Faculty of Engineering and Technology

Electrical and Computer Engineering Department

CIRCUITS AND ELECTRONICS LABORATORY– ENEE2103

Experiment No. 2 Prelab

Circuit Laws and Theorems

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Prelab instructions:

1. Simulate the circuits in the procedure section and determine the required values (set the parameters that must be assigned by the instructor in the procedure to proper values).

2. Verify if Simulation Results match the expected results

Procedure and Discussion

Part 1: KCL and KVL

Measure the value of the resistances given to you by the lab instructor and make sure they match those in Fig 1.

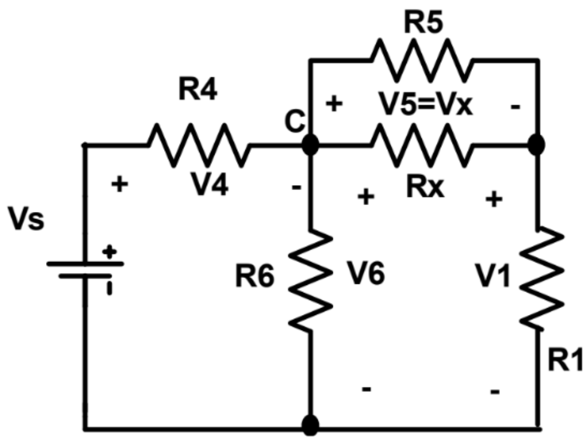

Figure 1 Original circuit

Measure and fill the values required in table 1.

When Rx = 1k Ω

Consider Rx=R1=R4=1kΩ, R5=3.3kΩ, R6=4.7kΩ, Vs = 15V for first part as the following circuit:

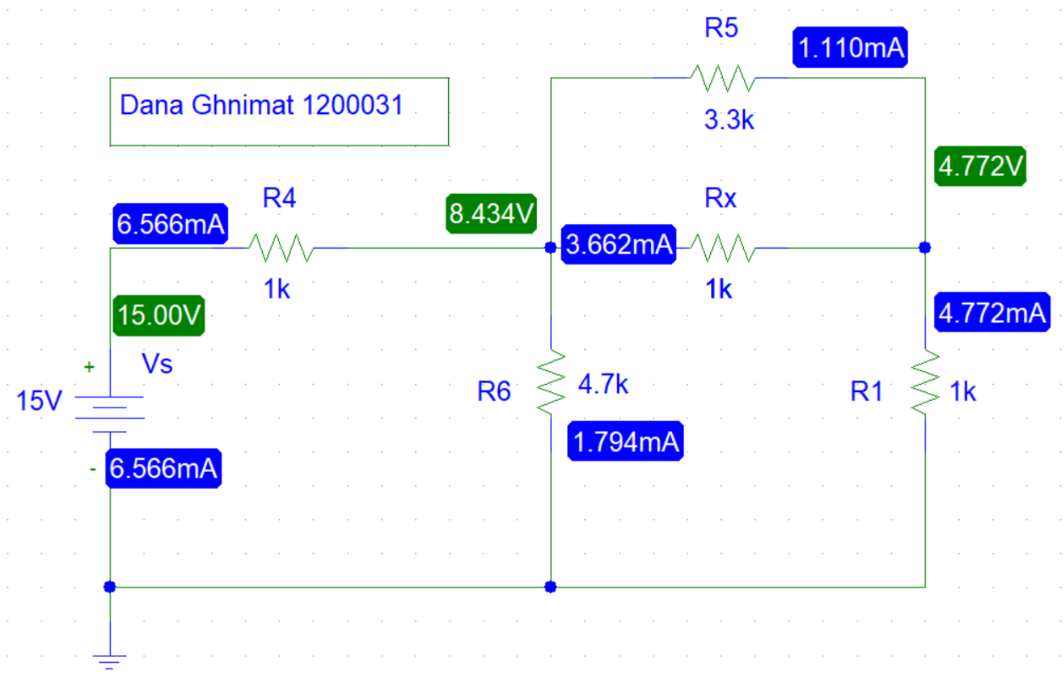

Figure 2 PSpice circuit KVL, KCL when R=1k

By taking R5 from figure 2 to get the value of the voltage, since V5 = Vx.

V= IR

= 1.110mA * 3.3kΩ = 3.66V

using KVL:

= 8.434V - 4.772V
= 3.66V

For other resistors:

V4 = 15 V - 8.434V = 6.566V

V5 = 8.434 V - 4.722V = 3.662 V

V1 = 4.772 V - 0 V = 4.772V

V6 = 8.434 V - 0 V = 8.434V

When Rx =0.5k Ω

Consider R1=R4=1kΩ, R5=3.3kΩ, R6=4.7kΩ, Rx = 0.5k **Ω**, Vs = 15V for second part as the following circuit:

