ELEC 2110

# Electric Circuit Analysis

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Section 002

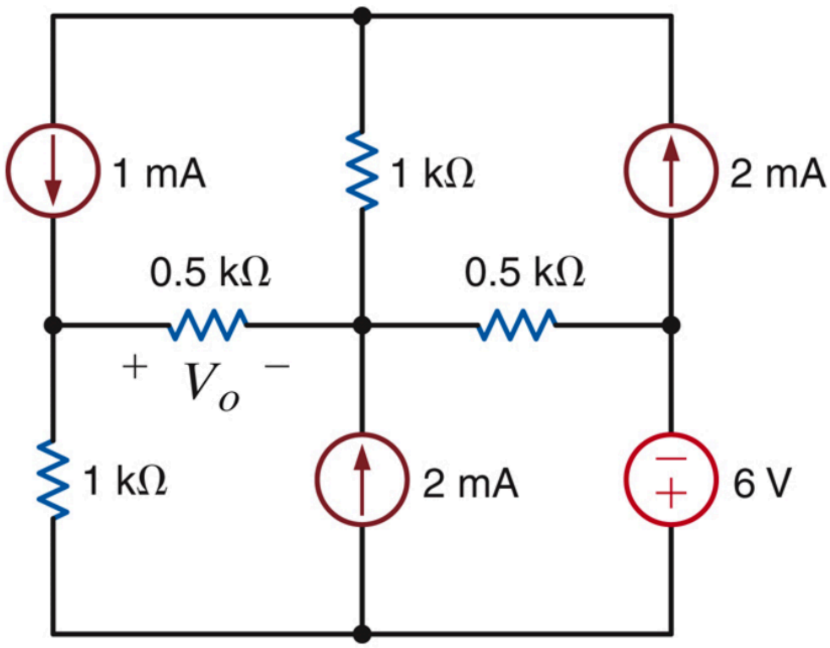
## Recitation & MultiSim: Thevenin’s and Norton’s Theorem

# Introduction

The student will work to solve problems related to Thevenin's and Norton's Theorem. Given circuits, solve using Thevenin's and Norton's. Theorem, then verify using Multisim.

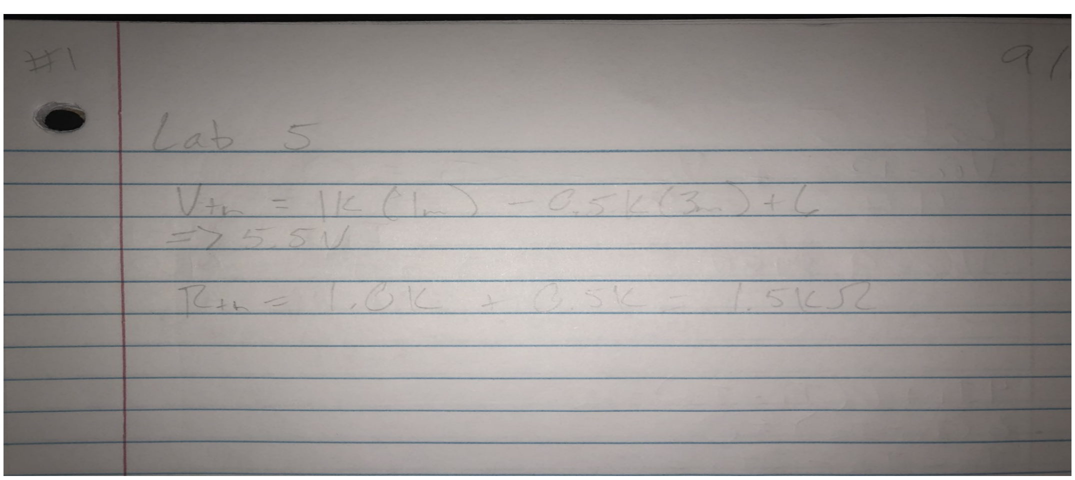
# Exercise 1

Use Thevenin's theorem to find Vo and use MultiSim to verify the answer.




(1)

Circuit 1



#1

Lab 5

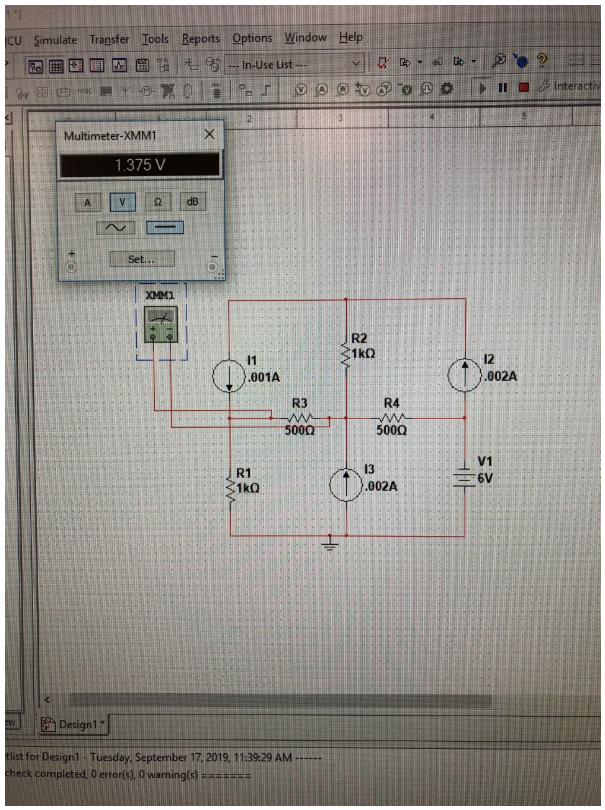
$V_{th} = 1k(1m) - 0.5k(3m) + 6$
$\Rightarrow 5.5V$

$R_{th} = 1.0k + 0.5k = 1.5k\Omega$

Equations for exercise 1 circuit 1 (2)

