UM-SJTU JI 2024FA VE215 Lab #2

We will evaluate the Thehevenin 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

Multimeter

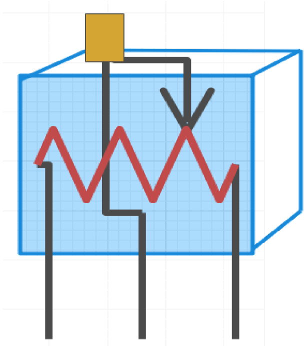
Breadboard and Wires

Resistors of 50Ω and 100Ω

Rheostat of 200Ω (or 500Ω)

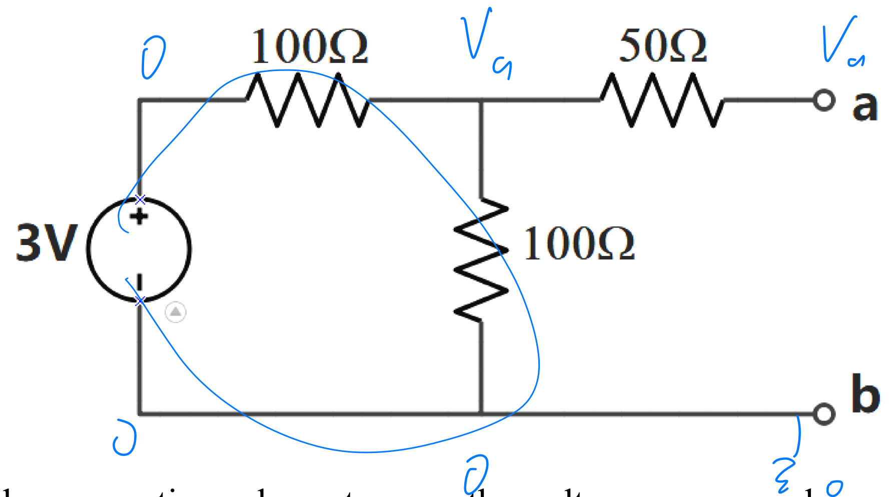
Instruments Introduction

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-circuit voltage $\mathbf{V_{ab}}$ between port **a** and port **b** by multi-meter. Then, please turn off the voltage source and measure the equivalent resistance $\mathbf{R_{ab}}$ between port **a** and port **b** by multi-meter. Please record your data in the table:

Term	Open-circuit voltage $\mathbf{V_{ab}}$	Equivalent resistance $\mathbf{R_{ab}}$
Value	1.498V.	100.3Ω.

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.

$R_{Th} = 100 \| 100 + 50 = 100\,\Omega$.

$\frac{3 - V_{Th}}{100} = \frac{V_{Th}}{100}$ $V_{Th} = 1.5V$.

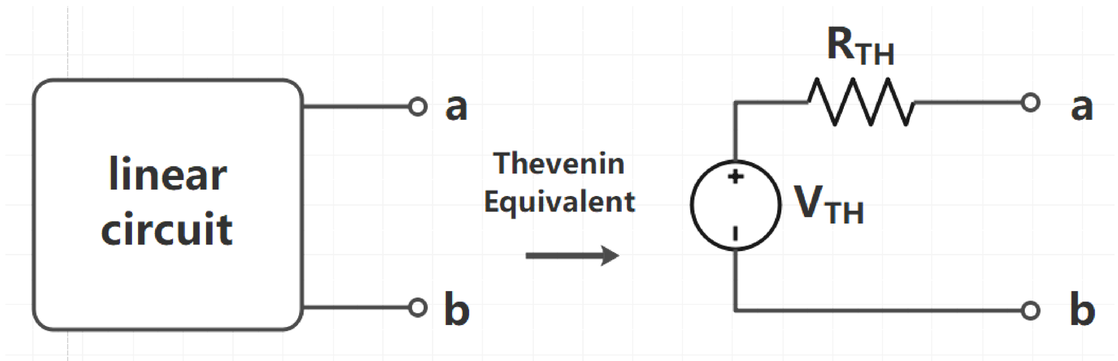
In our measurement, $R_{ab} = 100.3\Omega \cong R_{Th}$,

$V_{ab} = 1.498V \cong V_{Th}$.