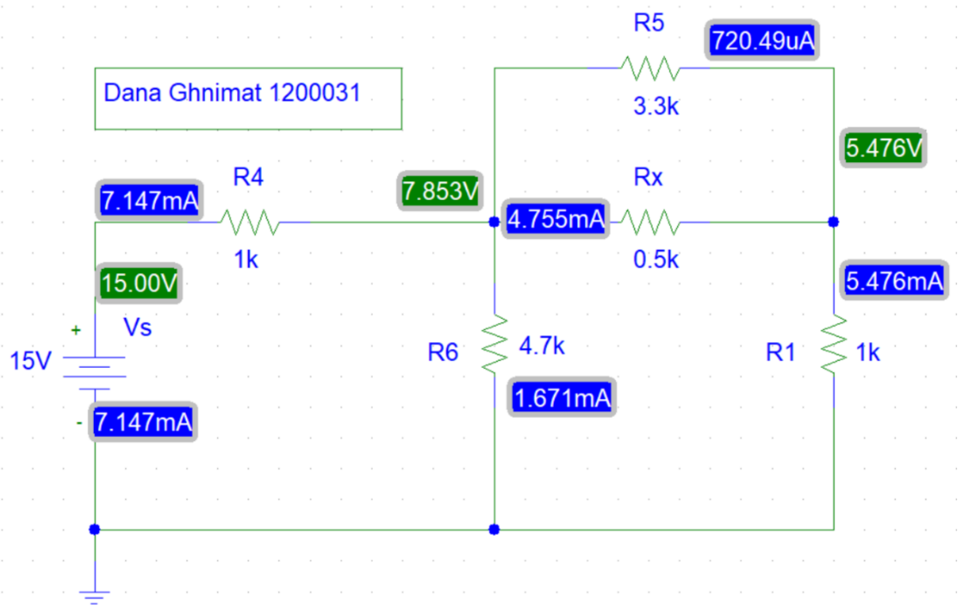

Figure 3 PSpice circuit KVL, KCL when Rx=0.5k

By taking R5 from figure 3 to get the value of the voltage:

$V = IR$

$= 720.49uA * 3.3k\Omega = 2.377\ V$

Using KVL:

$= 7.853V - 5.476V$
$= 2.377V$

For other resistors:

$V4 = 15V - 7.853V = 7.147V$

$V5 = 7.853V - 5.476V = 2.377V$

$V1 = 5.476V - 0V = 5.476\ V$

$V6 = 7.853V - 0V = 7.853V$

Table 1 Voltage and Current Values

Vs	**Pot**	**R1**		**Rx**		**R4**		**R5**		**R6**	
		V_1	I_1	V_x	I_x	V_4	I_4	V_5	I_5	V_6	I_6
15V	Rx	4.772V	4.77mA	3.66V	3.66mA	6.56V	6.56mA	3.66V	1.11mA	8.43V	1.79mA
15V	0.5Rx	5.476V	5.47mA	2.37V	4.75mA	7.14V	7.14A	2.37V	720.4uA	7.85V	1.67mA

We noticed from our previous analysis that the number of the simulation matched the KVL Rule on Rx.

For KCL when Rx = 0.5k.

$I5 + Ix = I1.$
4.75 + 0.720 = 5.475 mA which matches the simulation with small error.

Part 2: Voltage & Current Division:

I. Voltage division

After we disconnected the resistance R5 from the circuit, R4 = R1= Rx=1kΩ R6=4.7kΩ and made the voltage source equal 10V.

When Rx = 1kΩ:

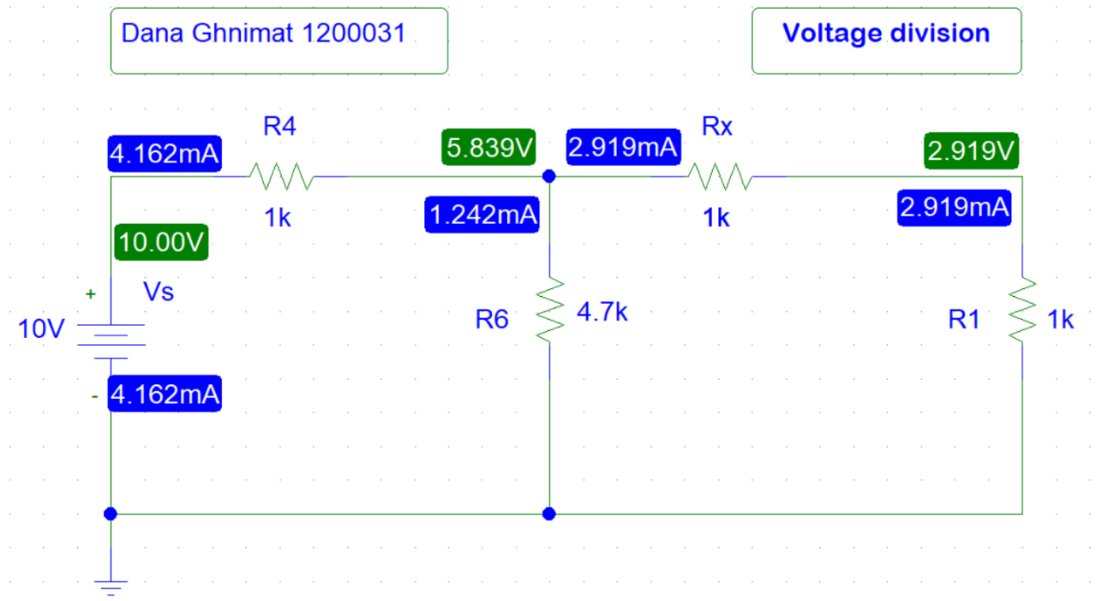

Figure 4 Pspice circuit Voltage divider when Rx=1k

For other resistors:

V4=10-5.839 =4.161V

Vx=5.839-2.919 = 2.920V

V1=2.919-0 =2.919V

V6=5.839-0 =5.839V

Using voltage divider rule:

V1 = Vin * R1 / (R1 + Rx)

= 5.839 * 1k / 2k = 2.919V

Vx = Vin *Rx/ (R1+Rx)

= 5.839 * 1k / 2k = 2.919V almost as the one in simulation.

