UM-SJTU JI VE215 Lab #2

We will evaluate the Thevenin equivalent in this lab.

- Please hand in your post-lab assignment before the due date. Please do your post-lab assignment following the requirements in each problem. Both hand-written and printed are accepted.
- You are encouraged to print this lab manual and then finish the post-lab questions on it. For pictures or diagrams, you may print it in a paper, cut it down and paste on this worksheet.

Instruments

DC power supply (**Agilent E3631A or MOTECH LPS 305**)

Multi-meter

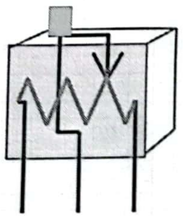
Breadboard and Wires

Resistors of **50Ω** and **100Ω**

Rheostat of **200Ω** (or **500Ω**)

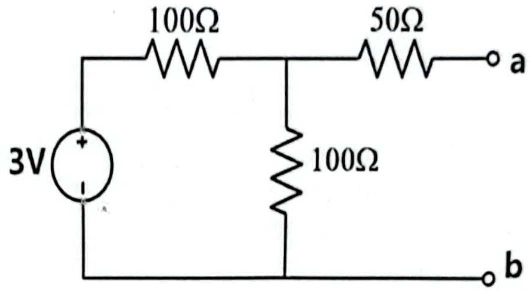
Instruments Introduction

For the **rheostats**, please connect the middle port and one of the sided ports inside the circuit (refer to the diagram). Please rotate the button at the top of rheostat using a mini-screwdriver to change its resistance.



Problem #1 Thevenin Equivalent

Please connect the circuit on your breadboard based on the schematic.



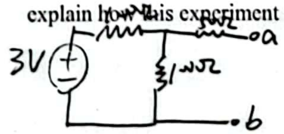
After the connection, please turn on the voltage source and measure the open-loop voltage V_{ab} between port **a** and port **b** by multi-meter. Then, please replace the DC voltage power supply by a wire and measure the equivalent resistance R_{ab} between port **a** and port **b** by multi-meter.

Please record your data in the table:

Term	Open loop voltage V_{ab}	Equivalent resistance R_{ab}
Value	1.525 V	101.4 Ω

Post-Lab Questions for (P1)

(1) Please calculate the theoretical values of the Thevenin's equivalent voltage and the equivalent resistance between port **a** and port **b**. Then, please compare the experimental values with the theoretical ones and explain how this experiment verifies the Thevenin theorem.



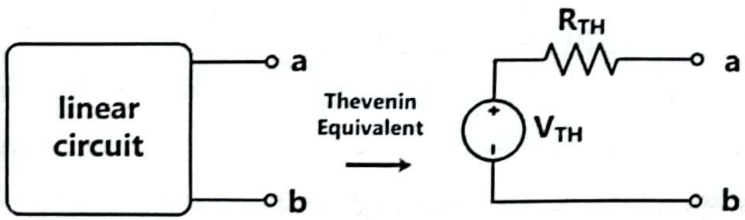
$V_{ab} = 3V \times \frac{100\Omega}{100\Omega + 100\Omega} = 1.5V$

$R_{ab} = 50\Omega + (100\Omega \| 100\Omega) = 100\Omega$

It verifies the Thevenin theorem in that it has similar open loop voltage and Equivalent resistance

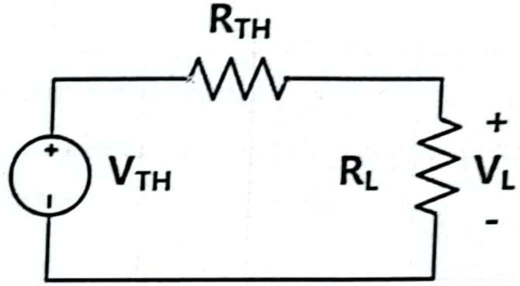
Problem #2 Application of Thevenin Equivalent

Based on Thevenin theorem, most of linear circuits could be replaced by equivalent models composed of an equivalent voltage source V_{TH} connected in series with equivalent resistance R_{TH}, which is represented by the following diagram:

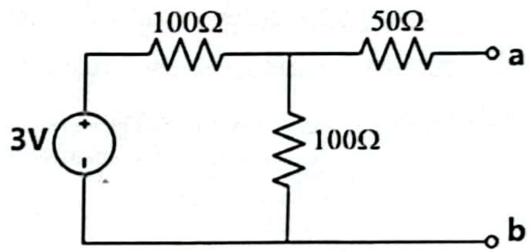


By adopting Thevenin transformation, the amount of calculation could be reduced significantly when analyzing complex circuits. For a linear circuit, suppose the Thevenin equivalent voltage is V_{TH} and the equivalent resistance is R_{TH}. If we connect a load resistance R_L between the two reference ports (please refer to the following schematics), the load voltage V_L will be:

$$V_L = V_{TH}\frac{R_L}{R_L + R_{TH}}$$



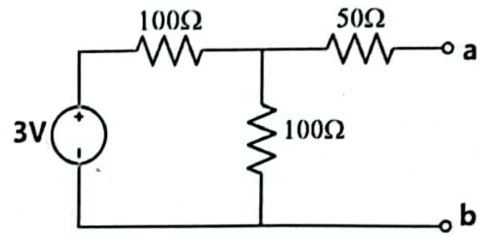
Please connect a **50Ω** resistor and an **100Ω** resistor respectively between port **a** and port **b** as the load in the following circuit (same as the circuit in problem 1). Then, please turn on the source, measure the load voltage V_{ab} (the voltage between port **a** and port **b**) by multi-meter and fill in the table next page:



Load Resistance	50Ω	100Ω
V_{ab}	2495V	2725V

Post-Lab Questions for (P2)

(1) Please calculate the theoretical values of the load voltage V_{ab} for the **50Ω** and **100Ω** loads. Then, please compare the experimental results with the theoretical ones.



