SARKAR, Mohul

Experiment Number 5&6

Thevenin's Equivalent Circuit

TUESDAY

April 9

ECE 1101L

Spring 2024

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Lab:

ECE 1101L Experiment 5&6

**THEVENIN’S EQUIVALENT CIRCUIT**

**OBJECTIVES**

- The objective of conducting a lab on Thevenin's equivalent is to understand the simplification of complex electrical networks into a simple equivalent circuit. By determining Thevenin's equivalent circuit, I will learn how to predict the behavior of a complex circuit with a more compact version of it consisting of a single power source and single resistor in series.

**MATERIALS REQUIRED BY STUDENT**

-11 clip leads

-A breadboard plus jumper wires

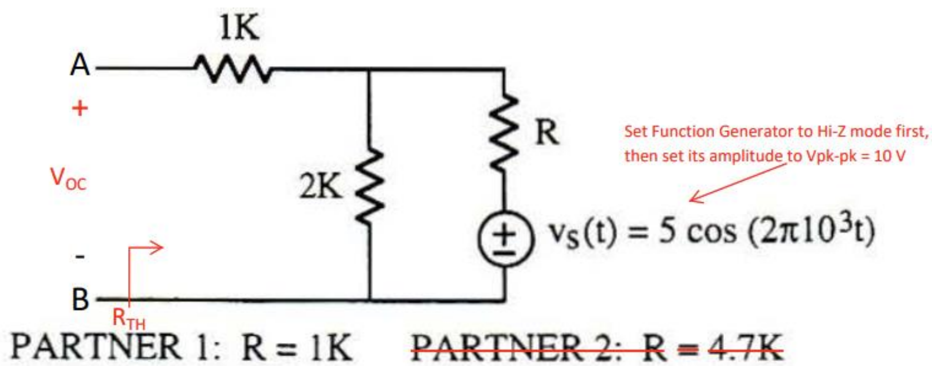
-Required Resistors and a 5 kΩ and 10 kΩ Potentiometers

**MATERIALS TO BE SUPPLIED**

-Power Cables

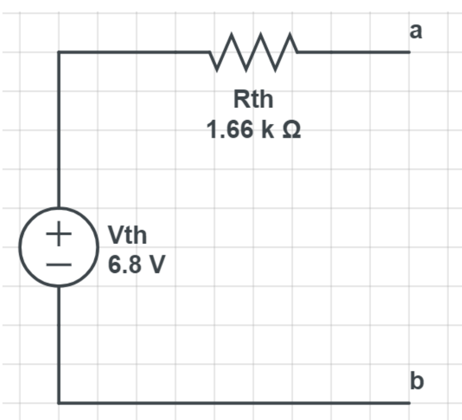
-Oscilloscope – S/N(MY50512828)

Given CKT1:

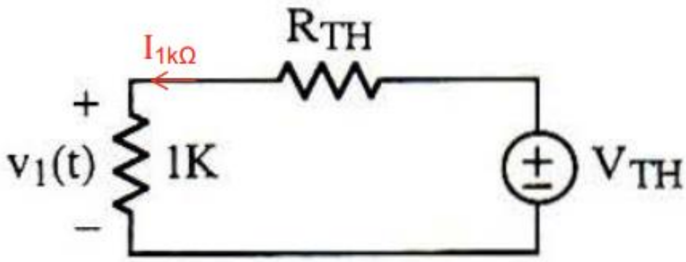



| Per sign convention shown on CKT1 | | | |
|---|---|---|---|
| Voltage | | Resistance | |
| Measured $V_{th}$ [V] | Calculated $V_{th}$ [V] | Measured $R_{th}$ [Ω] | Calculated $R_{th}$ [Ω] |
| 6.8 V | 3.33 V | 1.6K | 1.666K |