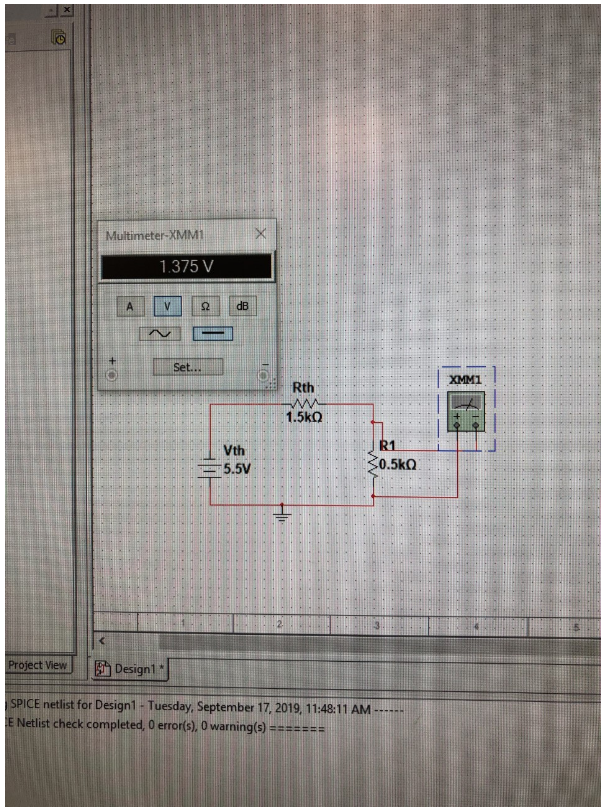
Summary Table

| | |
|---|---|
| Vth | 5.5V |
| Rth | 1.5k Ohm |
| Vo | 1.375V |




(3)

Verify Vo

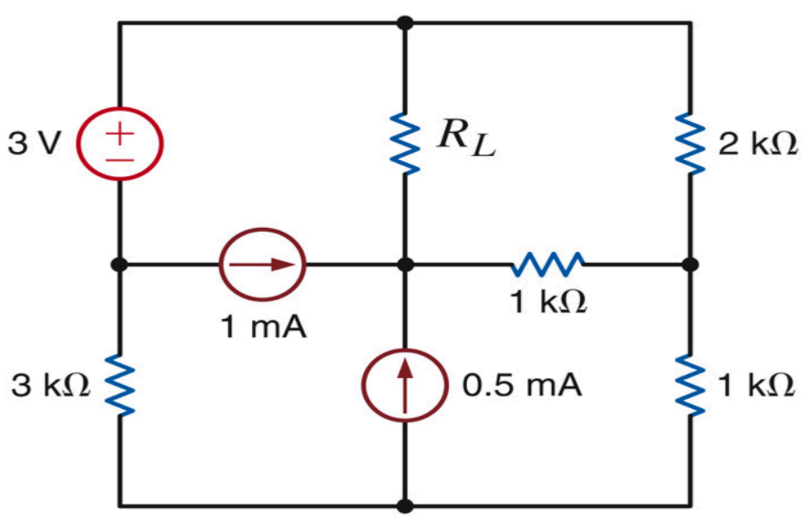



(4)

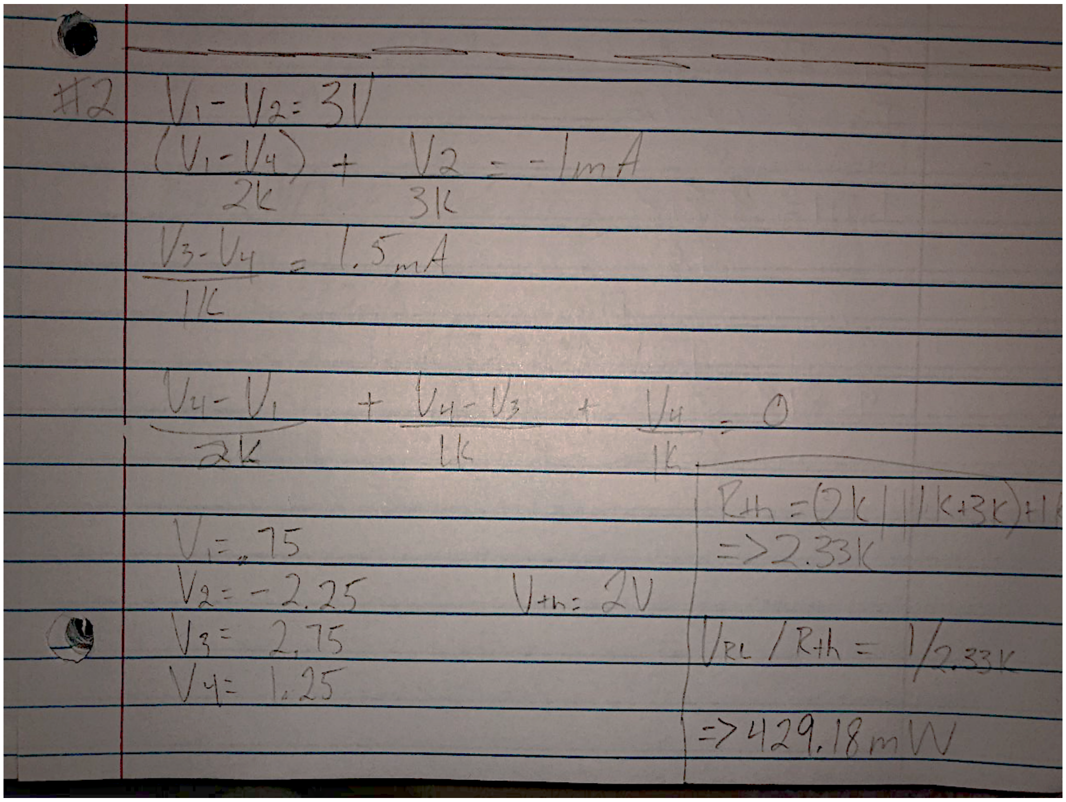
Verify using Thevenin's Circuit

# Exercise 2

Given a new circuit, find RL and use it to find maximum Power (Pmax) for RL. Then plot RL and Pmax.




