كلية المأمون الجامعة
قسم هندسة تقنيات القدرة الكهربائية

المرحلة: الاولى
المادة: مبادئ الهندسة الكهربائية (العملي)
استاذ المادة: ياسر خلدون

Experiment 1

Electrical Circuit Elements and Instruments

Objectives:

To introduce the basic electrical circuit elements and instruments to the students.

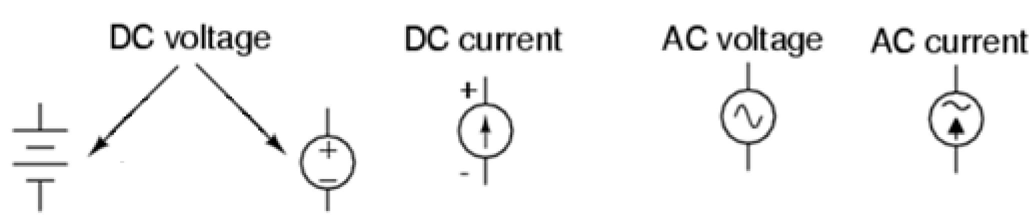
Theory:

Generally any electric circuit composed of three main elements, the power source such as voltage source or current source, the electrical load such as resistor, capacitor, inductor or a combination between them and the wires that connect them.

Also there are many measurement devices that is used to measure different values, Such as Voltmeter that is used to measure the Voltage, The Ammeter that is used to measure the Current and the Ohmmeter that is used to measure the resistor value.

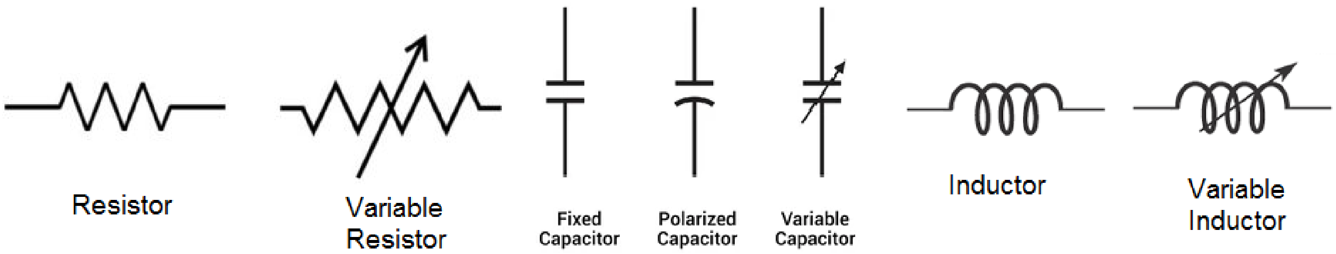
Power Sources:

The main power sources in any electrical circuit are the voltage sources and the current sources. The symbols of these sources are:



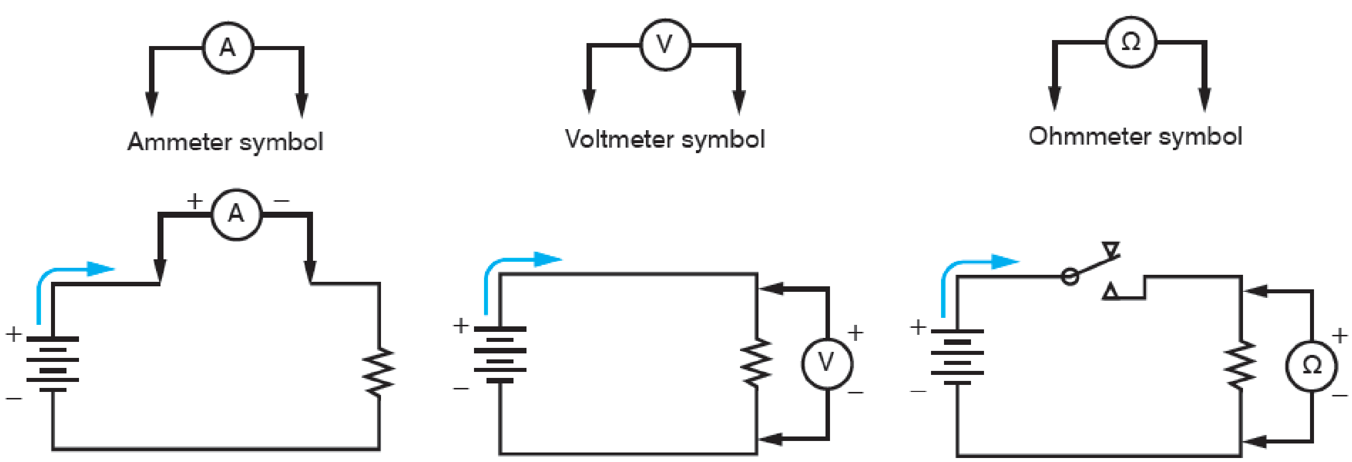
The Electrical Load:

