ELEC-2110

Electric Circuit Analysis

FROM: Jacob Howard

TO: Markus Kreitzer

DATE: September 11, 2019

LAB SECTION: 002

Recitation & MultiSim:
Thevenin's and Norton's Theorems

Introduction

The Objective of this lab was to practice more with Multisim. We use Multisim and Thevenin's and Norton's theorem to calculate voltage and resistance in various circuits.

Exercise 1

In exercise 1, we were asked to Use Thevenin's theorem to find V0 in the circuit shown in Figure 1 and to use MultiSim to verify the answer [1]. Figure 2 shows the circuit constructed in MultiSim and Figure 3 shows the circuit broken to measure the nodes. The data is show below in Chart 1. Worked out solutions are shown in Solutions 1.

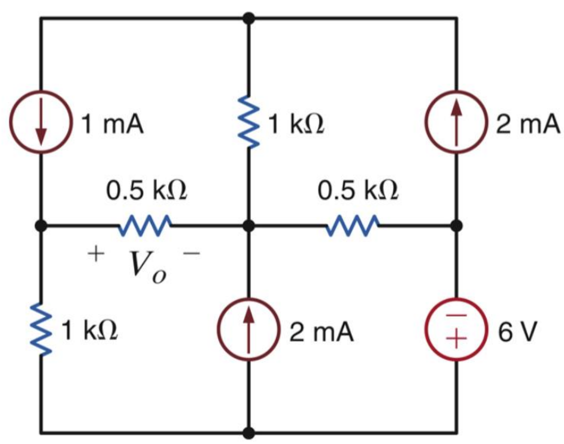


Figure 1

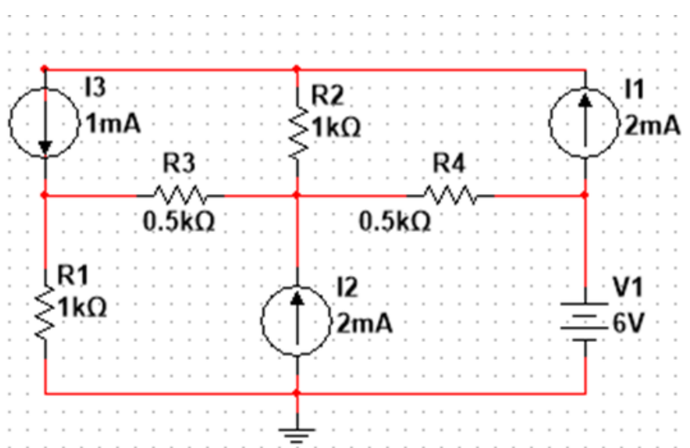


Figure 2

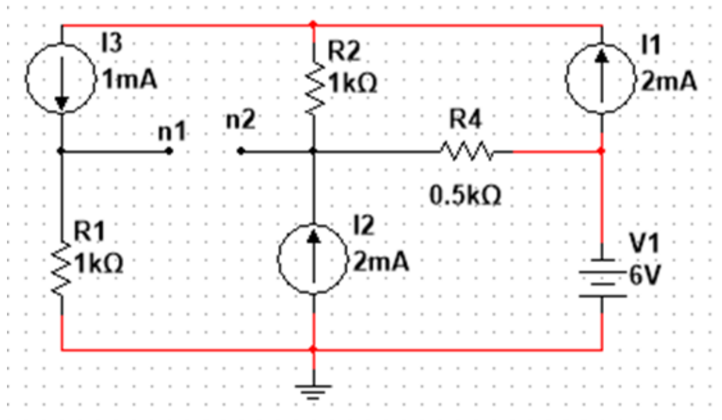
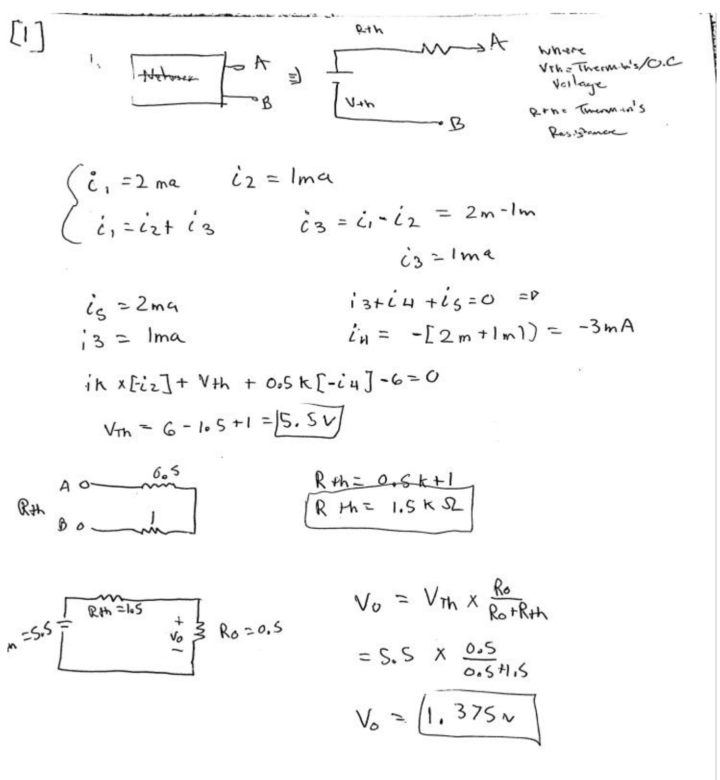


Figure 3

N_1	1.00v
N_2	-4.5v
N_1-N_2	5.5v
V_0	1.374v