Therefore, it verifies the Thevenin Theorem.

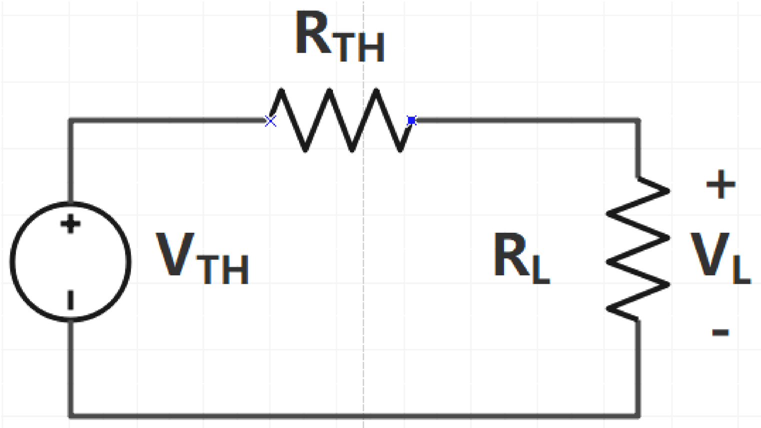
Problem #2 Application of Thevenin Equivalent

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

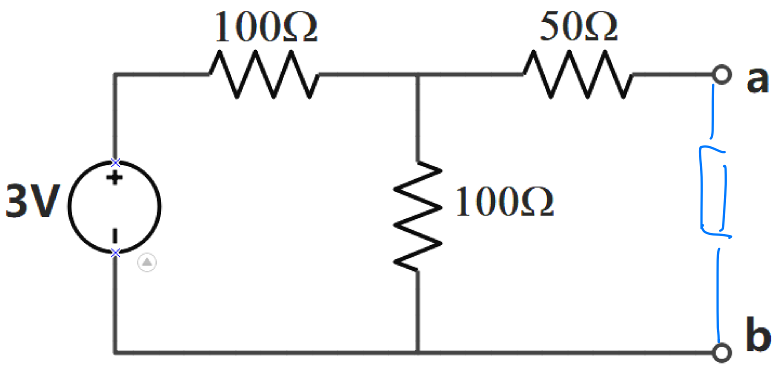


By adopting Thevenin transformation, the amount of calculation could be reduced significantly when analyzing complex circuits. For a linear circuit, suppose the Thevenin equivalent voltage is $\mathbf{V_{TH}}$ and the equivalent resistance is $\mathbf{R_{TH}}$. If we connect a load resistance $\mathbf{R_L}$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

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



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 $\mathbf{V_{ab}}$ (the voltage between port **a** and port **b**) by multi-meter and fill in the table next page:



TM5

0.5V, 2.5V,
50Ω, 250Ω;

0.75V, 2.25V,
100Ω - 300Ω,

Load Resistance	**50Ω**	**100Ω**
$\mathbf{V_{ab}}$	0.497 V	0.746V.

Post-Lab Questions for (P2)

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

50Ω: $V_{ab} = 1.5 \cdot \frac{50}{50+100} = 0.5V \approx V_{ab}$.

100Ω: $V_{ab} = 1.5 \cdot \frac{100}{100+100} = 0.75V \approx V_{ab}$.

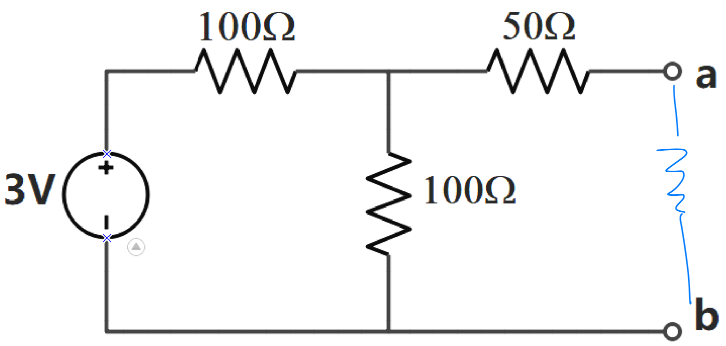
Therefore, the experimental results meets with the theoretical ones.