Circuit 2 (5)



#2

$V_1 - V_2 = 3V$

$\frac{(V_1 - V_4)}{2k} + \frac{V_2}{3k} = -1mA$

$\frac{V_3 - V_4}{1k} = 1.5mA$

$\frac{V_4 - V_1}{2k} + \frac{V_4 - V_3}{1k} + \frac{V_4}{1k} = 0$

$V_1 = .75$
$V_2 = -2.25$
$V_3 = 2.75$
$V_4 = 1.25$

$V_{th} = 2V$

$R_{th} = (2k \,||\, (1k+3k)) + 1k$
$\Rightarrow 2.33k$

$V_{RL} / R_{th} = 1/2.33k$

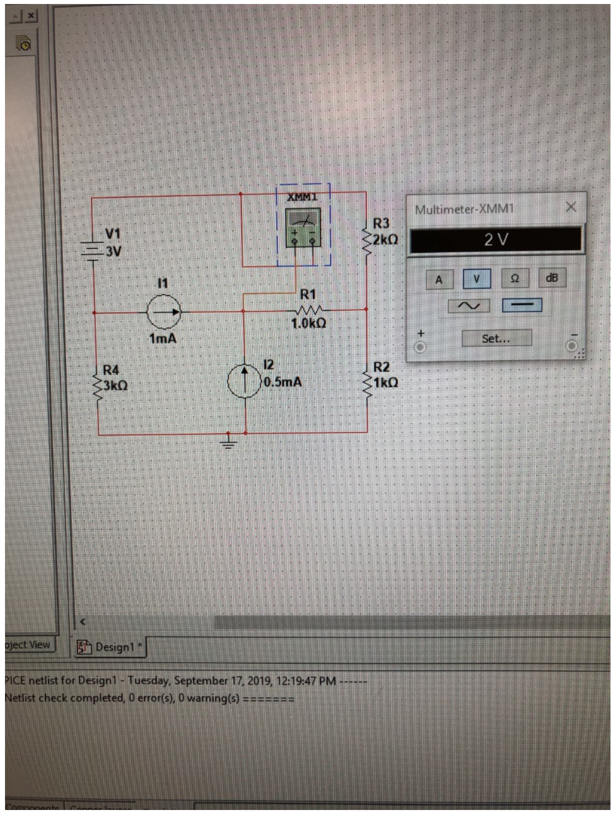
$\Rightarrow 429.18mW$

(6)

Equations for exercise 2 circuit 2

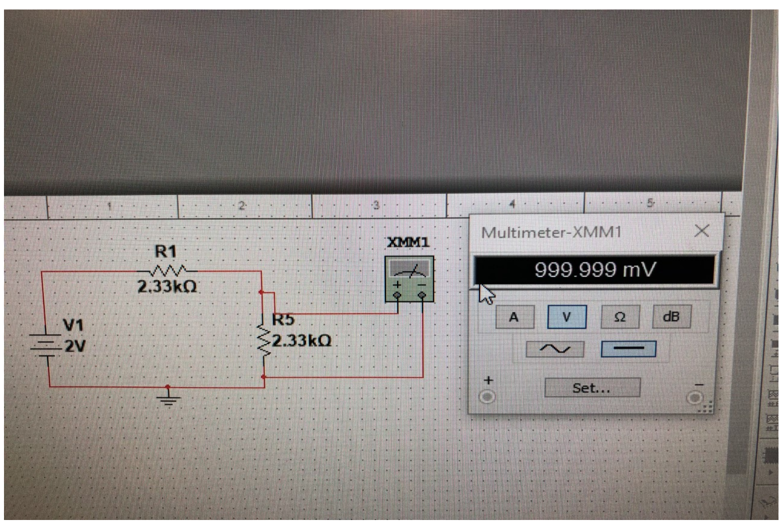
Summary Table

| | |
|---|---|
| V1 | 0.75V |
| V2 | -2.25V |
| V3 | 2.75V |
| V4 | 1.25V |
| Vth | 2.00V |
| Rth | 2.33k Ohm |
| VRL/Rth= Pmax | = 1/(2.33k)= 429.18mW |



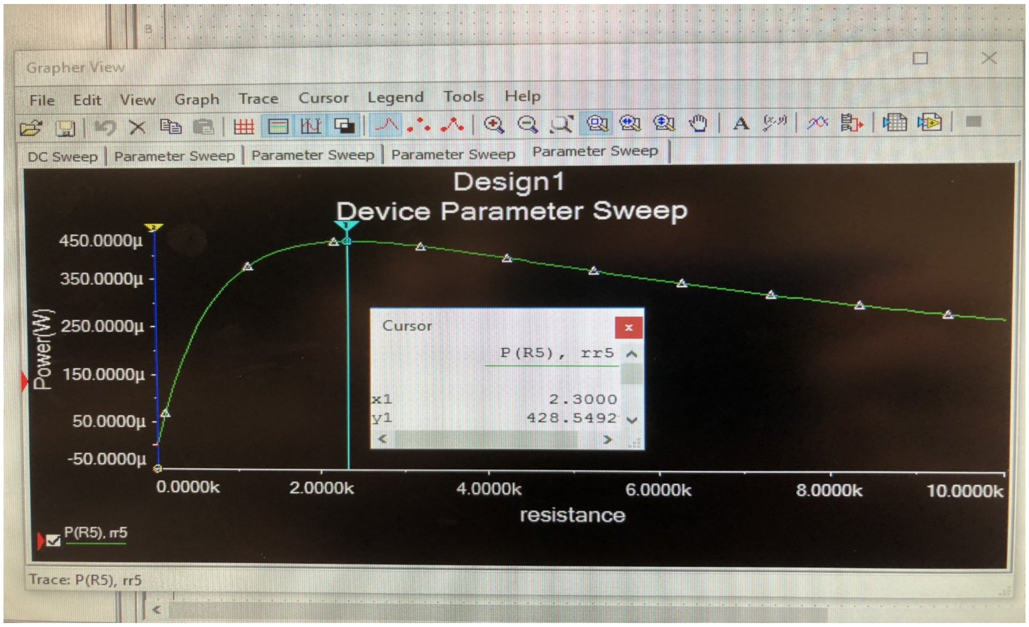

(7)

Verify Vth




(8)

Verify using Thevenin's Circuit

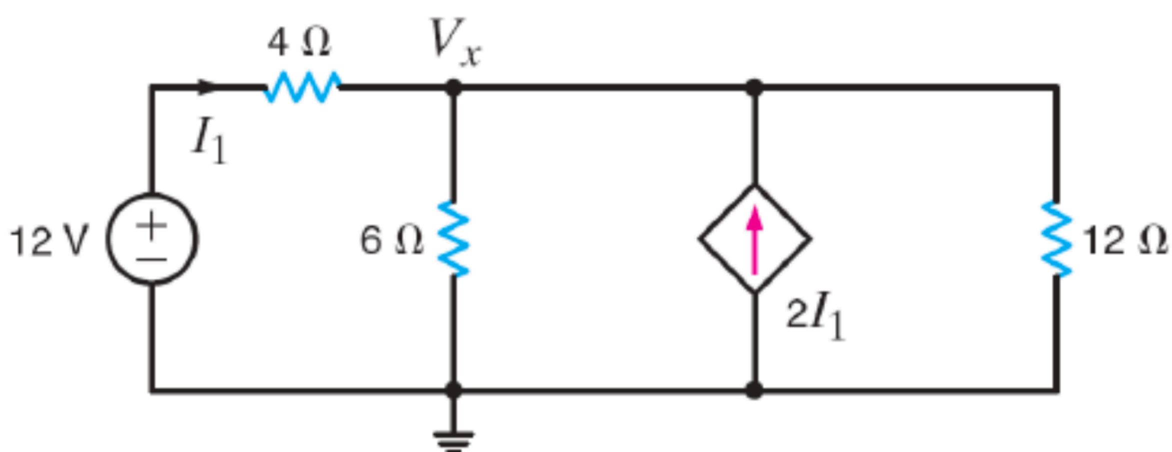



(9)