R_{TH}	1.5 k Ohms

Table 1



[1]

1. Network (A, B) $\Rightarrow$ R_{th}, V_{th} (A, B)

Where
V_{th} = Thevenin's/O.C Voltage
R_{th} = Thevenin's Resistance

$$\begin{cases} i_1 = 2\,ma & i_2 = 1\,ma \\ i_1 = i_2 + i_3 & i_3 = i_1 - i_2 = 2m - 1m \end{cases}$$

$$i_3 = 1\,ma$$

$i_5 = 2\,ma$ $\qquad$ $i_3 + i_4 + i_5 = 0 \Rightarrow$

$i_3 = 1\,ma$ $\qquad$ $i_4 = -[2m + 1m]) = -3\,mA$

$$1k \times [-i_2] + V_{th} + 0.5k[-i_4] - 6 = 0$$

$$V_{Th} = 6 - 1.5 + 1 = \boxed{5.5\,V}$$

R_{th}: A — 0.5 — 1 — B

$R_{th} = 0.5k + 1$

$$\boxed{R_{th} = 1.5\,k\Omega}$$

$V_{th} = 5.5$, $R_{th} = 1.5$, V_0, $R_0 = 0.5$

$$V_0 = V_{Th} \times \frac{R_0}{R_0 + R_{th}}$$

$$= 5.5 \times \frac{0.5}{0.5 + 1.5}$$

$$V_0 = \boxed{1.375\,v}$$

Solutions 1

Exercise 2

In exercise 2, we were asked to find R_L for maximum power transfer and the maximum power that can be transferred to R_L (P_{max}) from figure 4 [1]. The constructed circuit in Multisim is seem in Figure 5.

