V$

$I_1 = (5V – 2.92V)/R_2 = 2.07V/10k\Omega = 0.21mA$ --- by Ohm's Law
$I_2 = (3.77V - 2.92V)/R_2 = 0.85V/10k\Omega = 0.08mA$ --- by Ohm's Law
$I_3 = 3.77V/R_3 = 3.77V/3.3k\Omega = 1.14mA$ --- by Ohm's Law
$I_{11} = I_1 + I_2 + I_3 =$ **$1.44mA = I_{11}$** --- by KCL
$R_{ab} = 5V/1.44mA =$ **$3.48k\Omega = R_{ab}$** --- by Ohm's Law

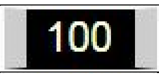
3.

Table 1

Resistors	Color Codes (10% Tolerance)
22 kΩ	Red, Red, Orange, Silver
3.3 kΩ	Orange, Orange, Red, Silver
12 kΩ	Brown, Red, Orange, Silver
18 kΩ	Brown, Grey, Orange, Silver
1 MΩ	Brown, Black, Green, Silver

4.

Table 3

SMD Resistor	Resistance Value	Calculation method
	10 Ω	$10*10^0\ \Omega = 10\ \Omega$
	4.7 kΩ	$47*10^2\ \Omega = 4700\ \Omega$
	0.1 Ω	0.1 Ω
	0.2 Ω	0.2 Ω
	10 kΩ	$100*10^2\ \Omega = 10000\ \Omega$

Comment: In the first and second questions, nodal analysis method is used for each circuit. I have used the node names that are consistent with the convention of LTspice. In the third and fourth questions, I can read the resistor values according to the tables given in the report sheet and what is taught at the laboratory demonstration.

2. Experimental Work: Simulation solutions

Your simulation circuits drawn in LTspice and results must be here in order like experiment sheet. You can use snipping tool, powerpoint, paint or any picture editor for taking circuits and results from LTspice screen.

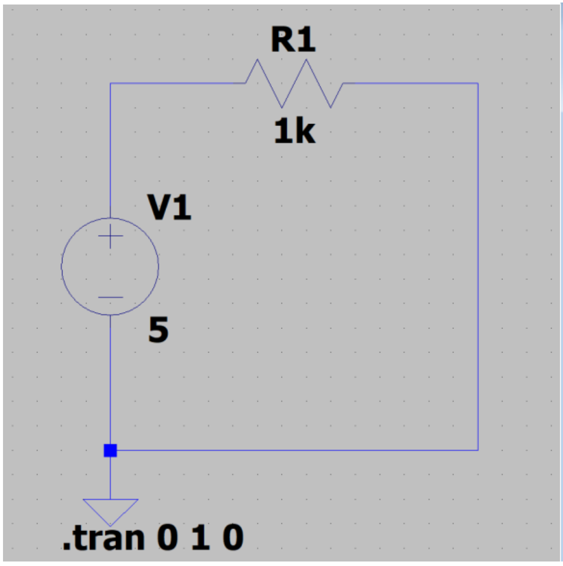
You can study the LTspice tutorials that we provide for your problematic issues.

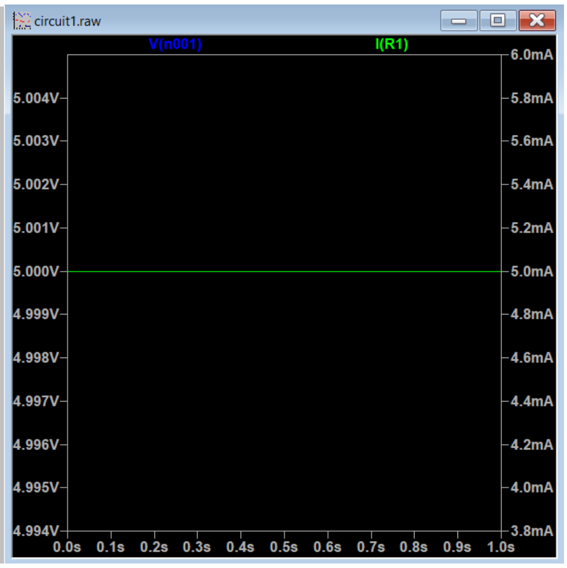
After obtained results, please fill and put the table given below end of this section.