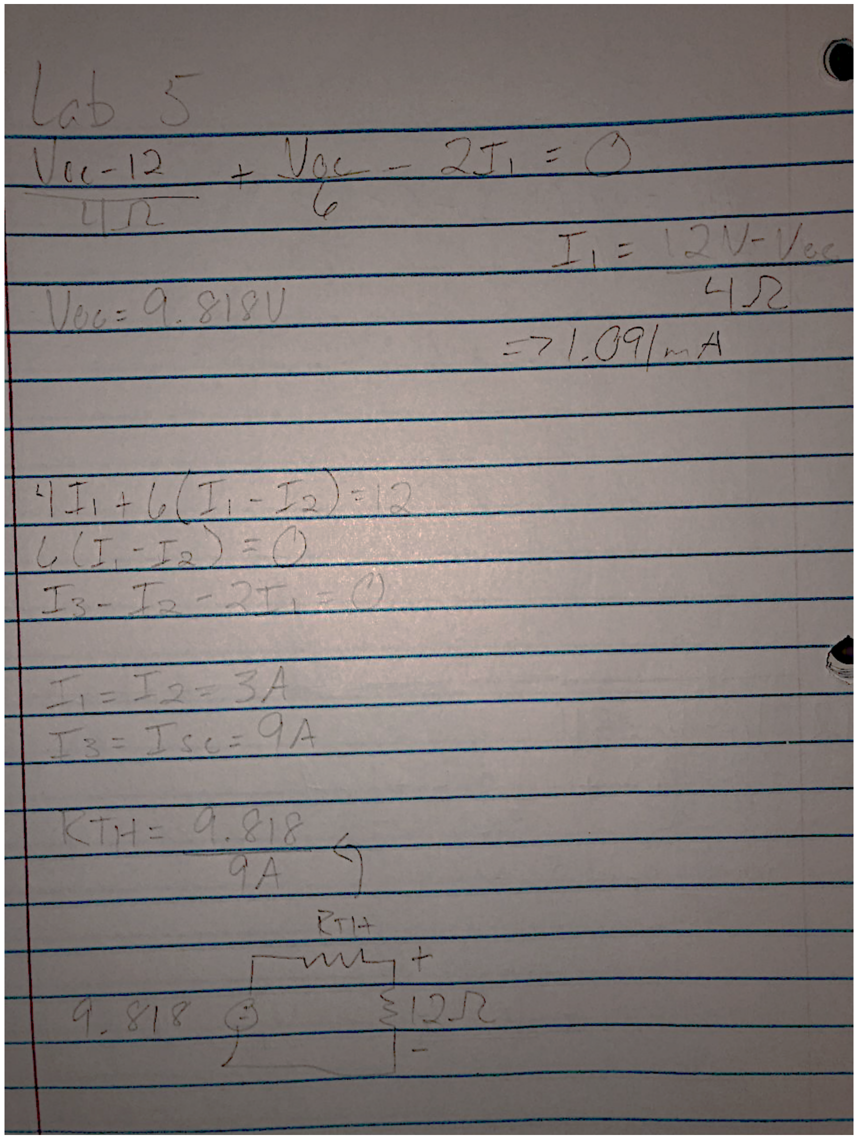
Parameter sweep for exercise 2 (very sorry it is black)

# Exercise 3

Use Thevenin's Theorem to solve for Vx in circuit 3. Use MultiSim to verify the answer.




Circuit 3 (10)



Lab 5

$$\frac{V_{oc}-12}{4\Omega} + \frac{V_{oc}}{6} - 2I_1 = 0$$

$$I_1 = \frac{12V - V_{oc}}{4\Omega}$$

$V_{oc} = 9.818V$

$=> 1.091 mA$

$4I_1 + 6(I_1 - I_2) = 12$

$6(I_1 - I_2) = 0$

$I_3 - I_2 - 2I_1 = 0$

$I_1 = I_2 = 3A$

$I_3 = I_{sc} = 9A$

$$K_{TH} = \frac{9.818}{9A}$$

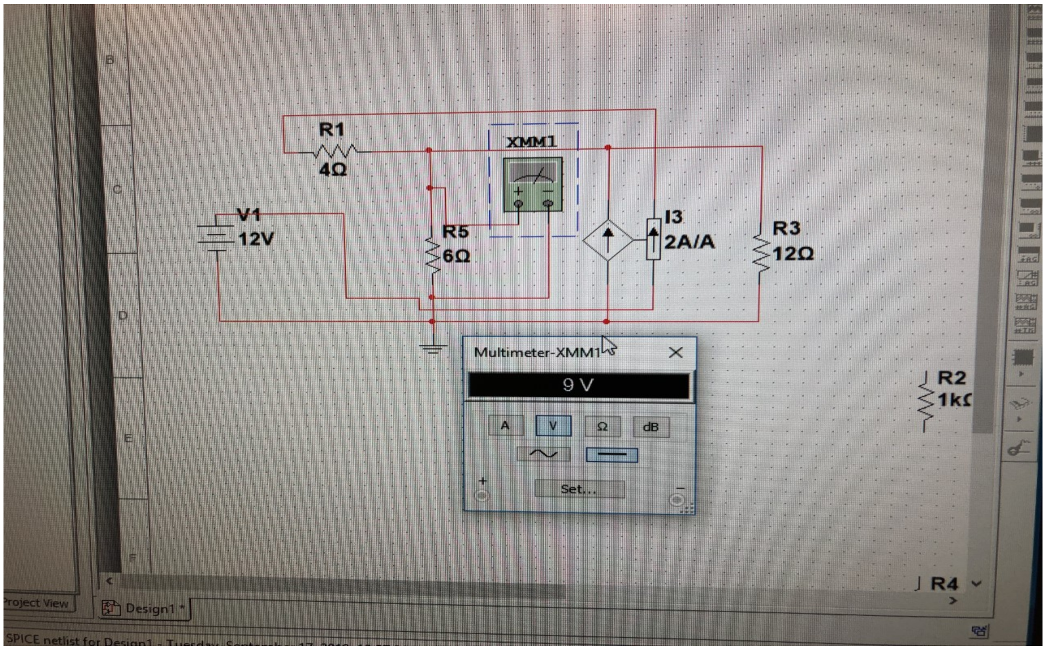


(11)