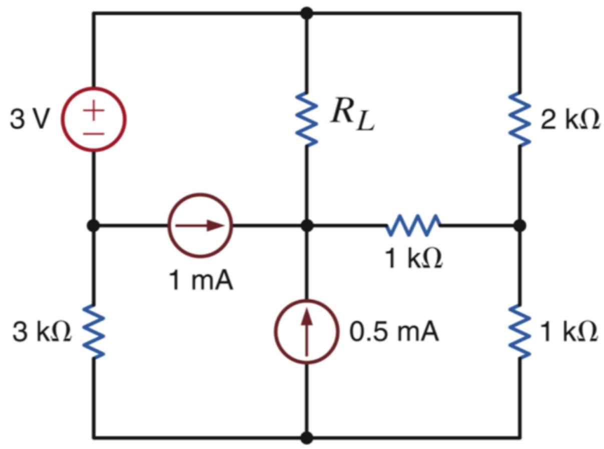


Figure 4

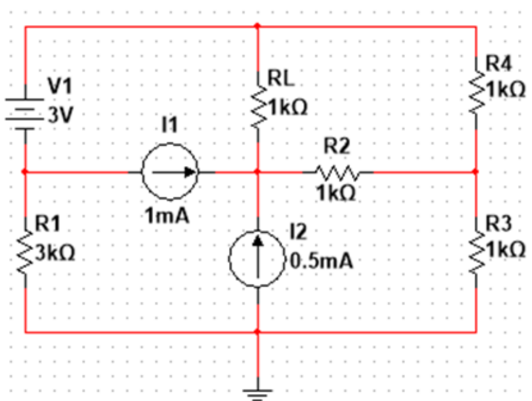


Figure 5

Exercise 3

In exercise 3, we were asked to use Thevenin's theorem to find V_x in the circuit shown in Figure 5. The circuit constructed in MultiSim to verfify V_0 is shown in figure 6. V_0 is shown in Table 2. Worked out solutions are shown in Solutions 2 [1].

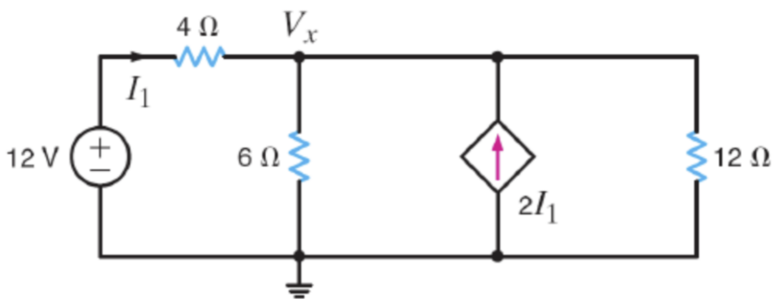


Figure 5

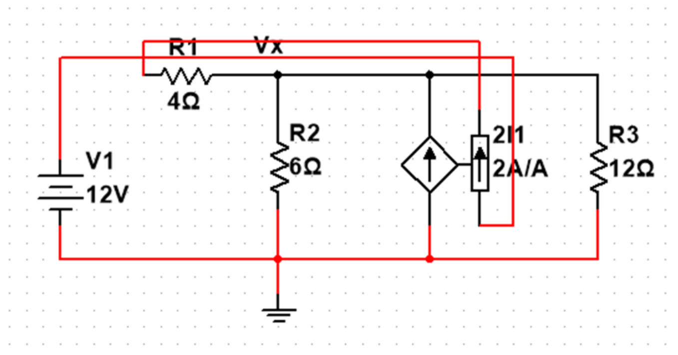


Figure 6

V_0	9.00v

Table 2

[3]