V4 = Vin *R4 / Rtotal Rtotal = (R4 + ((R1+Rx) // R6)) = 2.402985 kΩ

= 10 / 2.402985 = 4.161V

V6 = Vin *((R1+Rx) // R6) / Rtotal

= 10 * 1.402985 / 2.402985 = 5.838V almost as the one in simulation

When Rx = 0.5kΩ

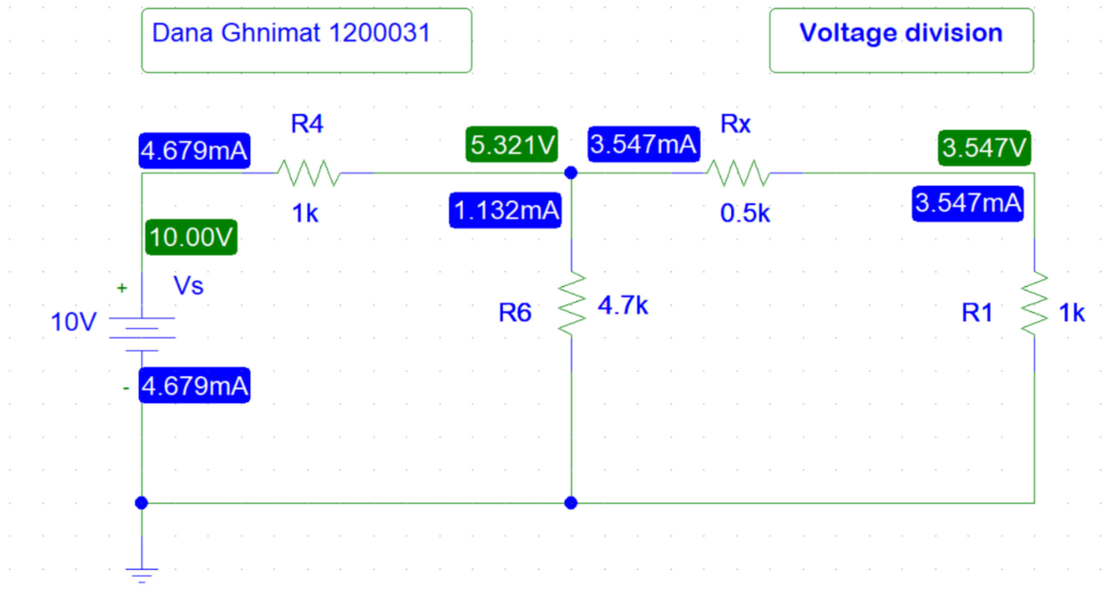

Figure 5 Pspice circuit Voltage divider when Rx=0.5k

For other resistors:

V4 =10-5.321 =4.679V

Vx=5.321-3.547=1.774V

V1=3.547-0 =3.547V

V6=5.321-0 =5.321V

Using voltage divider rule:

V1 = Vin * R1 / (R1 + Rx)

= 5. 321* 1k / 1.5k = 3.547V

Vx = Vin *Rx/ (R1+Rx)

= 5. 321* 0.5k / 1.5k = 1.774 same as the one in simulation.

V4 = Vin *R4 / Rtotal Rtotal = (R4 + ((R1+Rx) // R6)) = 2.137 kΩ

= 10 / 2.137 = 4.679V

V6 = Vin *((R1+Rx) // R6) / Rtotal

= 10 * 1.137 / 2.137 = 5.320V almost as the one in simulation

Table 2 Voltage divider

Vs(volt)	Pot.	V1	V4	V6	Vx
10	Rx	2.919V	4.161V	5.839V	2.920V
10	0.5 Rx	3.547V	4.679V	5.321V	1.774V

We noticed that the value in simulation matched the theory.

II. Current division

After we reconnected R5 and replace R1 by a short circuit and put value of Rx=R4=1kΩ, R5=3.3kΩ, R6=4.7kΩ.

When Rx=1kΩ.