The main electrical load elements are resistors, capacitors and inductors. The symbols of these elements are:



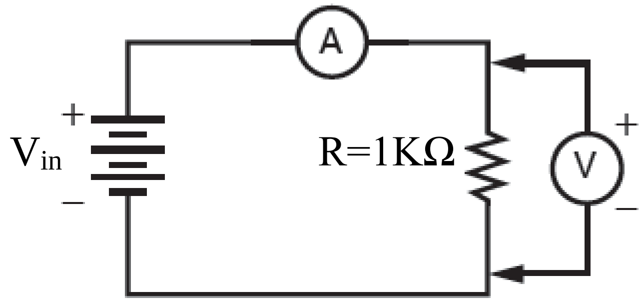
The Measurement Devices:

The main measurement devices in electrical circuits are Voltmeter that is used to measure the voltage between any two points and it is connected in parallel with these points, the Ammeter that is used to measure the current and it must be connected in series with the load and the Ohmmeter that is used to measure the total resistor value and it is connected in parallel with the resistor. The symbols of these devices are:



Procedure:

1- Connect the circuit as shown in figure below:



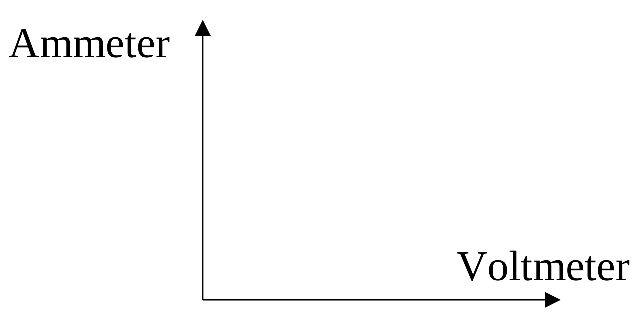
2- For V_{in}= (5V,10V,15V,20V), fill the following table from the readings of voltmeter and ammeter:

V_{in}	5V	10V	15V	20V
Voltmeter (V)				
Ammeter (A)				

Discussion:

1- For each case of V_{in} in step (2) of the procedure calculate theoretically the value of the current in circuit.

2- From the values obtained from step (2) of the procedure, draw the following graph:



3- For each reading values in step (2) of the procedure, calculate the consumed power in the resister.

4- Discuss the reasons behind the difference between the theoretical values and measured values in experiment.

Experiment 3

Parallel Connection of Resistors

Objectives:

To study the characteristics of parallel connection of resistors.

Theory:

When we connect resistors in parallel, the total conductivity of the circuit is equal to the summation of the conductivity of each branch in the parallel circuit, where the conductivity is the reverse of resistance. That is:

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots + \frac{1}{R_n}$$

The total voltage will be equal to the voltage across each resistor in parallel connection. That is:

$$V_T = V_1 = V_2 = \ldots = V_n$$

The total current will be equal to the summation of currents through each resistor. Which means that the total current will be divided between the resistors. That is:

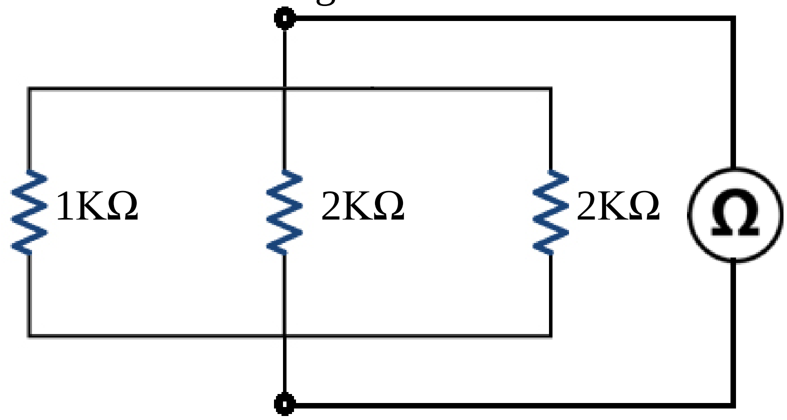
$$I_T = I_1 + I_2 + \ldots + I_n$$

The resistor with the highest value will have the lowest current than the resistor with the lowest value. According to Ohm's law:

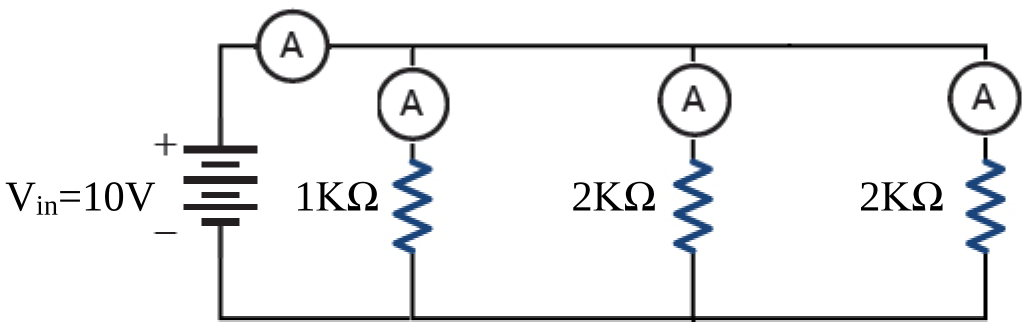
$$I = \frac{V}{R}$$

Procedure:

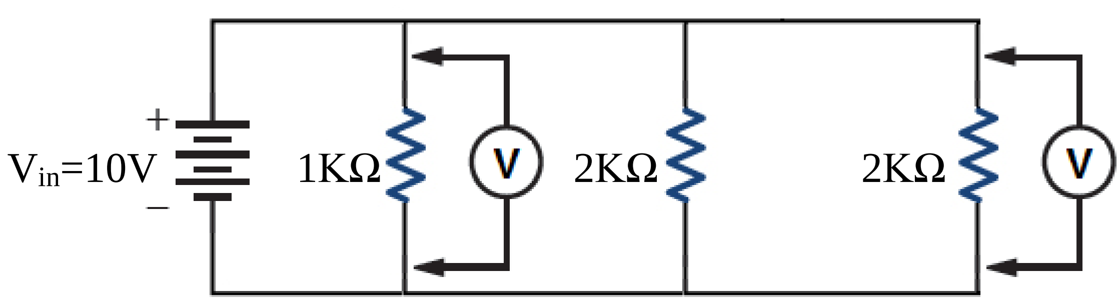
1- Connect the circuit as shown in figure below and measure the total resistance:



2- Connect the circuit as shown in figure below and measure the total current and the current through each resistor:



3- Connect the circuit as shown in figure below and measure the total voltage applied to the circuit and the voltage across the 4KΩ resister.



Discussion:

1- From the measured values in the procedure, calculate the consumed power in each resister.

2- For the circuit in procedure, calculate theoretically the current and voltage for each resistor.

3- For the circuit in procedure, if we replace the 1KΩ resistor with 2KΩ, how does the values of current and voltage across the resistors affected.