Equations for Exercise 3 Circuit 3

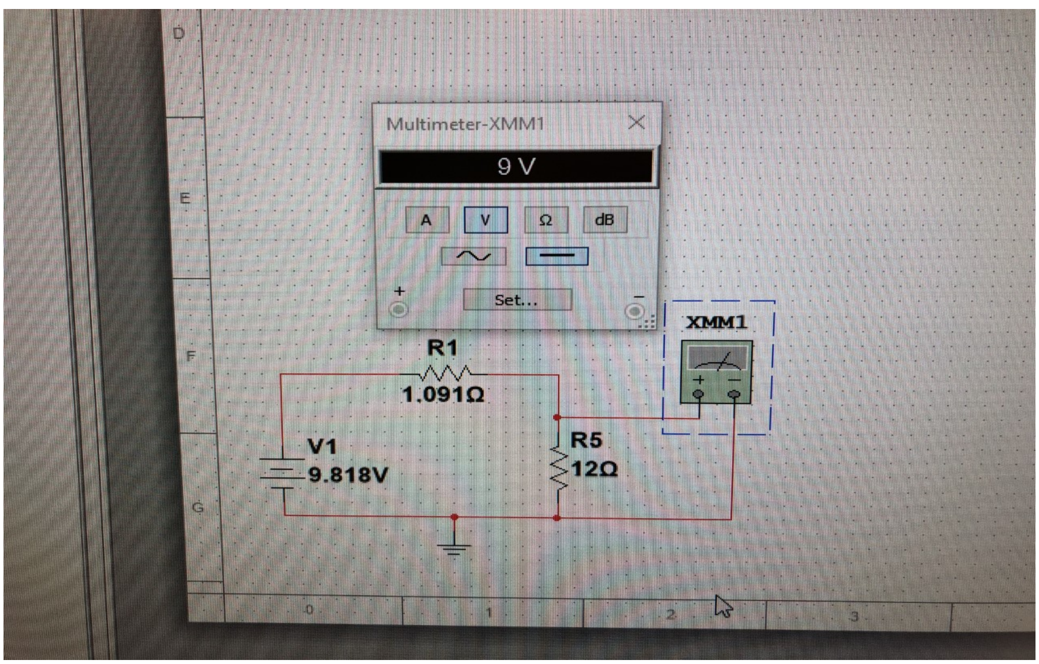
Summary Table

| | |
|---|---|
| Voc | 9.818V |
| Isc | 9A |
| Rth= Voc/Isc | = 9.818/9 = 1.091Ohms |




(12)

Verify Vx

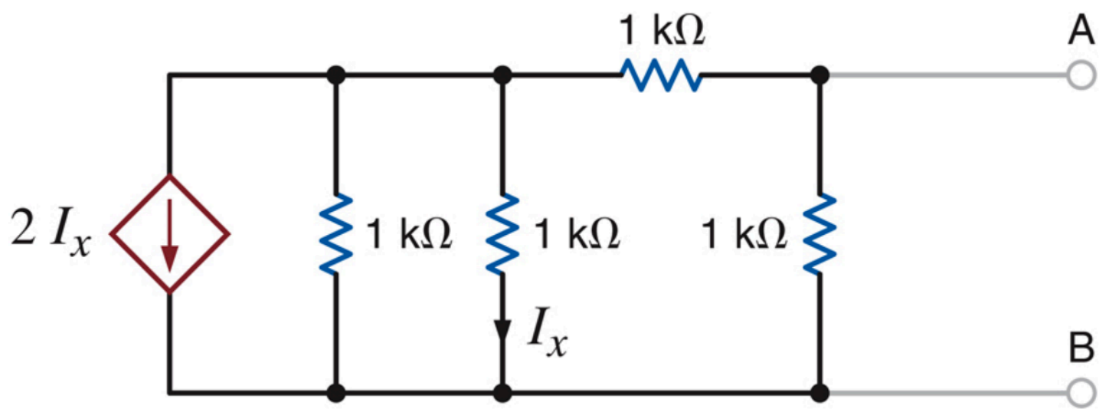



(13)

Verify using Thevenin's Circuit

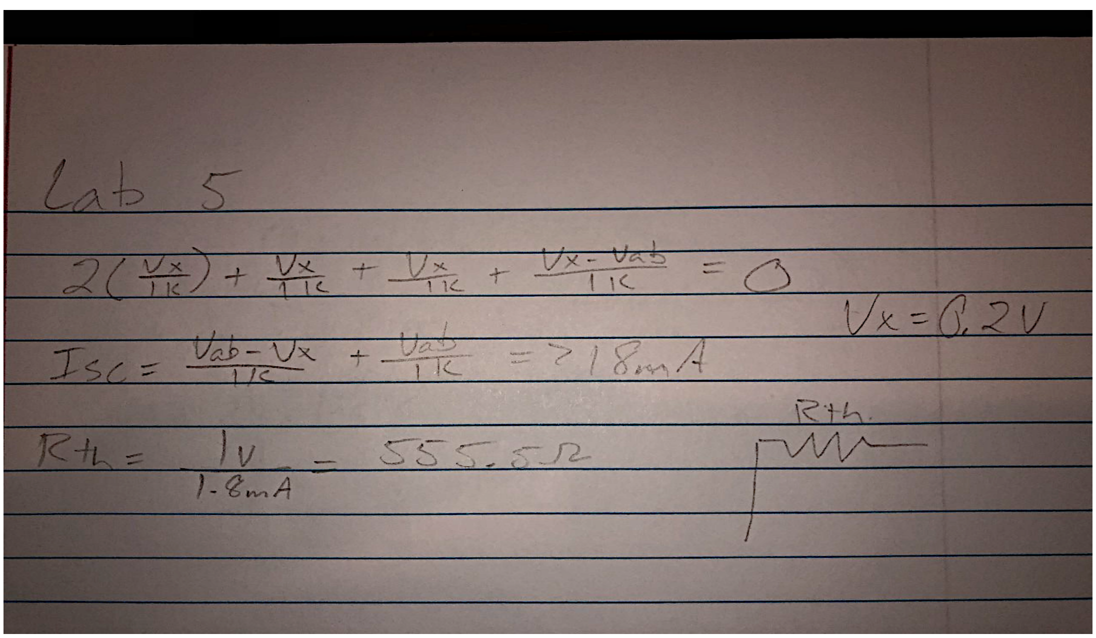
# Exercise 4

Build the Thevenin circuit between nodes A and B for the given circuit. Then build it in MultiSim and verify your answer using the Ohmmeter.