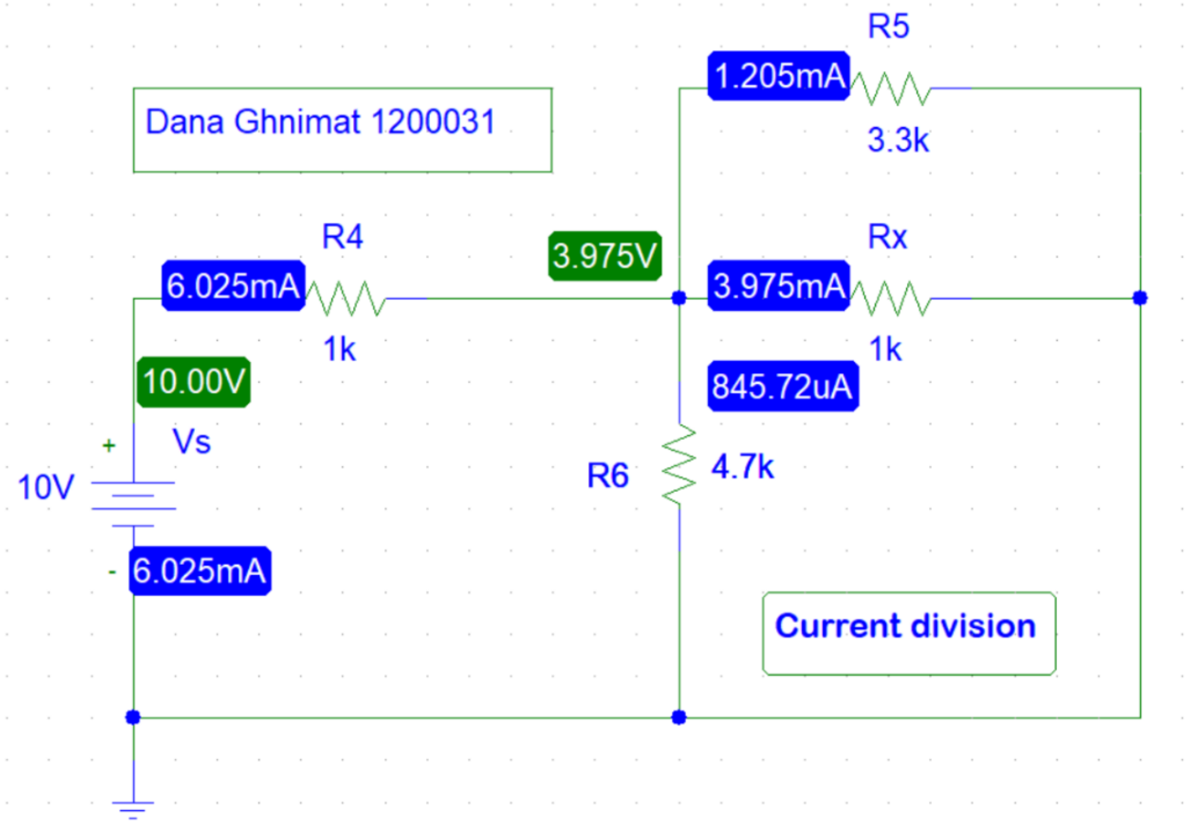

Figure 6 Pspice circuit Current divider when Rx=1k

Applying current divider rule:

I4 = I5 + Ix + I6

= 1.205+3.975+0.845

= 6.025 mA

Same as in the simulation.

When Rx=0.5kΩ.

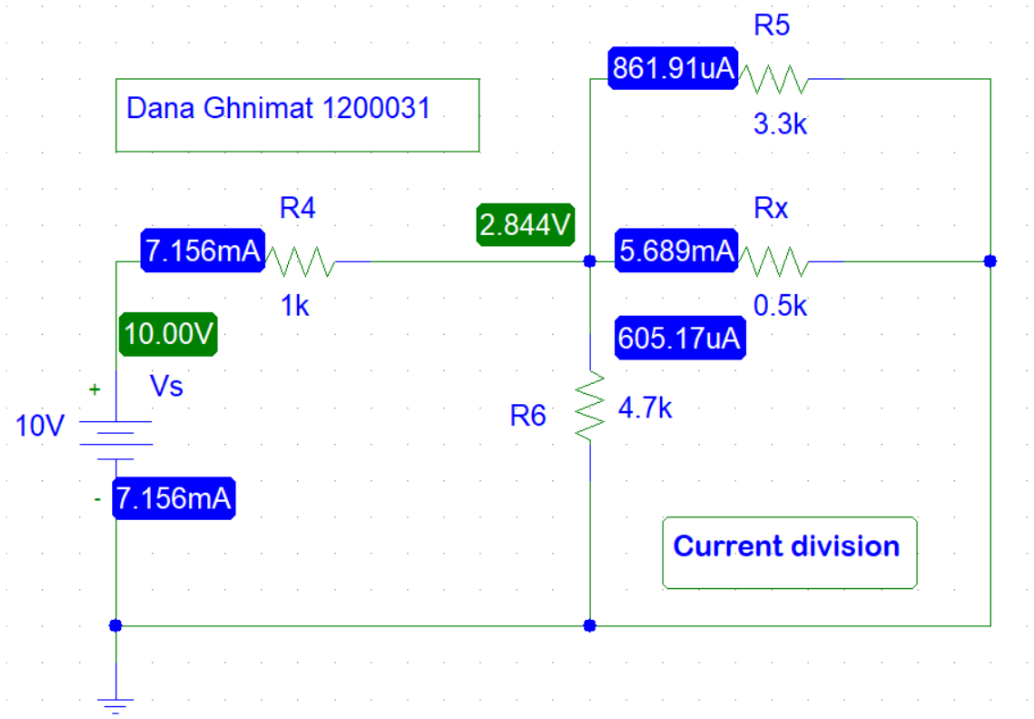

Figure 7 Pspice circuit Current divider when Rx=0.5k

Applying current divider rule:

I4 = I5 + Ix + I6

= 0.8619+5.689+0.6051

= 7.156 mA

Same as in the simulation.

Table 3 Current divider

Vs(volt)	pot	I4	I5	I6	Ix
10	Rx	6.025mA	1.205 mA	0.845 mA	3.975mA
10	0.5Rx	7.156mA	0.8619mA	0.6051mA	5.689mA

Part 3: Superposition

considering R1=R4=Rx=1kΩ, R6=4.7kΩ and VS1= 5V, VS2=10V as given.