Experiment 5

Superposition Theorem

Objectives:

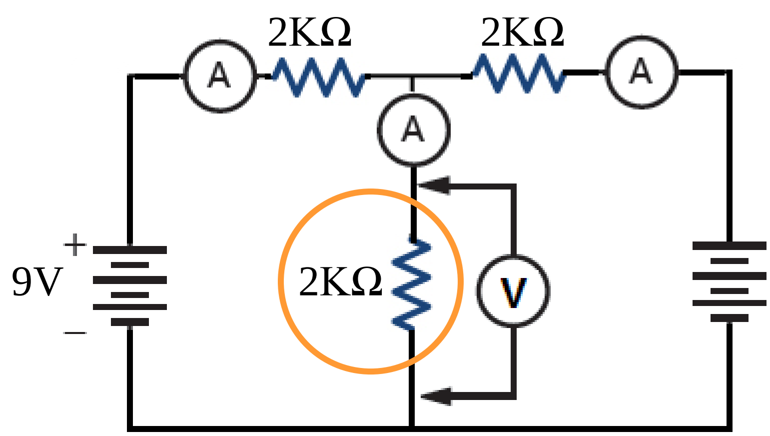
To introduce the principles of superposition theorem and its applications.

Theory:

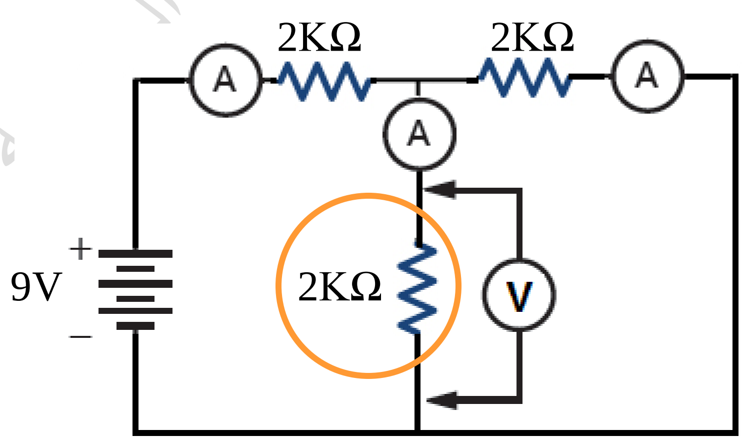
The superposition theorem is one of the most powerful in this field. In general, the theorem can be used to analyze networks that have two or more sources that are not in series or parallel and to reveal the effect of each source on a particular quantity of interest. The superposition theorem states the following: **"The current through, or voltage across, any element of a network is equal to the algebraic sum of the currents or voltages produced independently by each source"**. The term algebraic appears in this theorem statement because the currents resulting from the sources of the network can have different directions, just as the resulting voltages can have opposite polarities. If we are to consider the effects of each source, any voltage source removed from a network, is replaced with a direct connection (short circuit) of zero ohms. Also when removing any current source from a network, it is replaced by an open circuit of infinite ohms. Any internal resistance associated with any removed source must remain in the network.

Procedure:

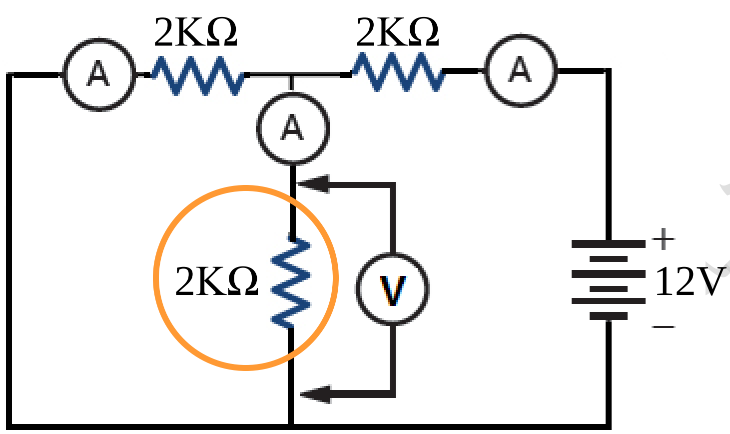
1- Connect the circuit as shown in figure below and measure the current in each branch and the voltage across the encircled 2KΩ resistor:



2- Connect the circuit as shown in figure below and measure the current in each branch and the voltage across the 2KΩ resistor:



3- Connect the circuit as shown in figure below and measure the current in each branch and the voltage across the 2KΩ resistor:

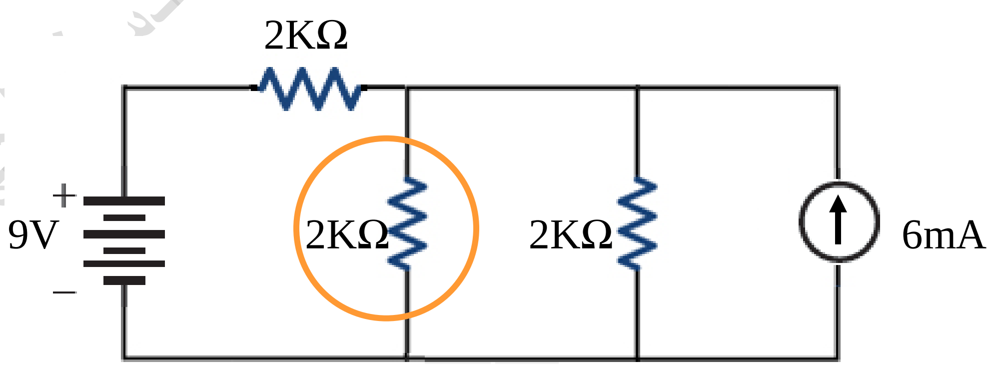


Discussion:

1- From the measured values of Ammeters and voltmeter in the procedure, what do you conclude?

2- For the circuit in procedure, apply the superposition theory to calculate theoretically the current and voltage across the encircled 2KΩ resistor.

3- For the circuit shown below, apply the superposition theory to calculate theoretically the current and voltage across the encircled 2KΩ resistor



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Experiment 6

Thevenin's Theorem

Objectives:

To introduce the principles of Thevenin's theorem and its applications.

Theory:

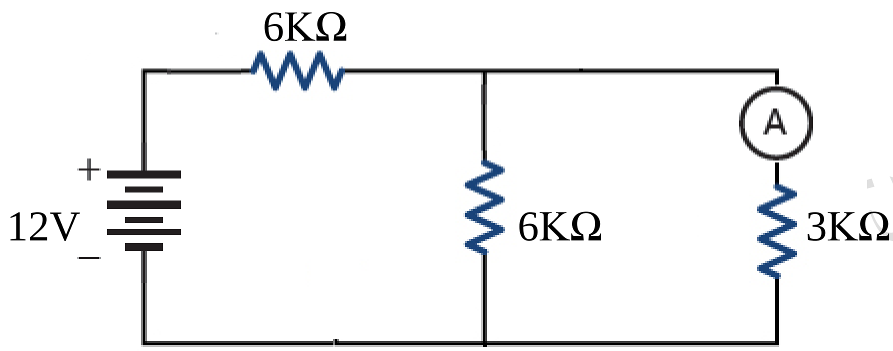
Thevenin's theorem, is an interesting theorem that it permits the reduction of complex networks to a simpler form for analysis and design. In general, it is used to analyze networks with sources that are not in series or parallel, Reduce the number of components required to establish the same characteristics at the output terminals and to Investigate the effect of changing a particular component on the behavior of a network without having to analyze the entire network after each change. Thevenin's theorem states the following: " **Any two-terminal dc network can be replaced by an equivalent circuit consisting solely of a voltage source and a series resistor**".

In order to implement Thevenin's Theorem we follow the procedure below:

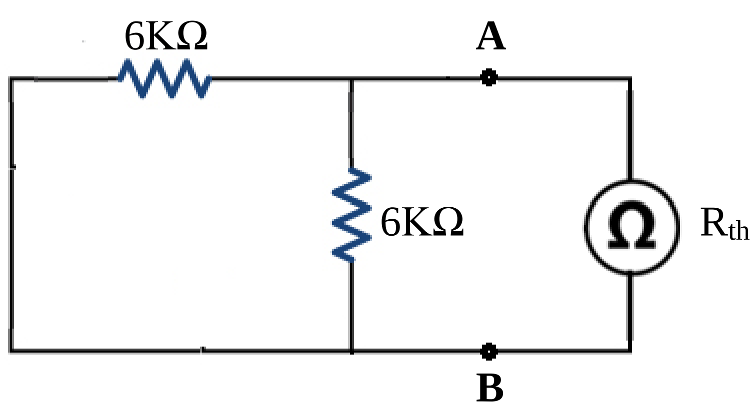
1. Remove that portion of the network where the Thevenin equivalent circuit is found. This requires that the load resistor RL be temporarily removed from the network.
2. Mark the terminals of the remaining two-terminal network.
3. Calculate RTh by first setting all sources to zero (voltage sources are replaced by short circuits and current sources by open circuits)and then finding the resultant resistance between the two marked terminals.
4. Calculate ETh by first returning all sources to their original position and finding the open-circuit voltage between the marked terminals.
5. Draw the Thevenin equivalent circuit with the portion of the circuit previously removed replaced between the terminals of the equivalent circuit.