(14)

Circuit 4

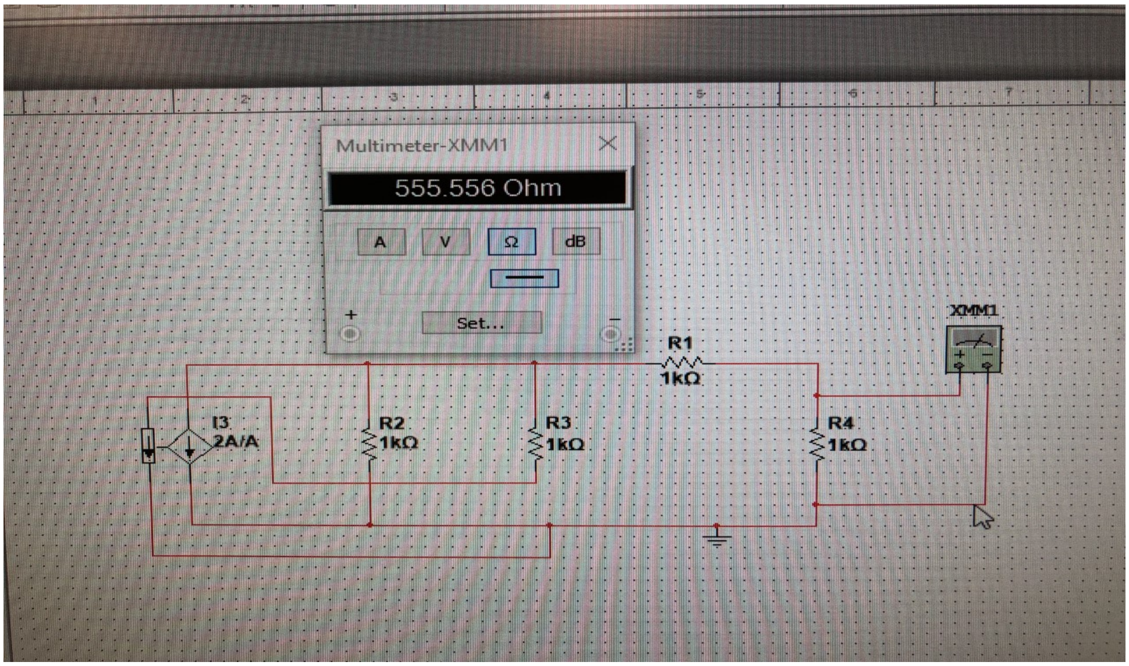



(15)

Equations for Exercise 4 Circuit 4

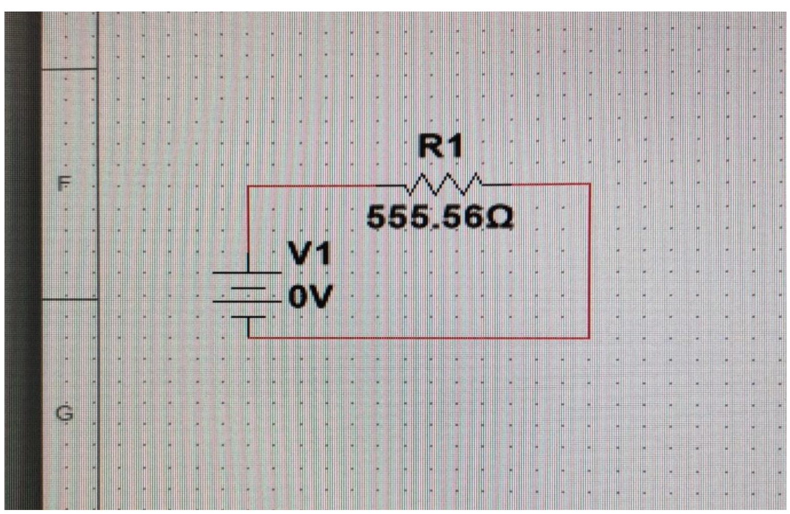
Summary Table

| | |
|---|---|
| Vx | 0.2V |
| Isc | 1.8mA |
| Rth | 555.5 Ohm |




(16)

Verify Rth

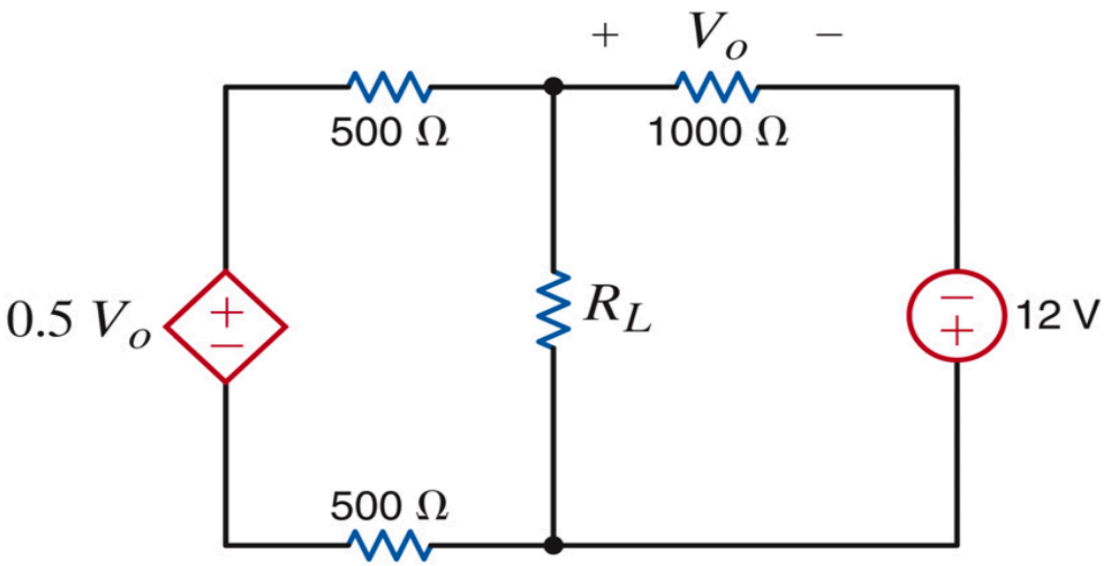



(17)