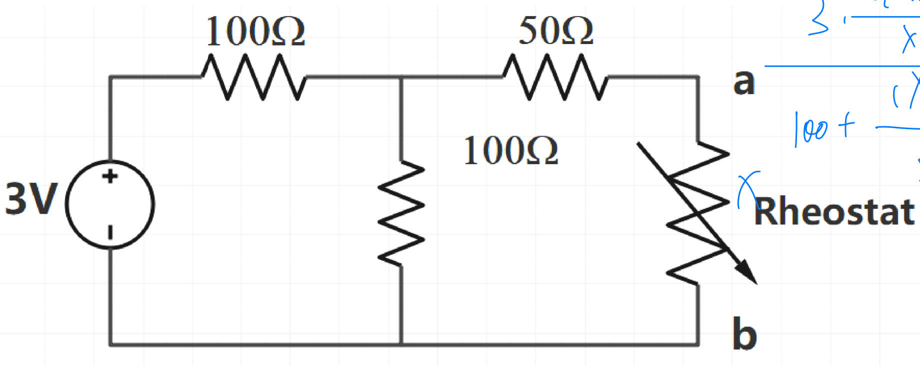
Problem #3 Maximum Power Transfer

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

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

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.





150

150 00 / 250 = 60

3 · (X+50)100 / X+150 ÷ (100 + (X+50)100 / X+150)

X / X+50

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

Rheostat Resistance $\mathbf{R_L}$	Load Voltage $\mathbf{V_L}$	Power absorbed by load $\mathbf{P_L}$
0Ω	0V	0W
10Ω	0.138V	0.00183
20Ω	0.245V	0.00300
30Ω	0.324V	0.00350
40Ω	0.449V	0.00504

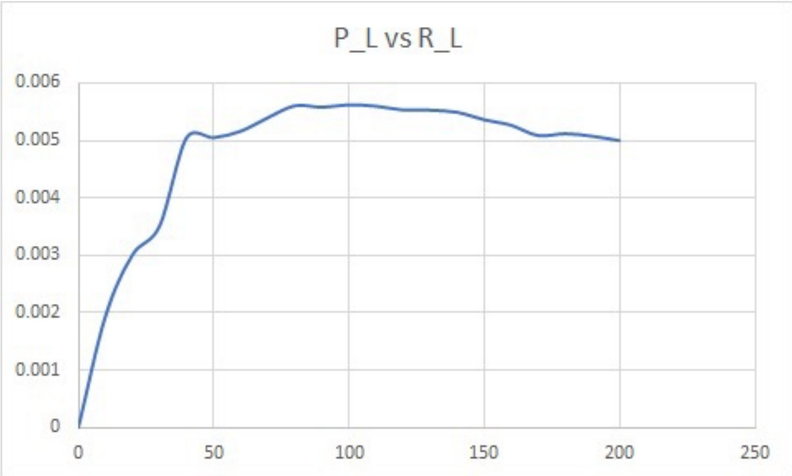
50Ω	0.502V	0.00504
60Ω	0.556V	0.00515
70Ω	0.614V	0.00539
80Ω	0.669V	0.00560
90Ω	0.708V	0.0056
100Ω	0.749V	0.00557
110Ω	0.784V	0.00561
120Ω	0.814V	0.00552
130Ω	0.842V	0.00551
140Ω	0.876V	0.00548
150Ω	0.896V	0.00535
160Ω	0.917	0.00526
170Ω	0.929V	0.00507
180Ω	0.959V	0.00511
190Ω	0.981V	0.00507
200Ω	0.999V	0.00499

Post-Lab Questions for (P3)

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

$$P_{max} = \frac{V_{Th}^2}{4R_{Th}} = \frac{1.5^2}{4\times100} = 5.625\times10^{-3}$$

(2) Please plot the curve of $\mathbf{P_L}$ and $\mathbf{R_L}$. 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?



when $R_L = 100\Omega$, P_L reaches the maximum, about 5.6×10^{-3} W, which meets the expectation.