The Hashemite University

Faculty of Engineering

Department of Electrical Engineering

Experiment “4“ (Techniques of circuit analysis (2))

Prepared by:

- Ala’a Al-Dada (**ID No. 1833678)**
- Qusai AL-Hasanat (**ID No. 1832752)**
- Saif Mifleh (**ID No. 1837584)**
- **Instructor’s Name : Dr. Amr Obeidat**
- **Eng. Name: Mohammed Alhattab**

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“Experiment 4”

Objectives:

The objective of this experiment is to simplify resistive circuits in DC employing the Thevenin and Norton equivalents. Experimental results will allow the verification of the theoretical analysis. Also to verify the maximum power transfer theorem, this will lead us to learn about some types of variable resistors such as decade resistance box and potentiometers.

Theory:

1. Thevenin’s Theorem:

Any linear network may, with respect to a pair of terminals. be replaced by an

equivalent voltage source Vth (equal to the open circuit voltage) in series with a resistance Rth seen between these terminals. The theorem presents a very useful method for simplifying complex circuits. We must realize that the equivalency is with respect to a selected pair of terminals. We replace the original circuit lying on one side of a pair of terminals by its equivalent Thevenin voltage source and resistance.

2. Norton’s Theorem:

Any linear network may, with respect to a pair of terminals, be replaced by a current source IN (equal to the short- circuit current) in parallel with the resistance Rth seen between the two terminals. Similar to Thevenin’s Theorem, we are presented with a simple method of reducing a more complex circuit to a simpler one. The difference lies in converting the reduced circuit to a current source instead of a voltage source, with the equivalent resistance in parallel rather than in series.

3. Maximum Power Transfer Theory:

An independent voltage source in series with a resistance Rth, or an independent

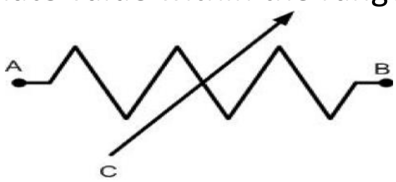
current source in parallel with a resistance Rth, delivers maximum power to a load resistance RL when **Rth = RL** .

The maximum power delivered, in this case, is

$$P(max) = \frac{Vth^2}{4Rth}$$

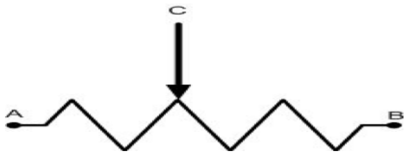
4. Variable resistors :

In addition to fixed- value resistors – which we dealt with in the previous three experiments- variable resistors, are used extensively in electrical and electronic circuits.The two types of variable resistors are rheostat and the potentiometer. A rheostat inessentially a two terminal device. Its circuit symbol is shown in below. Points A and B connect in to the circuit. A rheostat has a maximum resistance value, specified by the manufacturer, and a minimum value, usually 0 Ω, The arrowhead in the figure indicates a mechanical means of a adjusting the rheostat so that the resistance, measured between points A and B, can be adjusted to any intermediate value within the range of variation.



A Rheostat is a variable resistor with two terminals

The circuit symbol for a potentiometer below, shows that this is a three-terminal device. The resistance between points A and B is fixed. Point C is the variable arm of the potentiometer. The arm is a metal contactor that slides a long the un-insulated surface of the resistance element. The amount of resistance material between the point of contact and one of the end terminals determines the resistance between those two points. Thus the longer the surface between points A and C, the greater is the resistance between these two points. In other words, the resistance between points A and C varies as the length of the element included between points A and C. The same is true for points B and C. The resistance RAC from A to C plus the resistance RCB from C to B make up the fixed resistance RAB of the potentiometer. The action of the arm is to increase the resistance between C and one of the end terminals and at the same time to decrease the resistance Between C and the other terminal while the sum of the two resistances RAC and RCB remains constant.