Verify using Thevenin Circuit

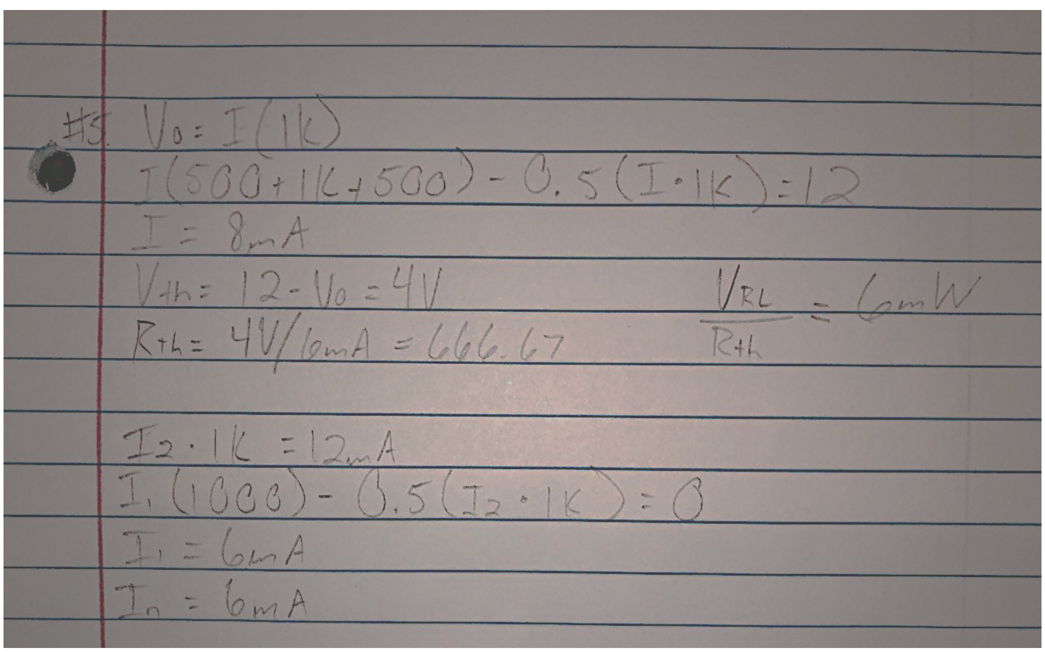
# Exercise 5

Given a new circuit, find RL and Pmax, and verify using MultiSim. Then plot resistance (RL) / Power (Pmax).




(18)

Circuit 5



#5. $V_o = I(1k)$

$I(500 + 1k + 500) - 0.5(I \cdot 1k) = 12$

$I = 8mA$

$V_{th} = 12 - V_o = 4V$

$R_{th} = 4V/6mA = 666.67$

$\frac{V_{RL}}{R_{th}} = 6mW$

$I_2 \cdot 1k = 12mA$

$I_1(1000) - 0.5(I_2 \cdot 1k) = 0$

$I_1 = 6mA$

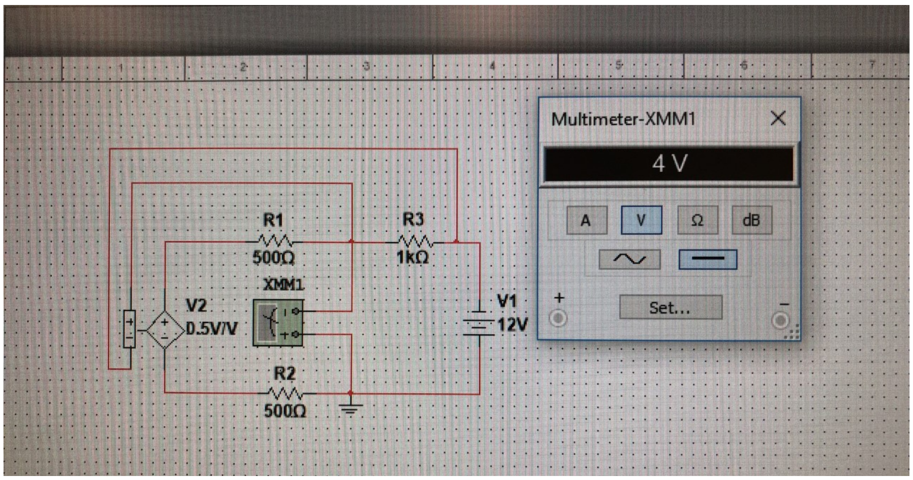
$I_n = 6mA$

(19)

Equations for Exercise 5 Circuit 5

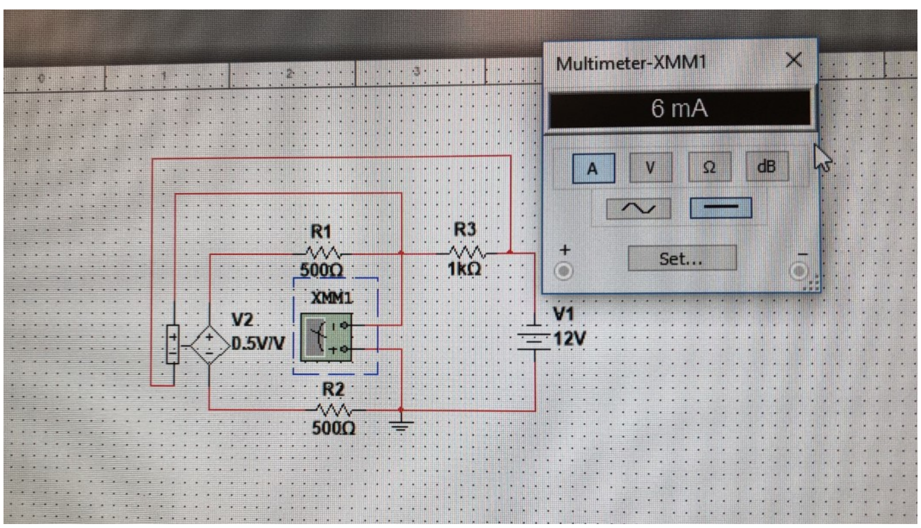
Summary Table

| | |
|---|---|
| I | 8mA |
| I1 | 6mA |
| I2 | 12mA |
| In | 6mA |
| Vth | 4V |
| Rth | 666.67 Ohm |
| Pmax | 6mW |