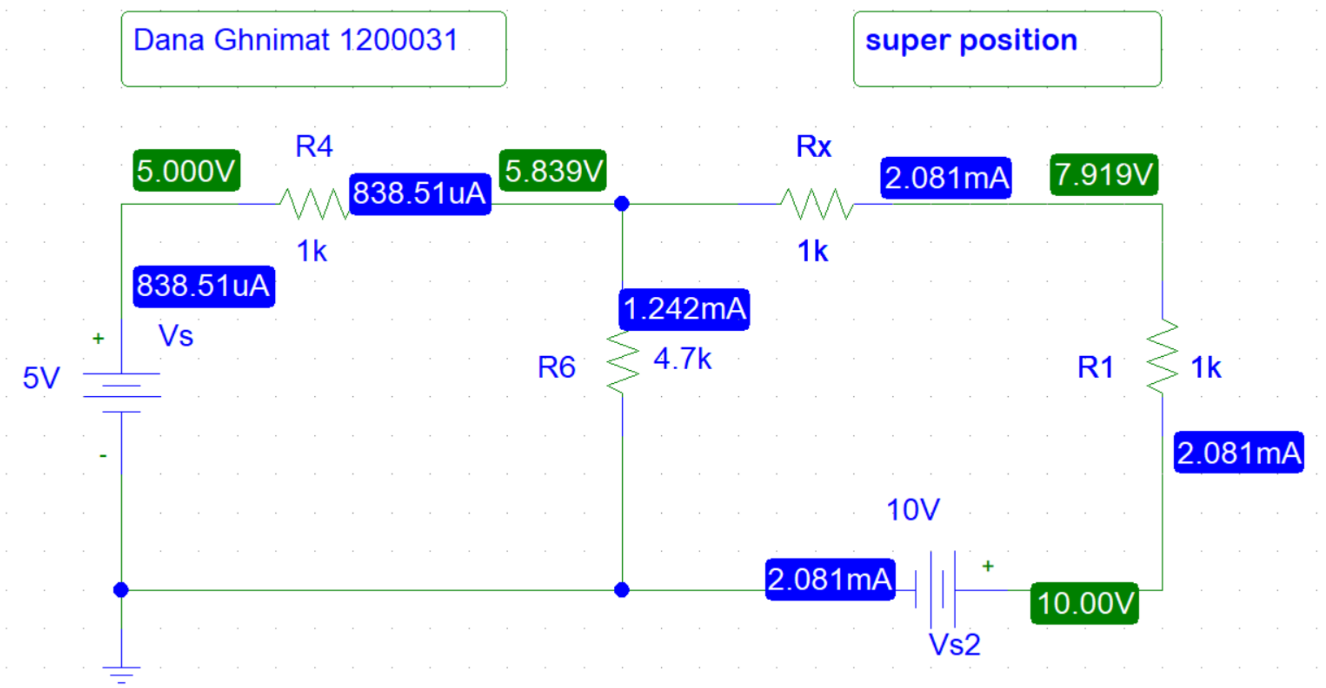

Figure 8 Superposition original circuit

Setting vs1 to zero and Vs2 to 10V (killing Vs1)

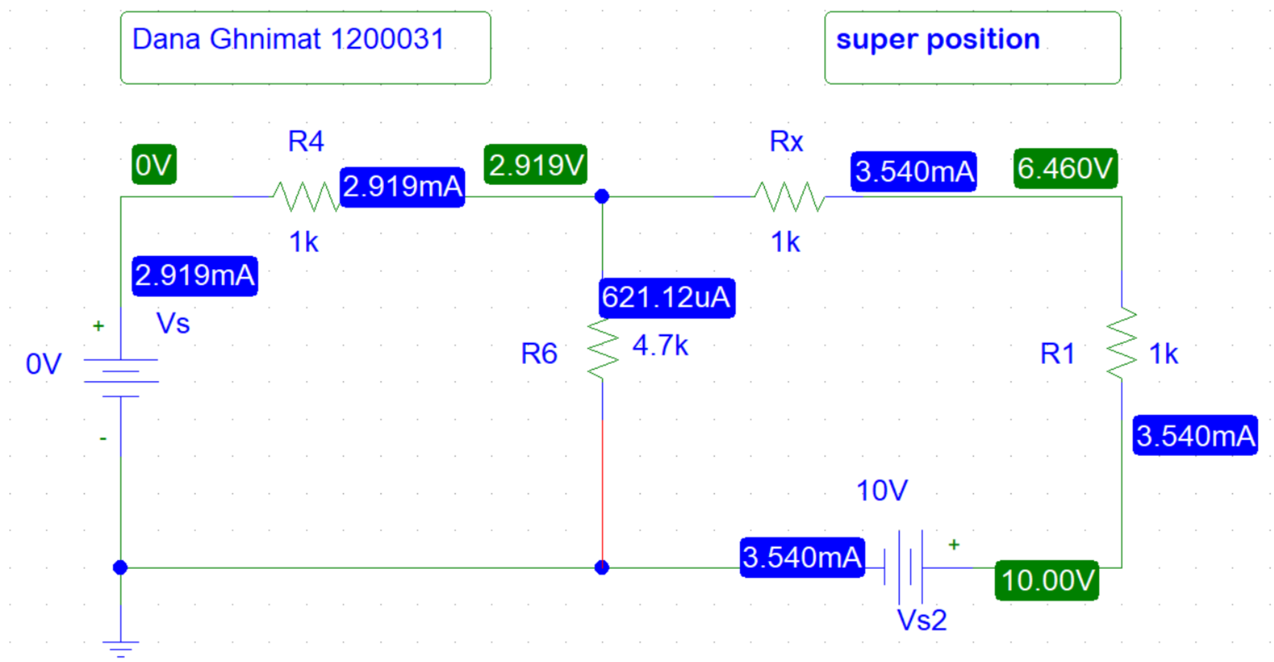

Figure 9 Superposition setting Vs1 to zero.