Procedure:

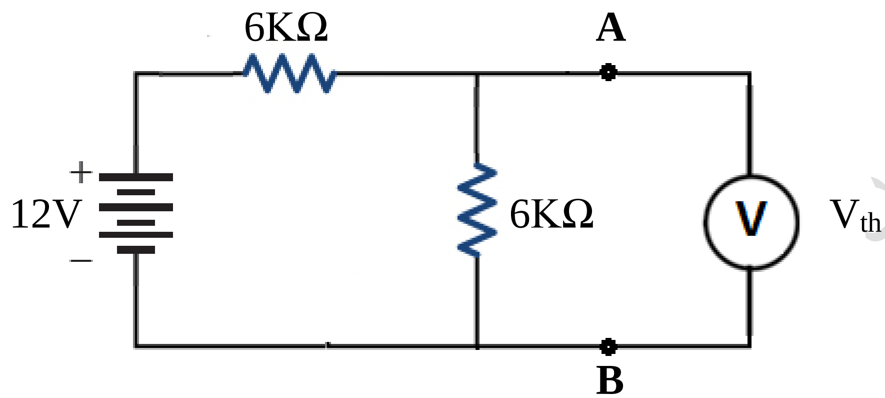
1- Connect the circuit as shown in figure below and measure the current passed through 3KΩ resistor:



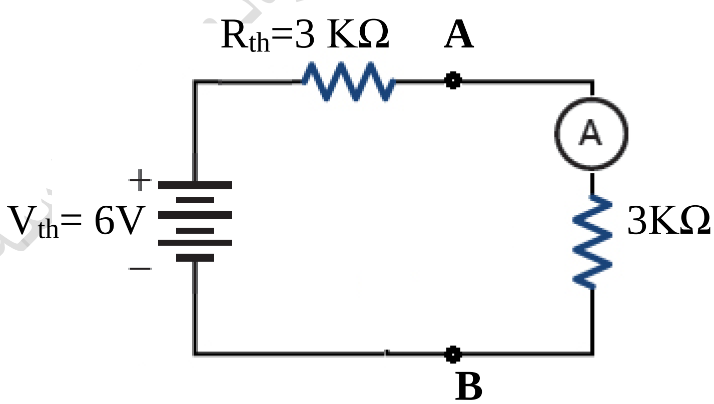
2- Connect the circuit as shown in figure below and measure equivalent resistor between the terminals A and B:



3- Connect the circuit as shown in figure below and measure voltage between the terminals A and B:



4- Connect the circuit as shown in figure below and measure voltage between the terminals A and B:



Discussion:

1- From the measured values of Ammeters in the procedure, what do you conclude?

2- For the circuit in procedure, apply the Thevenin's theorem to calculate theoretically the current and voltage across the encircled 3KΩ resistor.

3- If we replace the 3KΩ resistor with 1KΩ resistor, what is the value of the current passed through the 1KΩ resistor?

Experiment 7

Norton's Theorem

Objectives:

To introduce the principles of Norton's theorem and its applications.

Theory:

Norton's theorem permits the reduction of complex networks to a simpler form for analysis and design. It can be used to analyze networks with sources that are not in series or parallel and to reduce the number of components required to establish the same characteristics at the output terminals. Nortons's theorem states the following: "**Any two-terminal linear bilateral dc network can be replaced by an equivalent circuit consisting of a current source and a parallel resistor**".