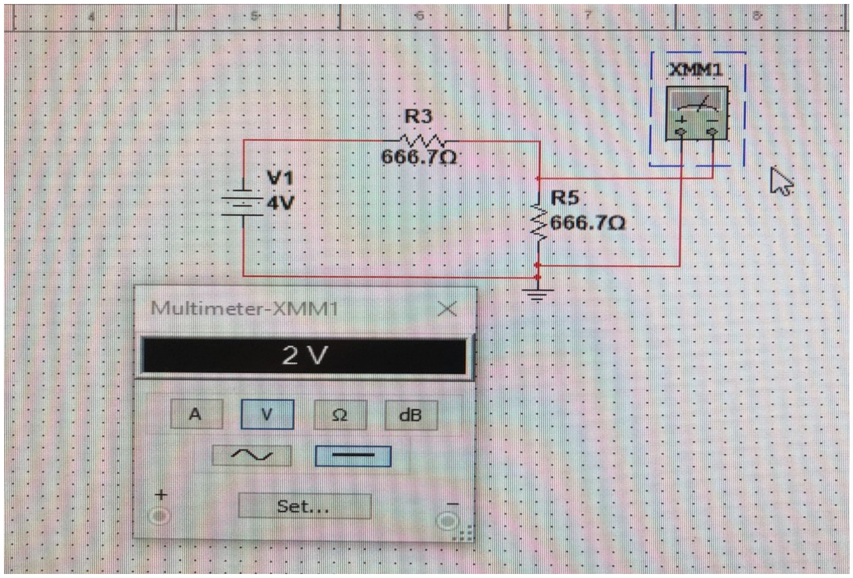

(20)

Verify Vth



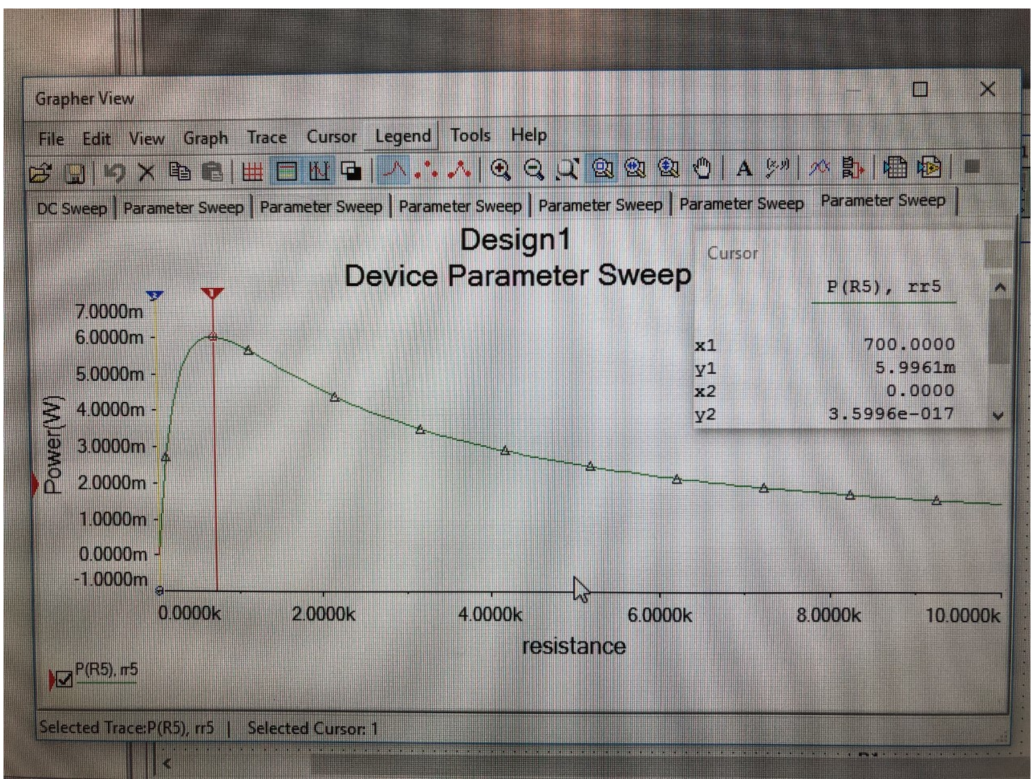

(21)

Verify Current




(22)

Verify V across Rth




(23)

Parameter sweep for Exercise 5

# Conclusion

Using Norton’s and Thevenin’s Theorem makes solving certain circuits much easier. Lab 5 is a crucial beginning for the student to understand there are many ways to solve circuits, and depending on the circuit, certain ways are easier than others. Thevenin’s Circuits play a big role in Electrical Engineering and it is very important to understand its strengths and weaknesses.

# Bibliography


1. Circuit 1 given for exercise 1
2. Hand-written equations for exercise 1, circuit 1
3. Verify Vo using MultiSim for exercise 1, circuit 1
4. Verify using Thevenin Circuit for exercise 1, circuit 1
5. Circuit 2 given for exercise 2
6. Hand-written equations for exercise 2, circuit 2
7. Verify Vth using MultiSim for exercise 2, circuit 2
8. Verify using Thevenin Circuit for exercise 2, circuit 2
9. Parameter sweep of Resistance and Power for exercise 2, circuit 2
10. Circuit 3 given for exercise 3
11. Hand-written equations for exercise 3, circuit 3
12. Verify Vx using MultiSim for exercise 3, circuit 3
13. Verify using Thevenin Circuit for exercise 3, circuit 3
14. Circuit 4 given for exercise 4
15. Hand-written equations for exercise 4, circuit 4
16. Verify Rth using MultiSim for exercise 4, circuit 4
17. Verify using Thevenin Circuit for exercise 4, circuit 4
18. Circuit 5 given for exercise 5
19. Hand-written equations for exercise 5, circuit 5
20. Verify Vth using MultiSim for exercise 5, circuit 5
21. Verify Current using MultiSim for exercise 5, circuit 5
22. Verify using Thevenin Circuit for exercise 5, circuit 5
23. Parameter sweep of Resistance and Power for exercise 5, circuit 5