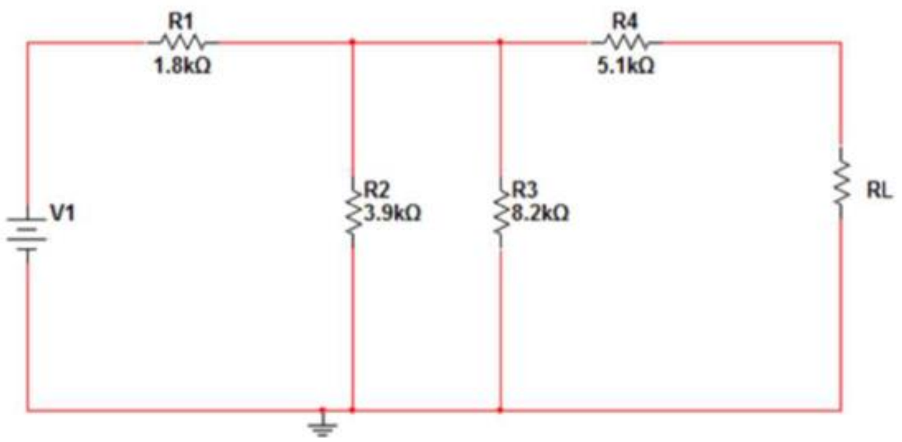
A potentiometer

Equipment:

- Breadboard
- Digital Multimeter (DMM)
- Power Supply
- resistors
- Potentiometer
- wires

Procedure:

1. at first We fixed the circuit in breadboard as shown in the figure
2. we remove RL and connect DMM (as a voltmeter) at the same place to measure Vth
3. We put the red wire onto the black in the power supply to make a short circuit (when you want to measure Req you should make this step to turn off your power supply) then we connect DMM as an ohmmeter to read the value of Rth



When
V1=10V

experiment's calculations

parameter	Vth	IN	Rth
Measured	**5.92 V**	**0.960 mA**	**6.15 kΩ**
Theoretical	**5.94 V**	**0.962mA**	**6.17 kΩ**

to calculate Vth

- **R23**= $\frac{1}{\left(\frac{1}{3.9}\right)+\left(\frac{1}{8.2}\right)}$ = **2.64 KΩ**
- **Req** = 2.64+1.8 = **4.44 kΩ**
- **Is** = $\frac{Vs}{Req}$ = $\frac{10}{4.44}$ = **2.25 mA**
- **Vth** = R23*Is = 2.25*2.64 = **5.94 V**

to calculate Rth

- **Rth = (R1//R23)+ R4**

Rth = $\frac{1}{\left(\frac{1}{1.8}\right)+\left(\frac{1}{2.64}\right)}$ + 5.1 = **6.17 kΩ**

to calculate IN

- **IN** = $\frac{Vth}{Rth}$ = $\frac{5.94}{6.17}$ = **0.962mA**

A potentiometer is required in this part

put the variable resistor on a value of 3 KΩ by measuring it in DMM and then we will measure the voltage on it. And the same on 6 ,9.1 kΩ

RL KΩ	**VL**	**PL**
3 KΩ	1.9 V	1.203 mW
6 KΩ	2.91 V	1.411 mW
9.1 KΩ	3.5 V	1.340 mW

experiment's calculations:

- **PL =** $\frac{VL^2}{RL}$

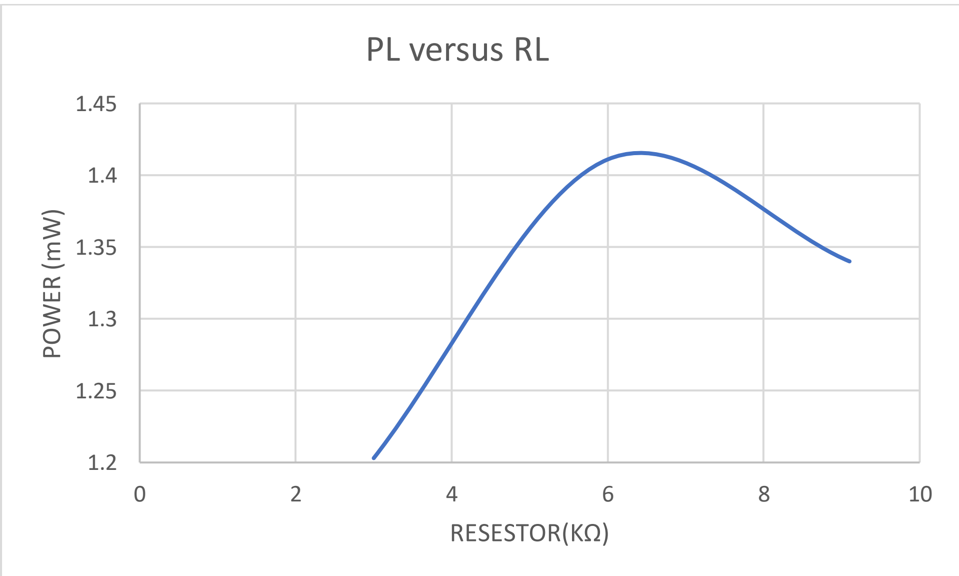
PL3= $\frac{1.9^2}{3}$**= 1.203mW**

PL6= $\frac{2.91^2}{6}$ **= 1.411mW**

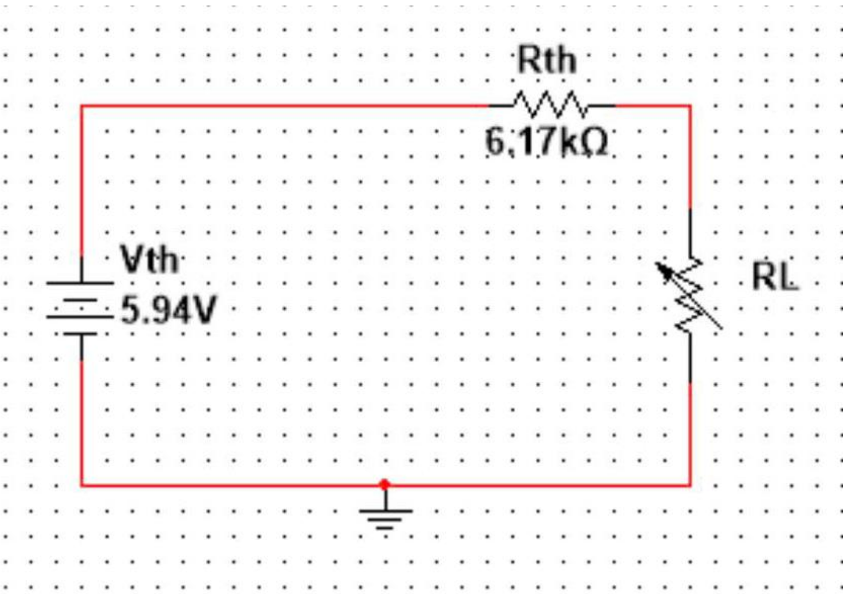
PL9.1= $\frac{3.5^2}{9.1}$**= 1.340mW**

the questions answers :

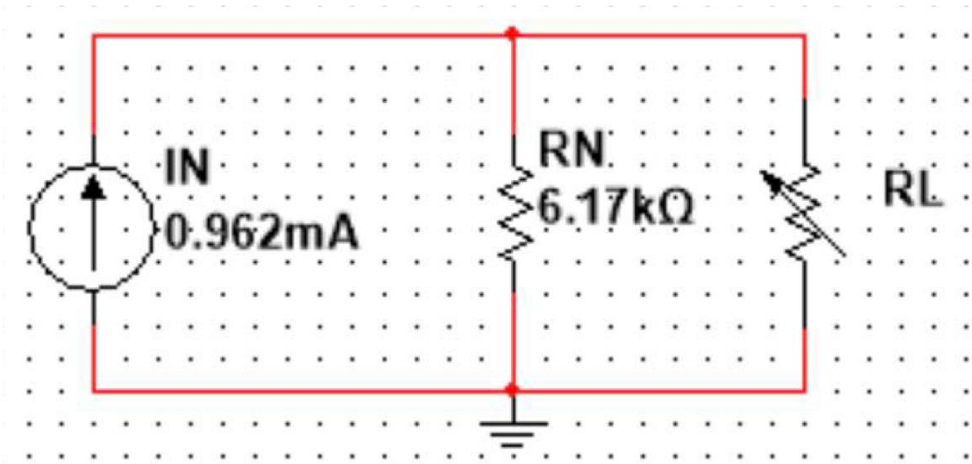
1. **Draw the power consumed by the load**



2. **Draw the THEVENIN equivalent circuit**



3. **Draw the NORTON equivalent circuit**



4. **Determine which resistor consumes the largest power from the second table?**

   The RL with the largest power is 6 kΩ(p=1.411 mW)

5. **Is this formula p(max) = $\frac{Vth^2}{4\,R\,th}$ verified the maximum power calculated from your measurements ? if yes , prove that .**

Yes , the value is so close

$P(max) = \frac{5.94^{2}}{4*6.17} = 1.43 \text{ mW}$

Conclusion:

1. *we learn how to use excel program to draw the relationships as a graphs.*

2. *in thevinen circuit we are carefull about the type of sources but in this experiment we use only independent voltage source.*

3. *We learn that thevinen and norton are important to simplify a complex circuits.*