$R = 50\Omega$, $V_{ab} = 1.5V \times \frac{50\Omega}{100\Omega + 50\Omega} = \cancel{\#\#}\ 0.5V$

$\varepsilon = \frac{-0.5V + 0.495V}{\cancel{0.495V}\ 0.5V} = -1.0\%$

The relative error is quite small, so it has little difference with the theoretical ones.

$R = 100\Omega$, $V_{ab} = 1.5V \times \frac{100\Omega}{100\Omega + 100\Omega} = 0.75V$

$\varepsilon = \frac{0.75V - 0.725V}{0.75V} = -3.3\%$

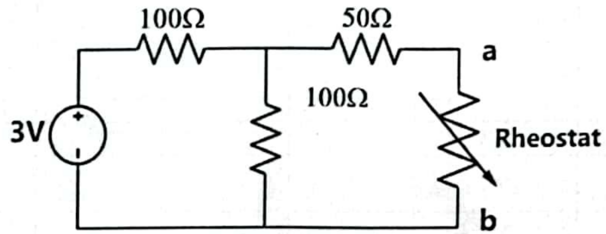
The relative error is quite small, so it has little difference with the theoratical ones

Problem #3 Maximum Power Transfer

According to the maximum power transformation theorem, for a linear circuit with Thevenin voltage V_{TH} and equivalent resistance R_{TH}, the power transformed to the load will reaches its maximum if the load resistance $R_L = R_{TH}$ and the maximum power absorbed by the load is:

$$P_{max} = \frac{V_{TH}^2}{4R_{TH}}$$

In order to evaluate the maximum power transformation theorem, please connect a **200Ω** (or **500Ω**) rheostat between port **a** and port **b** in the schematic.



Please set your rheostat at its minimum resistance (about **0Ω**) at first, use multi-meter to measure the load resistance (resistance of rheostat) R_L and the load voltage V_L. Then, please increase the resistance by **10Ω** or **20Ω** each time, measure R_L and V_L following the same procedure. Please record the data of R_L, V_L in the table and calculate the power transformed to the load P_L for each R_L.

Rheostat Resistance R_L	Load Voltage V_L	Power absorbed by load P_L
0Ω	~~0.2~~ 0.000V	0.000W ~~0.0016W~~
9.1Ω	0.122V	0.0016W
18.9Ω	0.238V	0.0030W
29.1Ω	0.332V	0.0038W
38.1Ω	0.426V	0.0048W

46.4Ω	0.520V	0.0058W
60.7Ω	0.553V	0.0050W
68.8Ω	0.601V	0.0053W
79.8Ω	0.661V	0.0055W
90.6Ω	0.701V	0.0054W
96.9Ω	0.735V	0.0056W
109.4Ω	0.787V	0.0057W
120.2Ω	0.809V	0.0054W
131.2Ω	0.844V	0.0054W
139.3Ω ~~142.2Ω~~	0.860V	0.0053W
153.6Ω	0.901V	0.0053W
161.9Ω	0.933V	0.0054W
170.9Ω	0.955V	0.0053W
181.1Ω	0.958V	0.0051W
190.9Ω	0.968V	0.0049W
200Ω	0.988V	0.0049W

Post-Lab Questions for (P2)

(1) Please calculate the theoretical values of the maximum power transferred to the load and the corresponding load resistance.

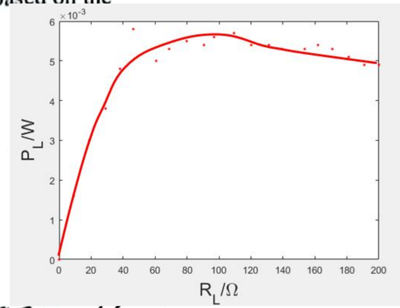
When it takes the maximum power transferred,

$R_L = R_H = 100\Omega$

$U = 1.5V \times \frac{100\Omega}{100\Omega + 100\Omega} = 0.75V$

$P = \frac{U^2}{R} = 0.0056W$

(2) Please plot the curve of P_L and R_L. What is the maximum power transferred to the load and the corresponding load resistance based on the curve you obtained? Is it consistent with the expected?



Based on the curve (except for an error), the maximum probable power transferred was 0.0057W and the resistance is 109.4Ω. It is basically consistent with my exceptation

Post-Lab Reflection Questions

(1) Is your experimental result the same as your analysis (Need data as proof)? If not, how do you interpret this difference? What do you think is the source of the experimental error?

(2) What do you learn from this experiment? (e.g. what experimental procedures, how to debug, etc.)

(1) Basically, yes, For example, in procedure 1, V_{ab} was 1.5V theoratically and 1.525V experimentally. The relative error was less than 2%. On top of that, except the 46.4Ω datas, the outcome of procedure 3 highly complies with the theoratical curve, and the data of maximum power and corresponding load resistance was ~~high~~ close to the theoratical ones. There are some difference awaded. For example when the resistance was ~~test~~ measured in the circuit, it is in parallel with other resistances.

(2) In this experiment, it is found that the inner structure of the rheostat was a —[200Ω]— c (b at the slider). Thus every time it is moved, it can be used to measure two groups of data, one with a.b and another with b.c