Setting Vs1 to 5 volts and Vs2 to zero.

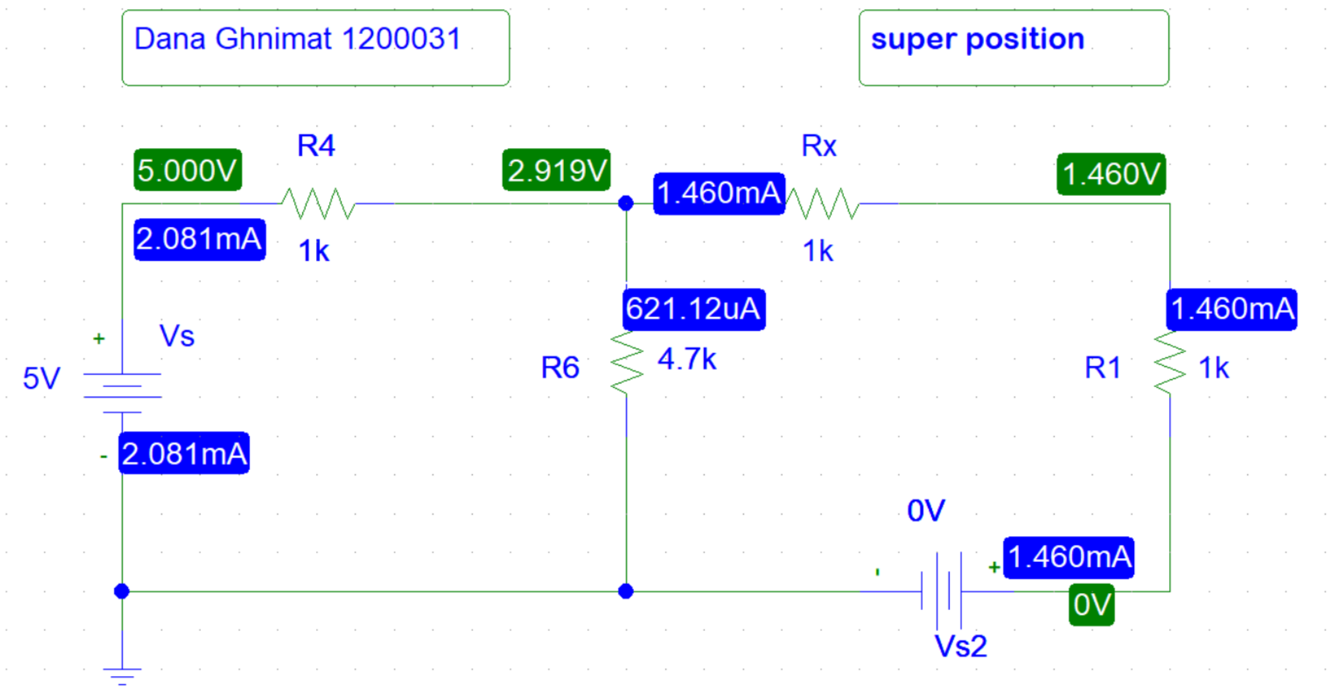

Figure 10 superposition setting Vs2 to zero.

Table 4 Superposition

Vs(volt)	Vs2(volt)	V6(volt)	I6(mA)
5	10	5.839	1.242
0	10	2.919	0.62112
5	0	2.919	0.62112

the superposition theorem is to eliminate all but one source of power within a network at a time. We repeat this process sequentially by individually kill every voltage and current source in the circuit. (open for current and short for voltage). After that we have to added algebraically the voltage and current values.

So, if we add the voltages on R6 = 2.919 when Vs=0, Vs2=10V, and the voltage on R6 = 2.919 when Vs=10V, Vs2=0.

The result of sum is 5.839V (when Vs=5, Vs2=10).

And for currents we have to add the current to R6 = 0.621 mA when Vs=0, Vs2=10V and the current to R6 = 0.621 mA when Vs=10V, Vs2=0.

The result of sum is 1.242 mA

Part 4: Thevenin and Norton equivalent circuits

Using the same circuit from the previous part, this time we will work on R1.

1-Set the Vs1 to 5volts and Vs2 to 10 volts and measure voltage across R1.