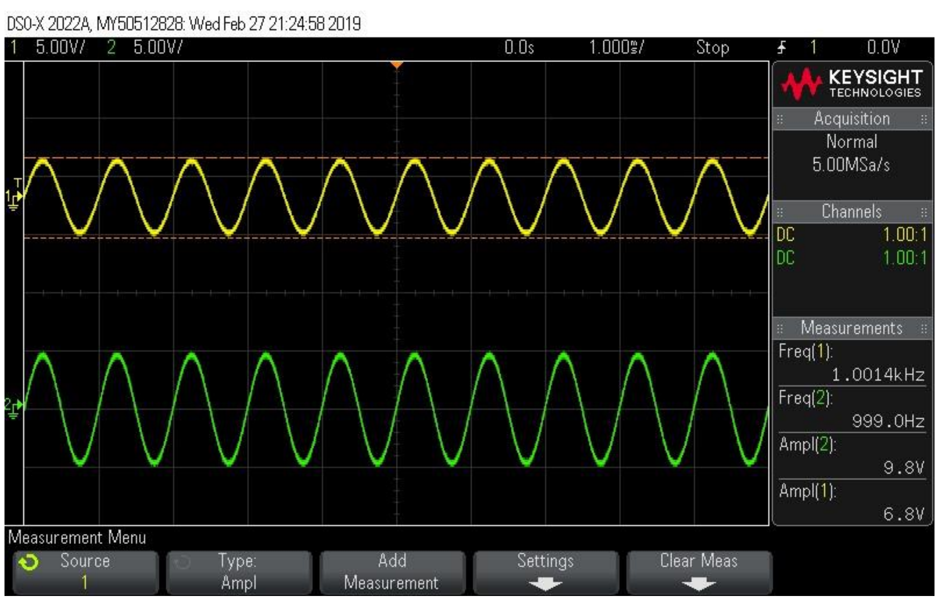
a. Measured $V_{th}$ = 6.8 V
b. Measured $R_{th}$ using method 1: $R_{th}$ = 1.6KΩ
c. Compare values, $V_{th}$ is the 2 times larger for the measured value than the calculated value. This would make sense because the oscilloscope reading should be double of what the measured value is as the graph is oscillating from the origin meaning the real value is half of that making the values equal. $R_{th}$ was measured and calculated as the same which also makes sense as they should result in the same short-circuit current value.
d.



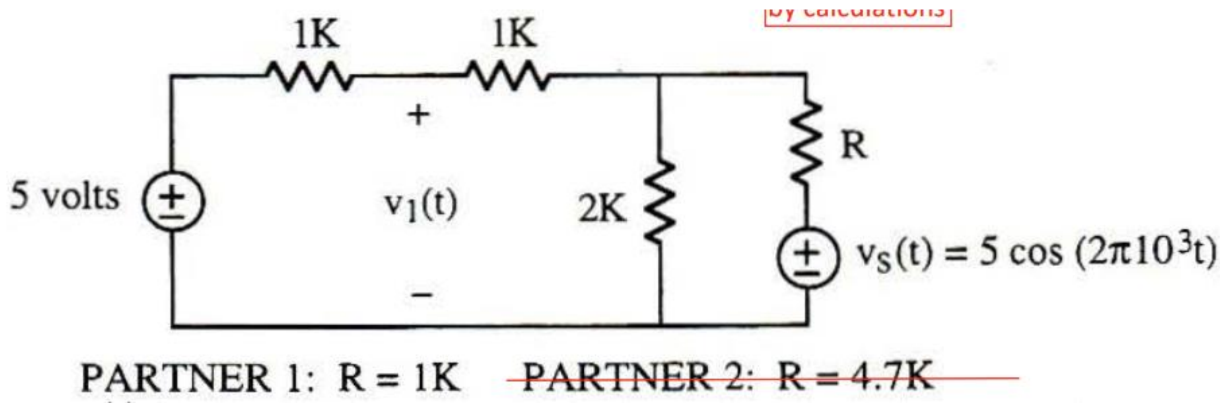
Given CKT1 Part F & I:



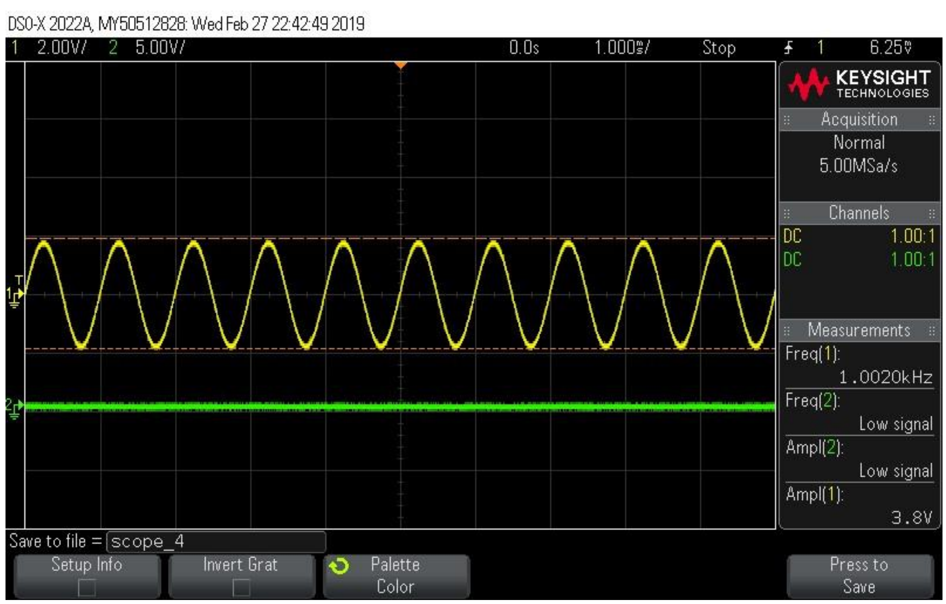

| Per sign convention shown on CKT1 | | | |
|---|---|---|---|
| Voltage | | Current | Resistance |
| Measured $V_{th}$ [V] | Calculated $V_{th}$ [V] | Calculated $I_{1k\Omega}$ [mA] | Calculated $R_{th}$ [Ω] |
| 3.4 | 6.4 | 3.4 | 1.6K |

- $I_{1k\Omega}$ = (3.4 V / 1K) = 3.4 mA
- Remove load resistor and measured value of $I_{sc}$ = 4 mA
- Use source transformation to put 1K resistor and 2K resistor in parallel. This gives a equivalent resistance of 1.66KΩ. Thus, $V_{th}$ = 4 mA * 1.66KΩ = 6.4 V.
- $V_{th}$ / $R_{th}$ = (6.4 / 1.66KΩ), $I_{sc}$ = 3.8 mA
- Comparing the values they are similar when measured and calculated using Thevenin's equivalent circuit.
- 

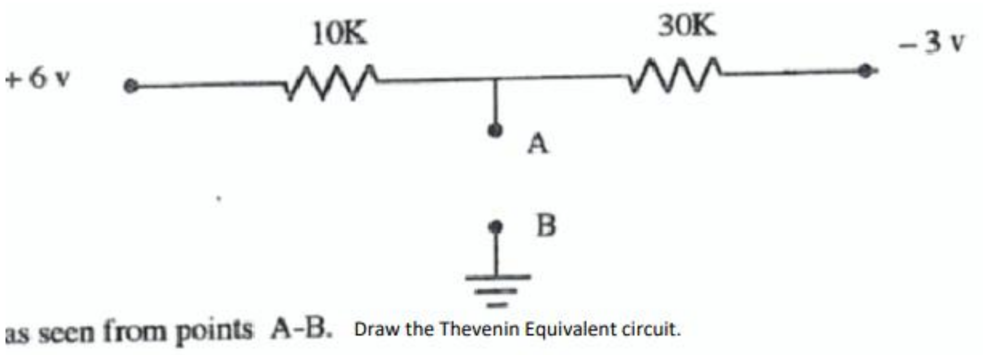
Given CKT1 Part J & K:

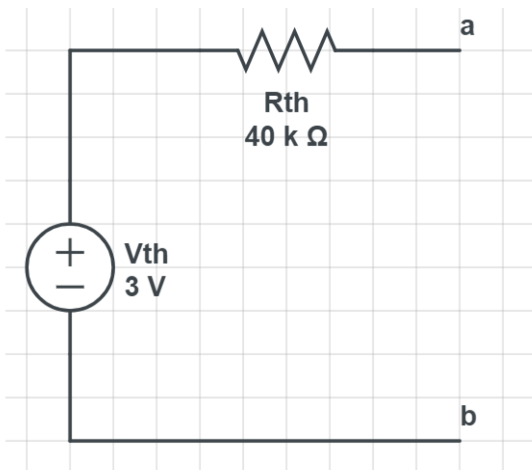



- Use superposition theorem to first deactivate 5 V source, putting both 1K resistors in series. Puth those two together making a 2K resistor an put that in parallel with the other 2K resistor. This will result in a single 1K resistor. Using voltage divider, 5 V * 1/2K = 2.5 V, which is the contribution of power from the source. Next, deactivate the other source, putting the 1K resistor and 2K resistor in parallel resulting in a equivalent resistance of 0.66KΩ resistor. Using voltage divider, 5 V * 0.66KΩ / 2.66KΩ = 1.25 V, which is the contribution from the other source. Adding both contributions, $V_{1(t)} = 3.75$ V.

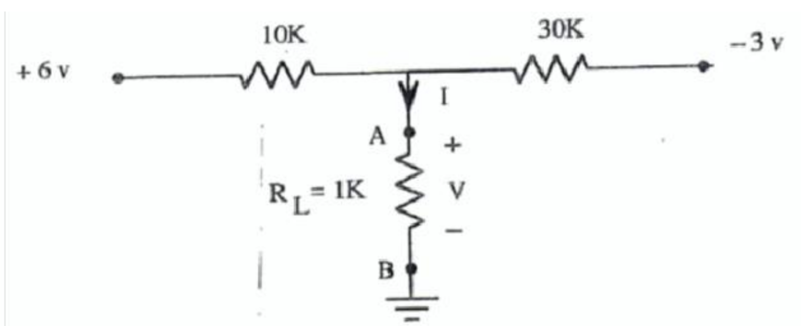


Given CKT2:



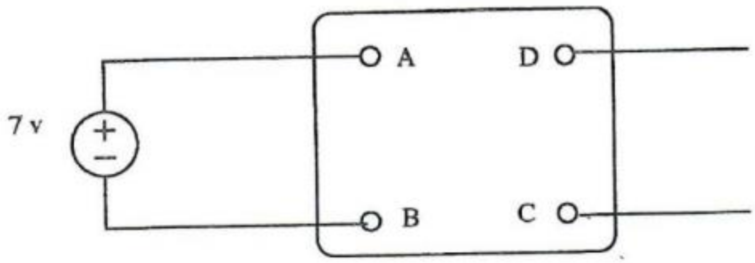




Given CKT3:

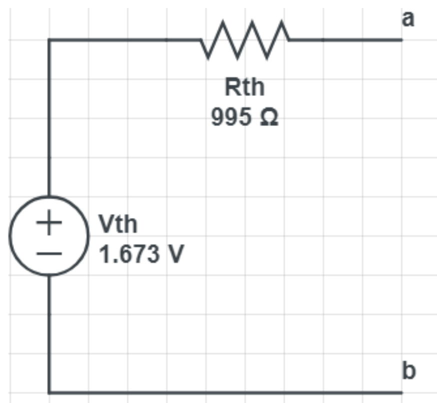



a. Measured V = 0.55 V and Measured I = 0.4 mA
b. Re-measured value of V from Thevenin's equivalent circuit = 0.715 V and re-measured I = 0.44 mA
c. The percent difference of the voltage is 26% and the percent difference of the current is 10%.

Given CKT4:




Thevenin’s equivalent circuit:

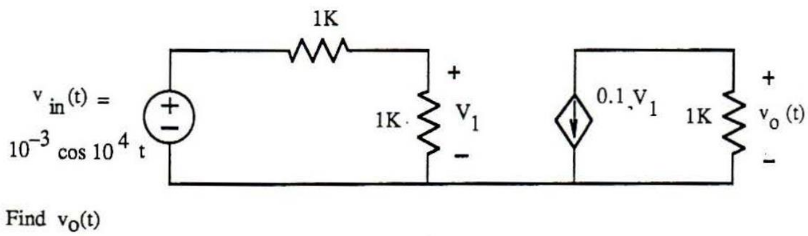



Discussion of Results:

In this lab, utilizing an oscilloscope to study Thevenin's equivalent circuit yielded insightful results. Despite theoretical predictions, our lab findings exhibited a small percent error. This experience provided me with a deeper understanding of circuit behavior beyond theoretical, calculative knowledge. By observing my expected values, I was able to analyze circuit elements more critically and gain practical insights into real-world applications.