$$-12 + 4I_1 + 3I_1(12) = 0$$

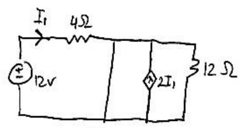
$$36I_1 + 4I_1 = 12$$

$$I_1 = \frac{12}{40}\text{ A}$$

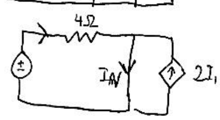
$$-V_{Th} - 4I_1 + 12 = 0$$

$$V_{th} = 12 - 4I_1 = 12 - 4\left(\frac{12}{40}\right)$$

$$V_{th} = 10.8\text{ V}$$



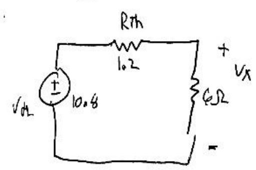
$$I_1 = \frac{12}{4}\text{ A}$$



$$I_N = I_1 + 2I_1 = 3I_1 = 3\left(\frac{12}{4}\right)$$

$$I_N = 9A$$

$$R_{th} = \frac{V_{th}}{I_N} = \frac{10.8}{9} = 1.2\,\Omega$$



$$V_x = 10.8\left(\frac{6}{6+1.2}\right) = 9V$$

$$V_x = 9V$$

Solutions 2

Exercise 4

In exercise 4, we were asked to find the Thevenin equivalent circuit between nodes A & B for the circuit shown in Figure 6. The circuit constructed in Multisim to verify I_x is shown in figure 7. Worked out solutions are shown in solutions 3[1].

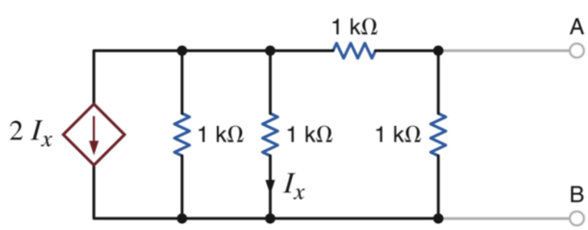


Figure 6

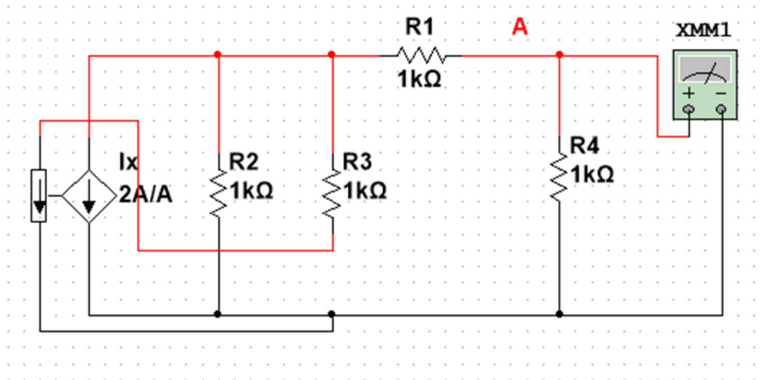


Figure 7

Calculated Resistance for I_x	555 Ohms
Measured Resistance for I_x	555.556 Ohms

Table 3

[4] KCL

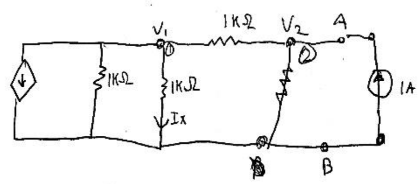
$$\frac{V_1-0}{1} + \frac{V_1-0}{1} + \frac{V_1-0}{2K} = 2I_x$$

$$\frac{2V_1+2V_1+V_1}{2k} = 2\left(\frac{V_1-0}{1}\right)$$

$$V_1 = \boxed{0\,V}$$

$$V_{Th} = V_1 \times \frac{1K}{1K+1K}$$

$$V_{Th} = \boxed{0\,V}$$



$$\frac{V_1-0}{1} + \frac{V_1-0}{1} + \frac{V_1-V_2}{1} + 2I_x = 0$$

$$5V_1 - V_2 = 0 \quad \text{node } 1$$

node 2 $$\frac{V_2-V_1}{1} + \frac{V_2-0}{1} = 1$$

$$-V_1 + 2V_2 = 1000 \quad \text{node } 2$$

$V_1 = 111.11V$ $V_2 = 555.55V$

$$R_{Th} = \frac{V_2}{I} = \frac{555.55}{1} = 555.55\,\Omega$$

Solutions 3

Exercise 5

In exercise 5, we were asked to find R_L for maximum power transfer and the maximum power that can be transferred to R_L (P_{max}). The circuit is shown below in Figure 8 and the constructed circuit is shown in figure 9. Data is shown in table 4 and solutions are shown in Solutions 4 [1].