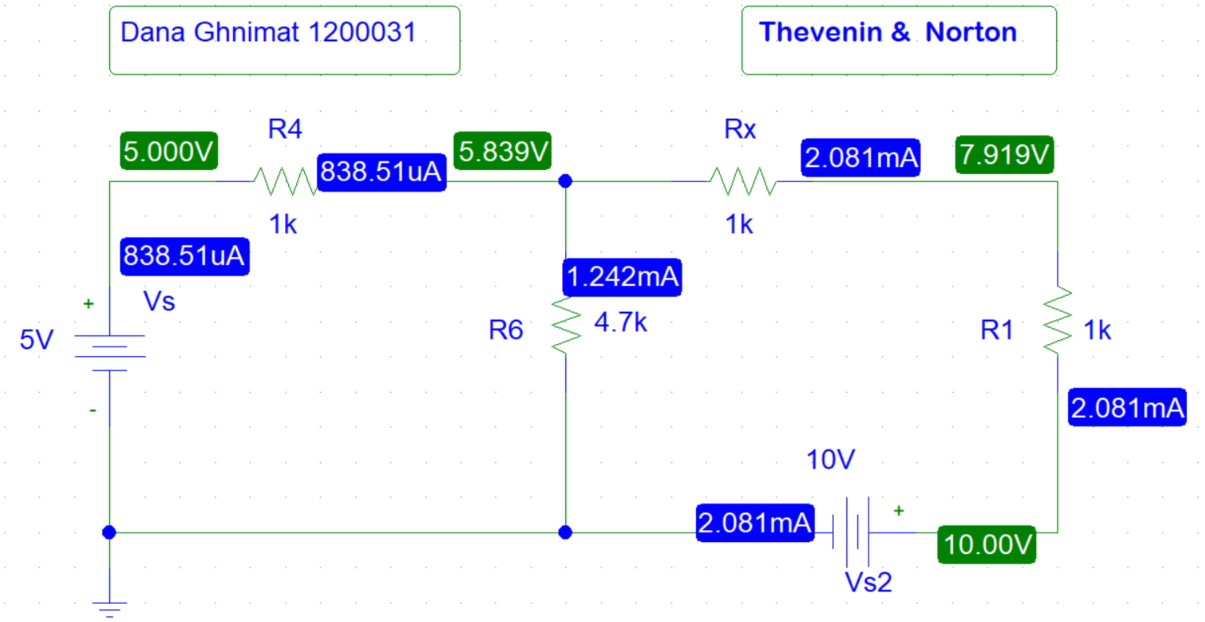

Figure 11 Thevenin & Norton

The voltage across R1= 10-7.919 = 2.081V and the current on R1 =2.081mA.

2- Disconnect R1 and measure the voltage on the terminals (a,b) where R1 was connected.

Open circuits don't work on Pspice, so we have to make R1 a large value (1000Mega) equals to infinity to mimic an open circuit causing the current not to pass through it,

Vth = Voc = 10-4.123 = 5.877v. (subtracting from the larger to get positive value).

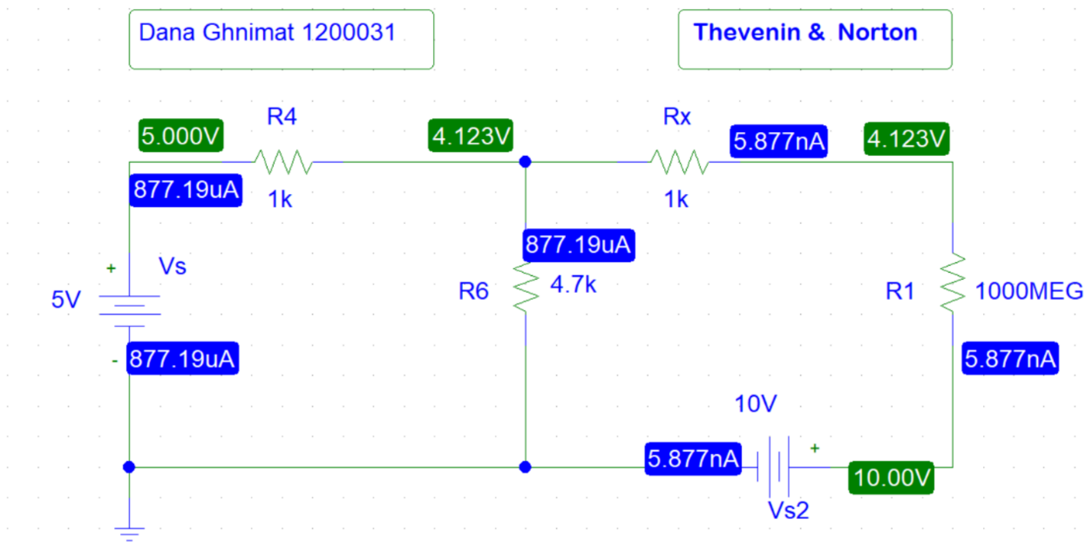

Figure 12 Thevenin & Norton, finding Voc

3- Short circuit on R1 and measure the current in the short circuit (Isc).

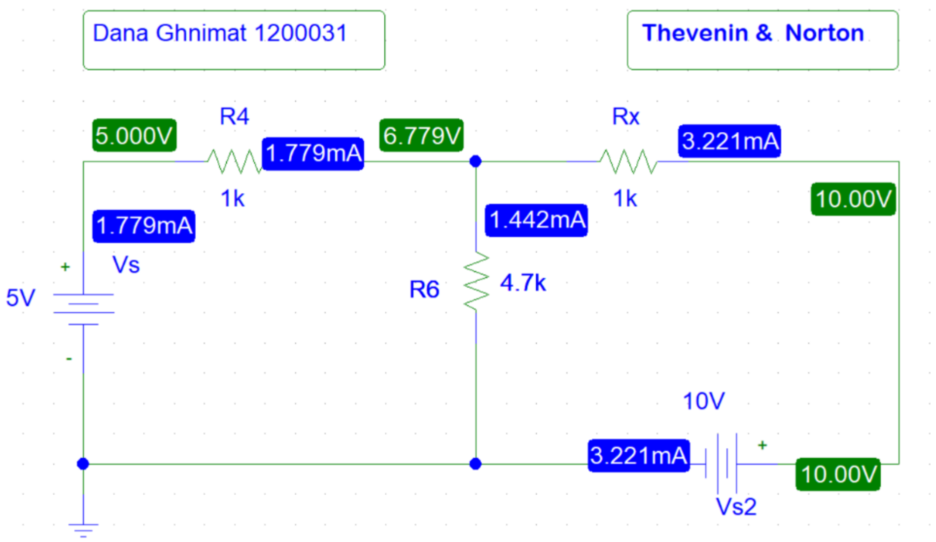

Figure 13 Thevenin & Norton, finding Isc

I short circuit is equal to 3.221mA.