Post Lab:

Problem 3.7:



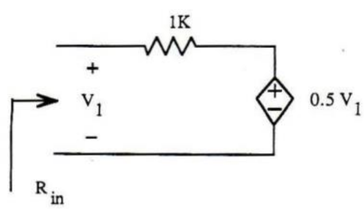

$V_1 = (V(t)*R_1)/R_1+R_2$

$V_1 = $ (10^-3cos(10^4t) * 1k)/2k

$V_o(t) = $ -100*cos(10^4t)/2000

$V_o(t) = $ -0.05cos(10^4t) V

Problem 3.11:



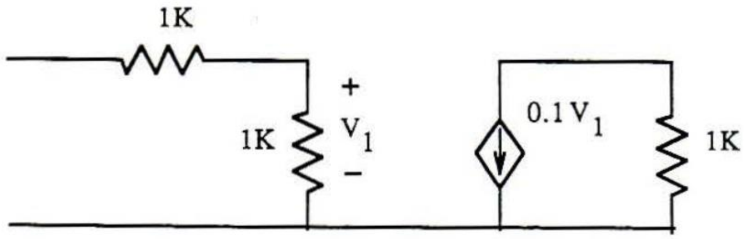

$V_1 – I_1 – 0.5V_1 = 0$

$V_1(1-0.5) = I_1 * 1K$

$V_1 = (1000 * I_1)/0.5$

$R_{in} = 2\ k\Omega$

Problem 3.12:



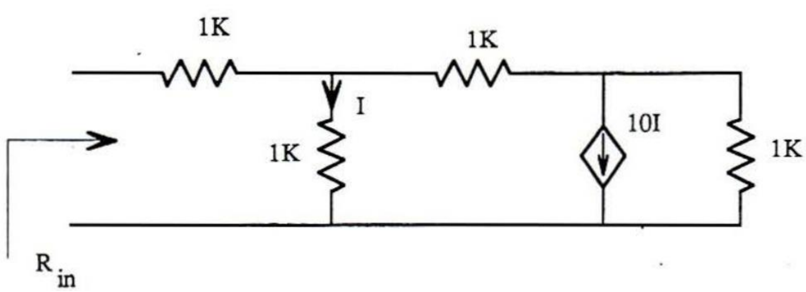

$R_{in} = V_{in} / I_{in}$

$I_{in} = (V_1 / 1K) = V_{in} / 2K$

$V_{in} / I_{in} = 2K$

$R_{in} = 2K$

Problem 3.13:




KVL loop 1:

$1(1\text{-}I) + 1(1\text{-}11I) – I = 0$

$1 – I + 1 – 11I – I = 0$

$2 – 13I = 0$

$I = 2/13$ mA

KVL loop 2:

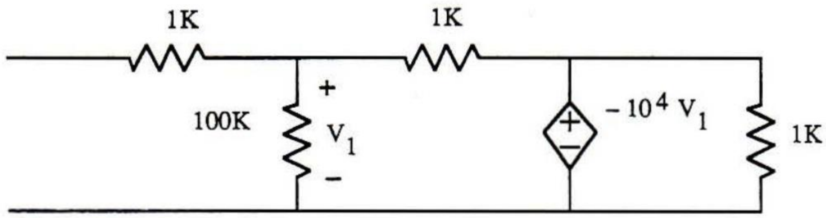
$-V + 1 + I = 0$

$V = 1 + 2/13$

$V = 15/13$ V

$R_{in} = 1.1538$ KΩ

Problem 3.14:



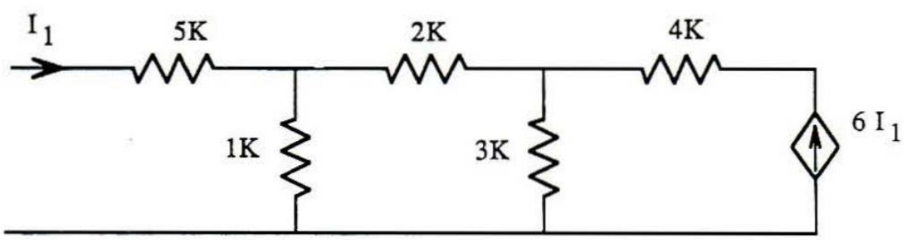

$(V_1 - 1) / 1K + V_1/100K + (V_1 + 10\text{^}4V_1)/1K = 1/1K$

$I_i = 0.999$ mA

$R_i = 1 V / I_i$

$R_i = 1$ KΩ

Problem 3.15:




$I_1 = (1 - V_1) / 5K$

Node $V_1$:

$(V_1 - 1) / 5K + V_1 / 1K + (V_1 - V_2) / 2K = 0$

$V_1 [1/5 + 1 + 1/2] - V_2 / 2k = 1/5$

$V_1[17/10] - V_2 / 2 = 1/5$

$17V_1 - 5V_2 = 2$

Node $V_2$:

$(V_2 - V_1)/2K + V_2/3K - 6I_1 = 0$

$V_2[1/2 + 1/3] - V_1[1/2 - 6/5] = 6/5$

$5/6V_2 + 7/10V_1$

$50V_2 + 42V_1 = 72$

$10(17V_1 - 5V_2) = 2(10)$

$170V_1 - 50V_2 = 20$

$+41V_1 + 50V_2 = 72$

$212V_1 = 92$

$V_1 = 92/212$

$V_1 = 0.434$ V

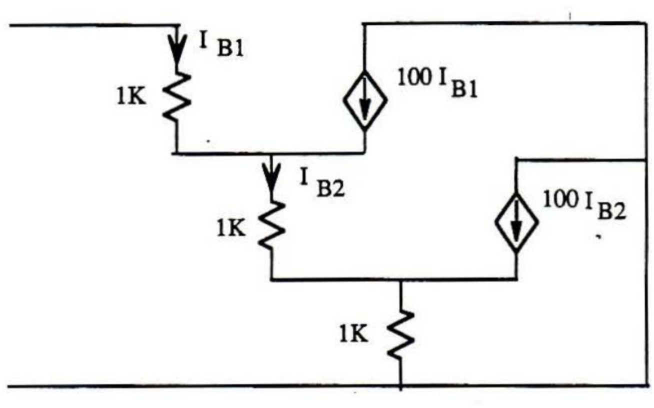
Ohm's law:

$I_1 = (1 - V_1) / 5000 = 0.1132$ mA

$R_{in} = V_{th} / I = 1/0.1132 * 10^{-3}$

$R_{in} = 8.834$ KΩ

Problem 3.16:




KCL at Node 1:

$IB_1+100B_1 = IB_2$

$I01B_1 = IB_2$

KCL at Node 2:

$IB_2+100B_2 = V_2 / 1K$

$I01B_2 = V_2 / 1K$

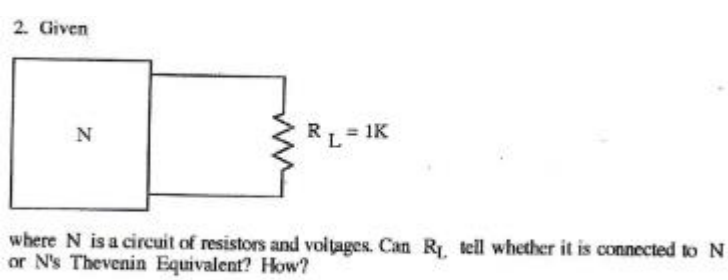
$V_2 = (101)^2 * 10^3IB_1$

$V_i = 1K * IB_1 + 1K * IB_2 + V_2$

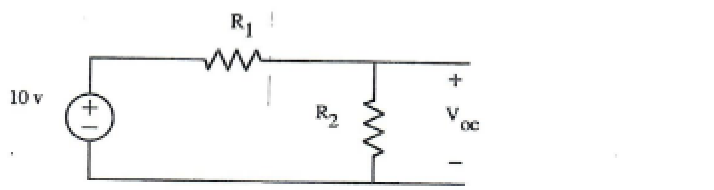
$V_i / IB_1 = 10^3(1 + 101 + 101^2)$

$R_i = 10.303\ M\Omega$

8. To experimentally find the Thevenin's equivalent of a circuit, you would first disconnect any loads attached to the circuit. Then, you would apply a test voltage across the terminals where the load was connected. Measure the voltage across these terminals and the current flowing through them. By varying the test voltage and measuring the currents, you can plot a graph of voltage against current. The slope of this graph represents the Thevenin equivalent resistance, while the intercept on the voltage axis gives the Thevenin equivalent voltage.

9. 


The voltage across Load Resistor is $V_{th}$ the current going through the is $I_n$ so $R_{eq}$ can be calculated with Ohm's Law




10. Find and draw the Thevenin Equivalent if $V_{OC}$ = 2 volts and $R_1 + R_2$ = 10K

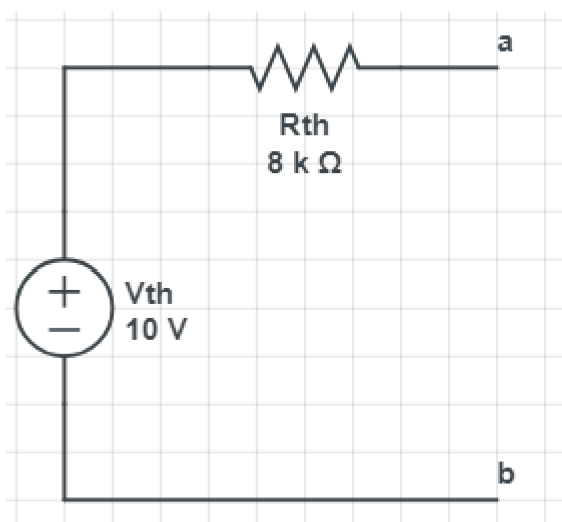
$(2-10) / R_1 + 2 / R_2 = 0$

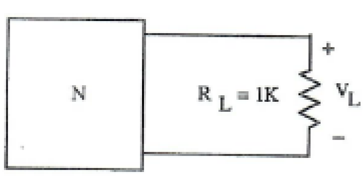
$-8 / R_1 + 2 / R_2 = 0$

$-80 + 8R_1 + 2R_1 = 0$

$R_1 = 8K\Omega$

$R_2 = 2K\Omega$




11.

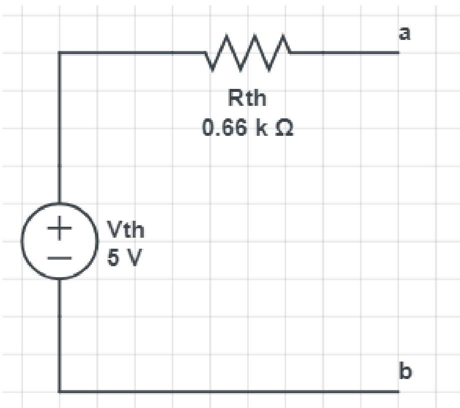
KCL at Node A:

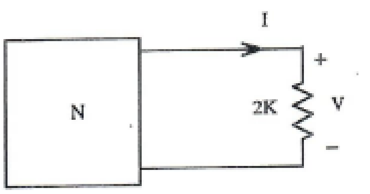
$3 + 3-5 / R = 0$

$3R - 2 = 0$

$R = 2/3 = 0.66K\Omega$

$V_{th} = 5V$




12. Find I and V if the Thevenin Equivalent of N is $V_{TH} = -5$ volts and $R_{TH} = 4K$.

$I_o = V/R = 5/b = 0.833$ mA

$I = -0.833$ mA

$V_{ab} = V_a - V_b = 3.34 - 5 = -1.66$ V