1.

i.

Circuit 1 with no tolerances:



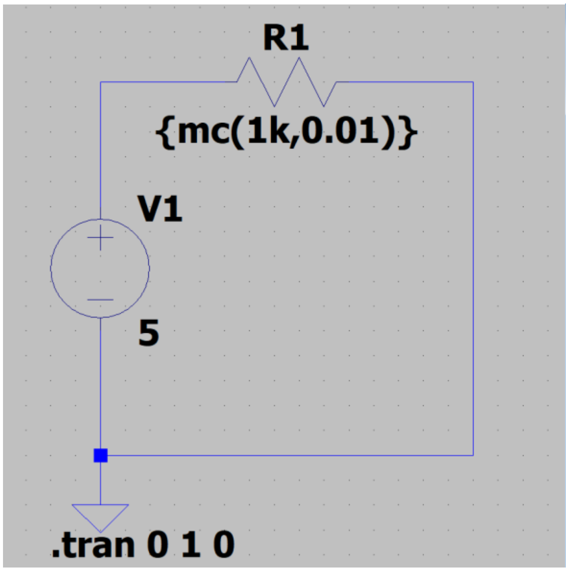


$I_1 = I(R1) = 5.00mA$

$V_1 = V(n001) - ground = 5.00V - 0V = 5.00V$

ii.

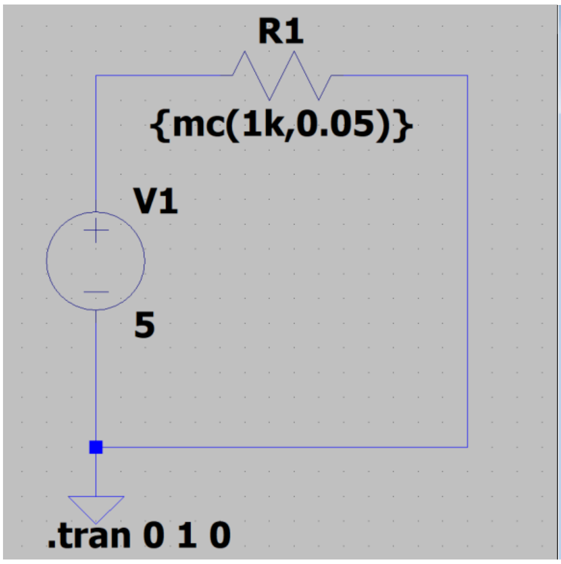
Circuit 1 with 1% tolerances:



$I_1 = I(R1) = 5.05mA$

$V_1 = V(n001) - ground = 5.00V - 0V = 5.00V$

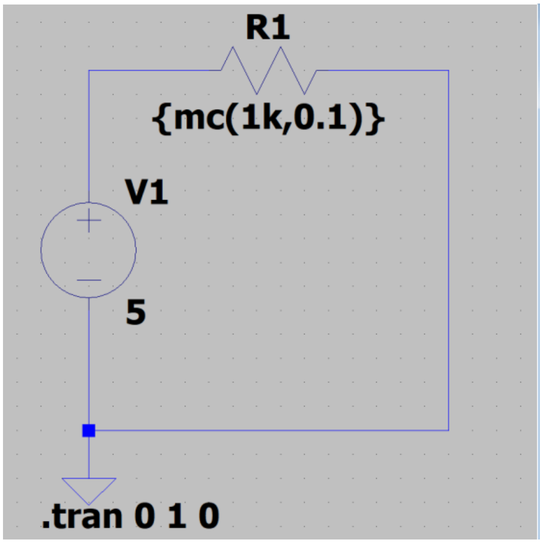
Circuit 1 with 5% tolerances:

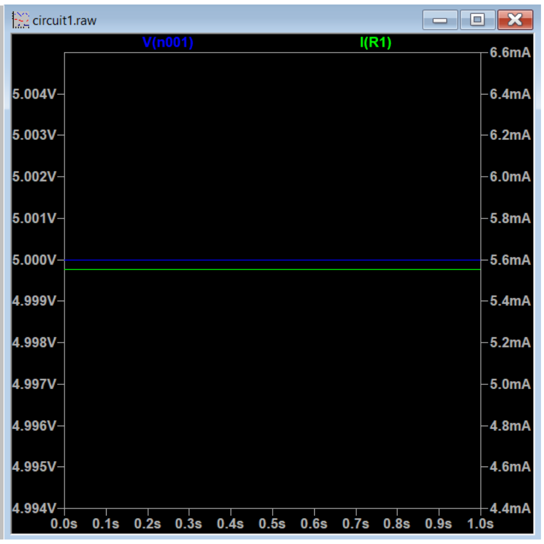


$I_1 = I(R1) = 5.26mA$

$V_1 = V(n001) - ground = 5.00V - 0V = 5.00V$

Circuit 1 with 10% tolerances:





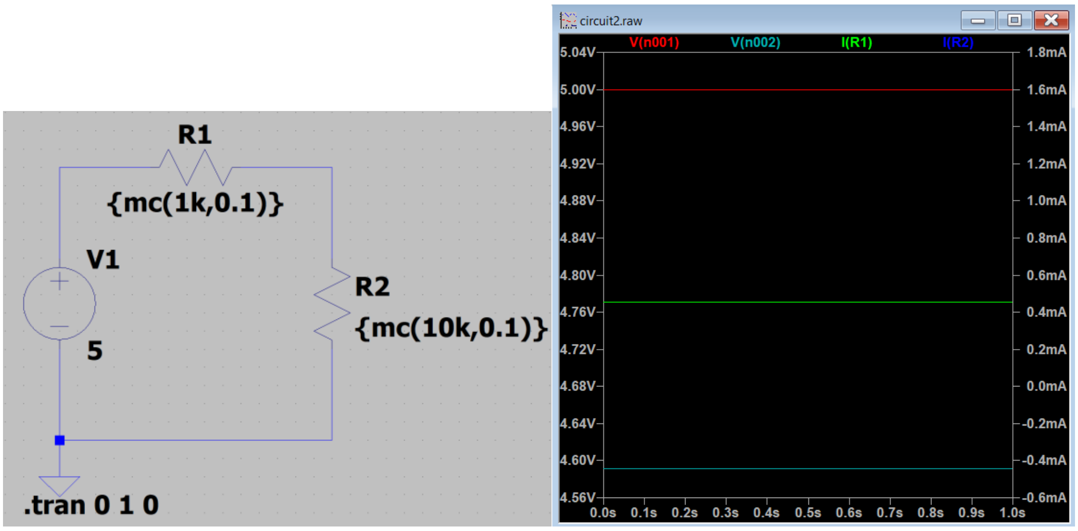
$I_1 = I(R1) = 5.55mA$

$V_1 = V(n001) - ground = 5.00V - 0V = 5.00V$

iii. As the tolerance rate increases, the gap between the toleranced and the nominal values of currents increases. However, the potential differences between the ends of resistors remain the same at each scenario. The worst case for current is the one that has a resistor with 10% tolerance.

2.

Circuit 2 with 10% tolerances:

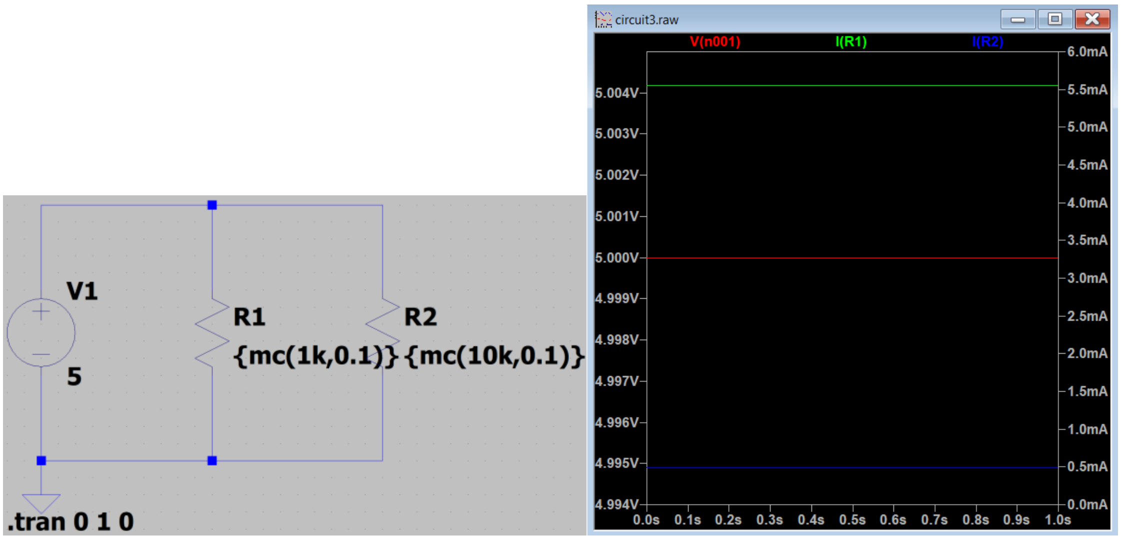


$I_2 = I(R1) = I(R2) = 453.42\mu A$

$V_2 = V(n001) - V(n002) = 5.00V - 4.59V = 408.19mV$

$V_3 = V(n002) - \text{ground} = 4.59V - 0V = 4.59V$

Circuit 3 with 10% tolerances:

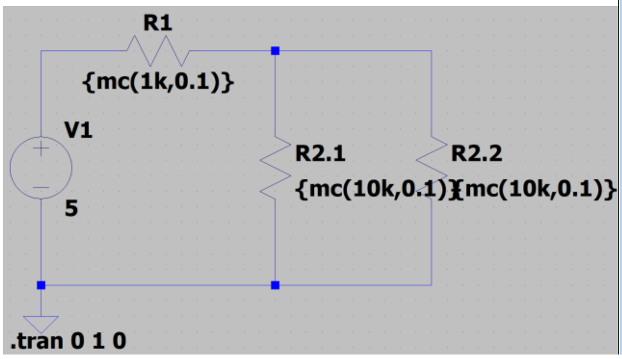


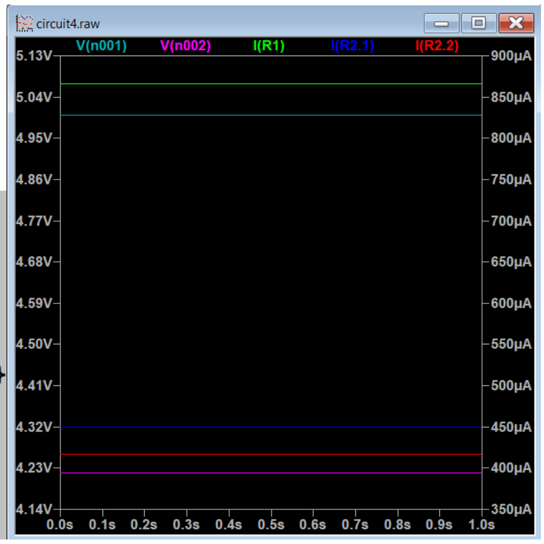
$I_3 = I(R1) = 5.55mA$

$I_4 = I(R2) = 493.72\mu A$

$V_4 = V_5 = V(n001) - \text{ground} = 5.00V - 0V = 5.00V$

Circuit 4 with 10% tolerances:





I_5 = I(R1) = 866.30µA

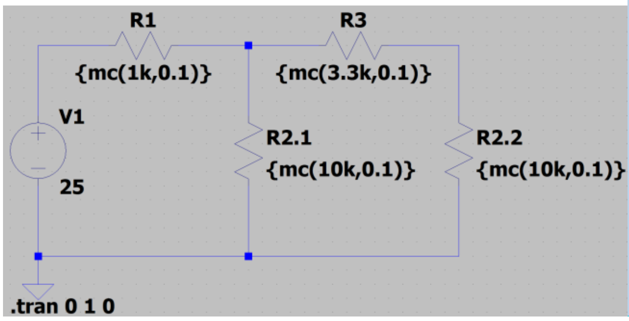
I_6 = I(R2.1) = 449.59µA

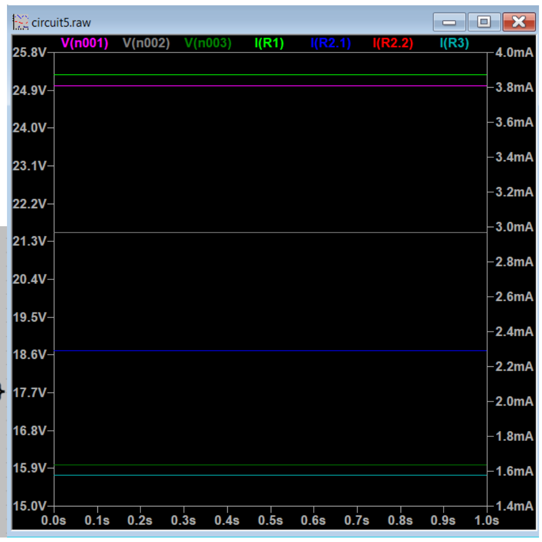
I_7 = I(R2.2) = 416.71µA

V_6 = V(n001) - V(n002) = 5.00V - 4.22V = 779.89mV

V_7 = V_8 = V(n002) - ground = 4.22V - 0V = 4.22V

Circuit 5 with 10% tolerances:





I_8 = I(R1) = 3.87mA

I_9 = I(R2.1) = 2.29mA

I_{10} = I(R2.2) = I(R3) = 1.58mA

V_9 = V(n001) - V(n002) = 25.00V - 21.52V = 3.48V

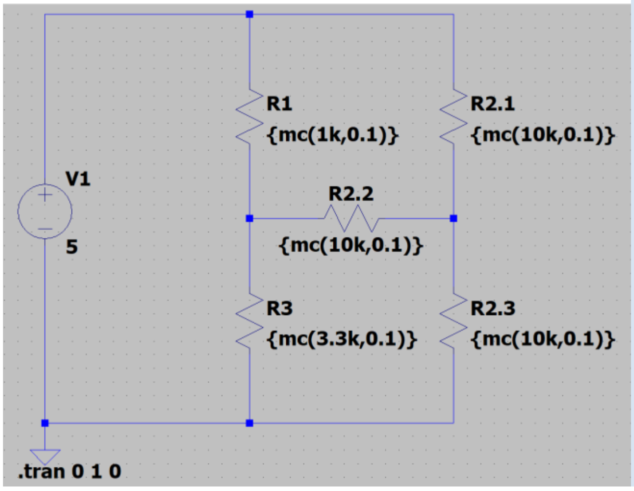
V_{10} = V(n002) - V(n003) = 21.52V - 15.99V = 5.53V

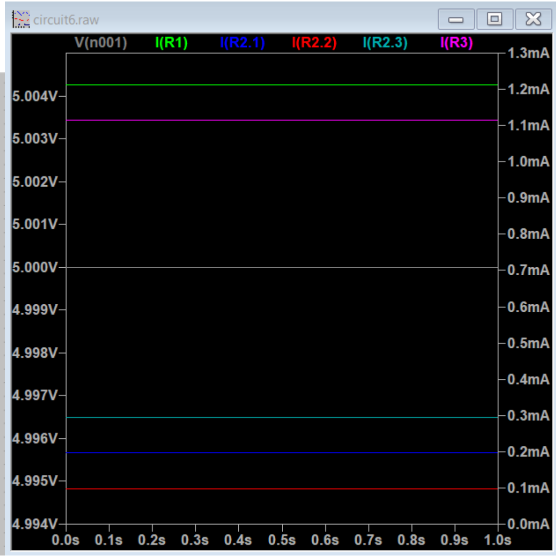
V_{11} = V(n002) - ground = 21.52V - 0V = 21.52V

V_{12} = V(n003) - ground = 15.99V - 0V = 15.99V

4.