4- To find the Rth we must set all voltage sources to zero by making them short circuits.

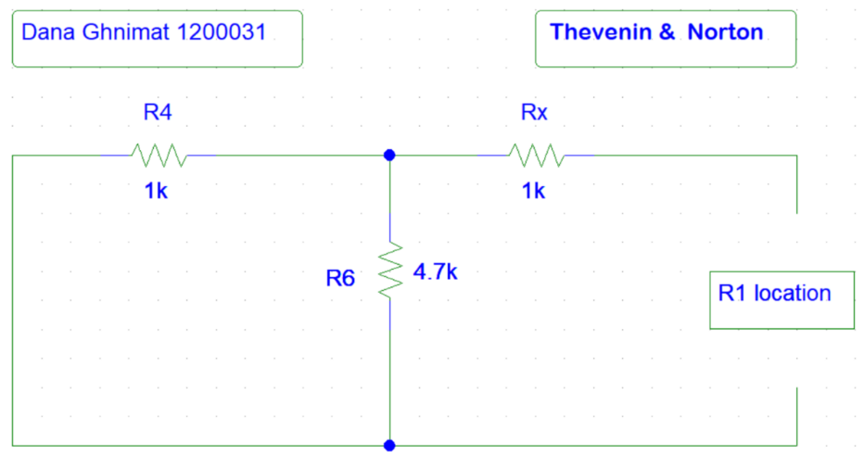

Figure 14 Thevenin & Norton, finding Rth

Rth = (R4// R6) + Rx

= (824) + 1 = 1.824 kΩ.

Using Isc and Vth.

Rth = Vth / Isc

= 5.877/3.221 m = 1.824kΩ. which is identical to the theoretical value.

5- measure the voltage on the opened terminals of the series connection:

To be able to measure the voltage on the open terminal we have to replace it with almost infinite resistor like the previous parts. Here Roc is 1000Mega.

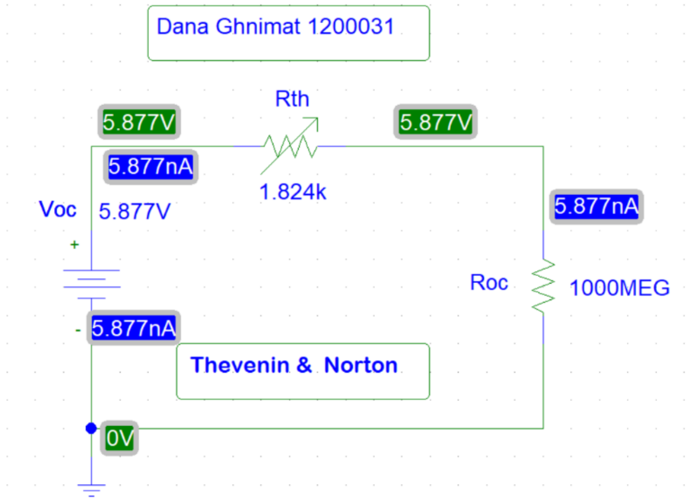

Figure 15 Thevenin & Norton, finding voltage on open terminals

We noticed that Voc is same as Vth, since the both terminals are on parallel.

6- Short circuit the terminals of the series connection and measure the current in the short circuit

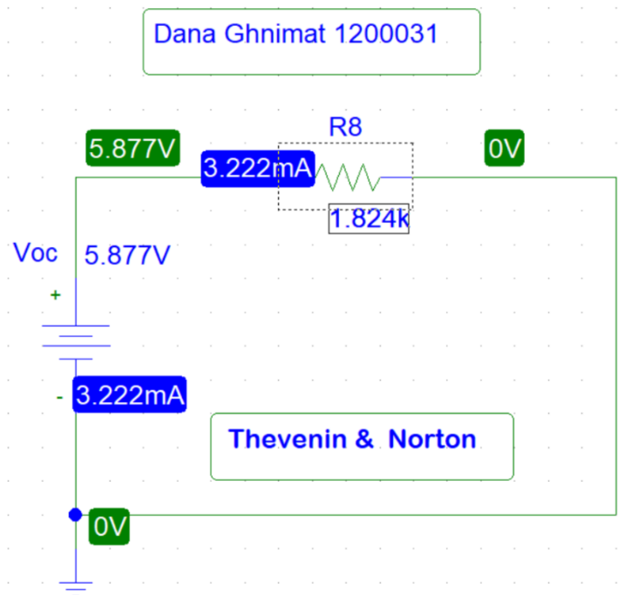

Figure 16 Thevenin & Norton, finding current in short circuit

Current short circuit is equal to 3.222mA in this circuit and this value equal to Isc on the original circuit, so our calculations are true.

The value of short circuit current in original circuit equals the short circuit current in Thevenin circuit and its should be happened to ensure our solution is true.

Conclusion

Simulation is a great way to detect and analysis the circuits and find errors before applying them into real circuits, this will make us avoid damaging real circuits, as well electrical hazards.

Using KCL and KVL along with Thevenin and Norton's laws help us to simplify the complex circuits and give us results identical or close to real simulation circuits, so we should make good use of this laws to help us improve our circuits.