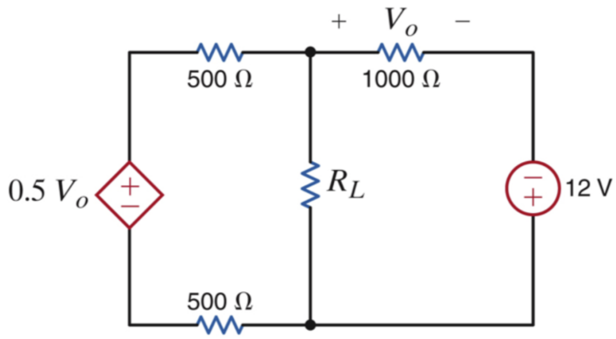
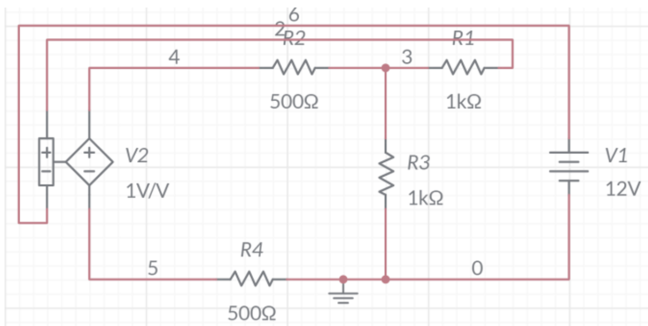


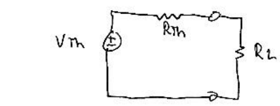
Figure 8



Equations 3

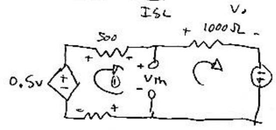
V_0	8v
V_{Th}	-4v
I	8mA
P_{RL}	6mW

1 [5]



$R_L = R_{Th}$

$R_{Th} = \frac{V_{Th}}{I_{sc}}$



$-0.5V_o + i(500) + i(1000)$

$-12v + i(500) = 0$

$i(2000) = 12 + 0.5V_o$

$V_o = i(1000)$

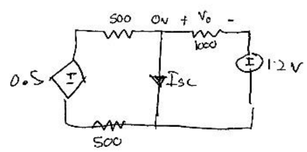
$2000i = 12 + 0.5(1000i)$

$1500i = 12$

$\underline{i = 8\,mA}$ $\underline{V_o = 8v}$

$-V_{Th} + V_o - 12 = 0$

$V_{Th} = 8 - 12 = \underline{-4v}$



$I = \frac{0-12}{1000}$

$V_o = I(1000)$

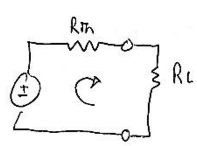
$= \frac{-12}{1000} \times 1000 = \underline{-12}$

$\frac{0 - 0.5V_o}{1000} + \frac{0-12}{1000} + I_{sc} = 0$

$\frac{-0.5(-12)}{1000} - \frac{12}{1000} + I_{sc} = 0$

$1000\,I_{sc} = 6 \Rightarrow I_{sc} = 6mA$

$R_{th} = \left|\frac{V_{th}}{I_{sc}}\right| = \underline{666.68\,\Omega}$



$R_{th} = R_L = \underline{666.68\,\Omega}$

$P_{RL} = I^2 \cdot R_L = \left(\frac{V_{th}}{R_{th}+R_L}\right) \times R_L = \frac{V_{th}^2}{4R_L^{\cancel{2}}} R_L$

$= \frac{16}{4 \times 666.68} = \underline{6mW}$

Conclusion

This lab was used as an overview of Thevenin'sand Norton's theorem. We were given circuits and asked to calculate various things using Thevinin equations and then verify it through Multisim. I did have some struggles with this lab. The TA helped explain some things before we started so the lab was clearer.

Bibliography

[1] Nelms, R. Mark, and Elizabeth Devore. *Recitation & MultiSim: Thevenin's and Norton's Theorems*. 2016, p. 5, Accessed 4 Sept 2019.