Circuit 6 with 10% tolerances:





I_{11} = I(R1) + I(R2.1) = 1.21mA + 197.72µA = 1.410mA

V_{ab} = V(n001) - ground = 5.00V - 0V = 5.00V

R_{ab} = V_{ab}/I_{11} = 5.00V/1.41mA = 3.55kΩ

The theoretical results are consistent with the experimental results with some differences due to tolerances of the resistors.

	Voltages				Currents	
	Simulation	Calculated			Simulation	Calculated
V_1	5.00V	5.00V		I_1	5.55mA	5.00mA
V_2	408.19mV	0.45V		I_2	453.42µA	0.45mA
V_3	4.59V	4.55V		I_3	5.55mA	5.00mA
V_4	5.00V	5.00V		I_4	493.72µA	0.50mA
V_5	5.00V	5.00V		I_5	866.30µA	0.83mA
V_6	779.89mV	0.83V		I_6	449.59µA	0.42mA
V_7	4.22V	4.17V		I_7	416.71µA	0.42mA
V_8	4.22V	4.17V		I_8	3.87mA	3.73mA
V_9	3.48V	3.73V		I_9	2.29mA	2.13mA

V_{10}	5.53V	5.28V		I_{10}	1.58mA	1.60mA
V_{11}	21.52V	21.27V				
V_{12}	15.99V	15.99V				

Comments: The theoretical results are consistent with the experimental results with some differences due to tolerances of the resistors. In simple circuits, the current values differ up to 10%, which is the tolerance rate.

3. Conclusion:

This part is prepared after online laboratory demonstration. You must compare the results from your simulations and online laboratory demonstration. Also, answer the questions from online laboratory demonstration.

Comments: In general, my simulation results tend to have bigger differences to the theoretical results than the ones found in the online laboratory demonstration. The current values I have found in simulation have a distortion rates up to 10%, which is the tolerance rate of all resistors used in each circuit; however, the voltage values of the nodes that the voltage sources are connected to are exact. For example, V1 value is exactly 5V in the first circuit because there are just two nodes. On the other hand, in the online laboratory demonstration, the current and voltage values have small distortion rates that are around 1%, and bigger distortions tend to occur less frequently. In physical conditions, the difference of the values depends also on the complexity of the circuit, temperature of the circuit elements, precision of the sources etc. as well as the resistor tolerances.

Q-1: How many measurement terminals of multimeter are used when measuring resistance, current and voltage? What is the importance of the polarity of the measurement terminals?

Two terminals are used to measure resistance, current, and voltage. The polarity of the terminals changes the polarity of potential difference and current values; however, it does not have any effect on the resistor value.

Q-2: How to connect the ammeter and voltmeter to the measured element? Parallel or series and how?

Ammeter is connected to circuit in series. The red cable is connected between high potential node on circuit and mA port on the multimeter, and the black cable is connected between low potential node on circuit and COM port on the multimeter. Voltmeter is connected to circuit in parallel. The red cable is connected between high potential node on circuit and V port on the multimeter, and the black cable is connected between low potential node on circuit and COM port on the multimeter.

Q-3: If I used 1 Ohm instead of 1k Ohm in figure 1 circuit, what happens on the physical circuit?

The current would be 5A. The energy supplied by the voltage source and dissipated by the resistor would also be multiplied by a thousand, namely 5W. However, since the physical resistor has a power limit, which is 250mW in the demo, the resistor would burn due to over limit.

Q-4: How tolerances distort measurements for circuits containing resistors only? How the situation changes for serial and parallel connections.

The current values change up to the rate of the tolerances in the worst cases. When resistors are connected in series, since the current value depends on all the resistors, the distortion on it also depends on the tolerance rates of all the resistances. On the other hand, when resistors are connected in parallel, the tolerance of the resistor distorts the current on its own branch. The current at the parallel branch does not depend on the tolerance of that resistor.