In order to implement Norton's Theorem we follow the procedure below:

1. Remove that portion of the network across which the Norton equivalent circuit is found.

2. Mark the terminals of the remaining two-terminal network.

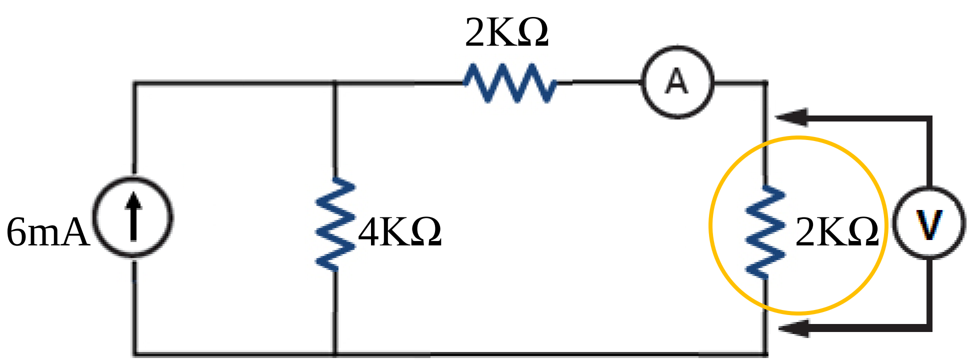
3. Calculate RN by first setting all sources to zero (voltage sources are replaced with short circuits and current sources with open circuits) and then finding the resultant resistance between the two marked terminals. ($R_N = R_{Th}$)

4. Calculate I_N by first returning all sources to their original position and then finding the **short-circuit** current between the marked terminals.

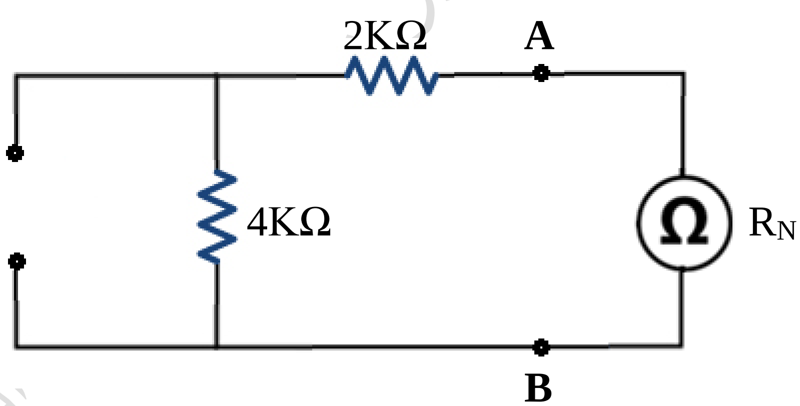
5. Draw the Norton equivalent circuit with the portion of the circuit previously removed replaced between the terminals of the equivalent circuit.

Procedure:

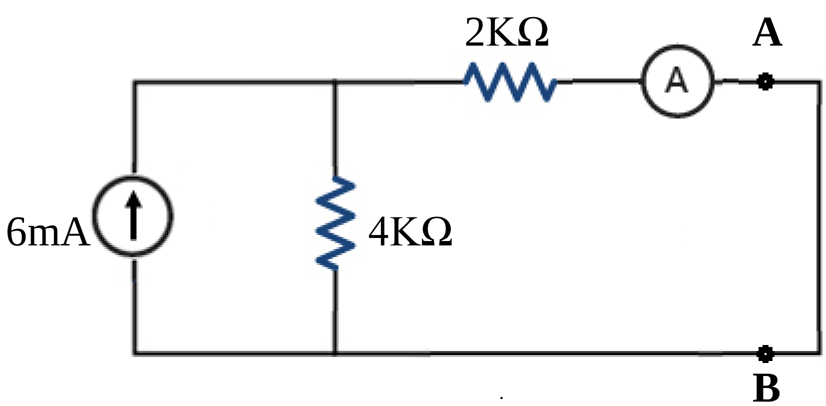
1- Connect the circuit as shown in figure below and measure the current and the voltage across the encircled 2KΩ resistor:



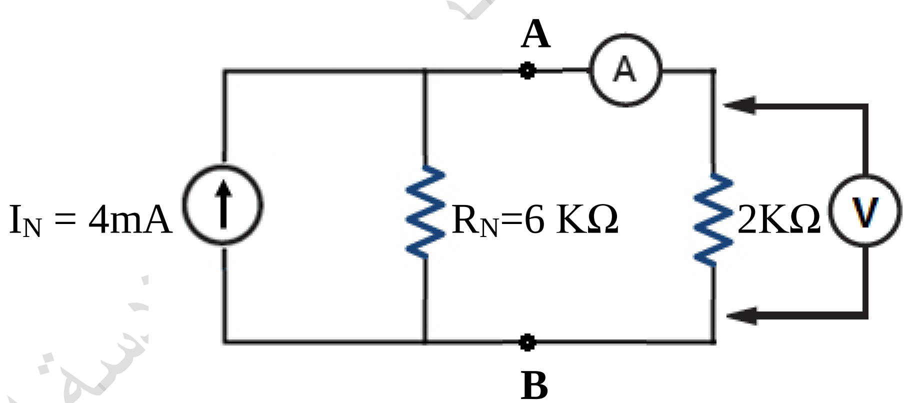
2- Connect the circuit as shown in figure below and measure equivalent resistor between the terminals A and B:



3- Connect the circuit as shown in figure below and measure the current through the short circuit between the terminals A and B:



4- Connect the circuit as shown in figure below and measure the current and the voltage across the terminals A and B:



Discussion:

1- From the measured values of Ammeters and Voltmeter in the procedure, what do you conclude?

2- For the circuit in procedure, apply the Norton's theorem to calculate theoretically the current and voltage across the encircled 2KΩ resistor?

3- If we replace the encircled 2KΩ resistor with 18KΩ resistor, what is the value of the current passed through the 18KΩ resistor?

Experiment 8

Capacitors and Inductors

Transients Response

Objectives:

To introduce the principles of capacitance and inductance and to determine the transient response of their networks.

Theory:

The **capacitor** is constructed of two conducting surfaces separated by a gap. while the **capacitance** is a measure of a capacitor's ability to store charge on its plates. It can be defined as the rate of charge developed on capacitors plates to the applied voltage and is defined by the following equation:

$$C = \frac{Q}{V}$$

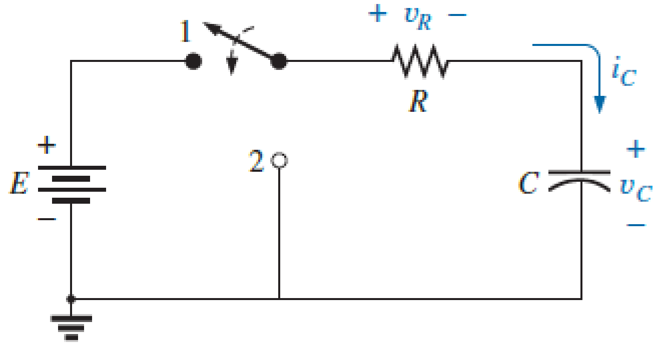
Where:
C = farads (F)
Q = coulombs (C)
V = volts (V)

Larger plates permit an increased area for the storage of charge, the smaller the distance between the plates, the larger is the capacitance, and higher levels of permittivity result in higher levels of capacitance, since the following is the general equation for capacitance:

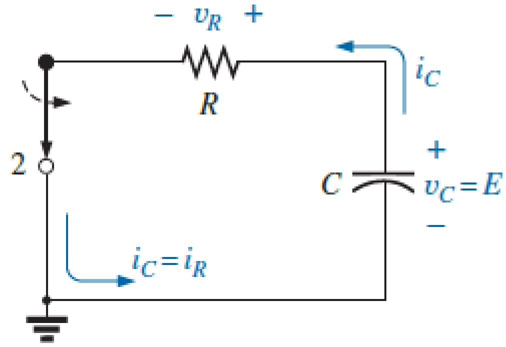
$$C = \varepsilon \frac{A}{d}$$

Where:
C = farads (F)
ε = permittivity (F/m)
A = area (m^2)
d = distance (m)

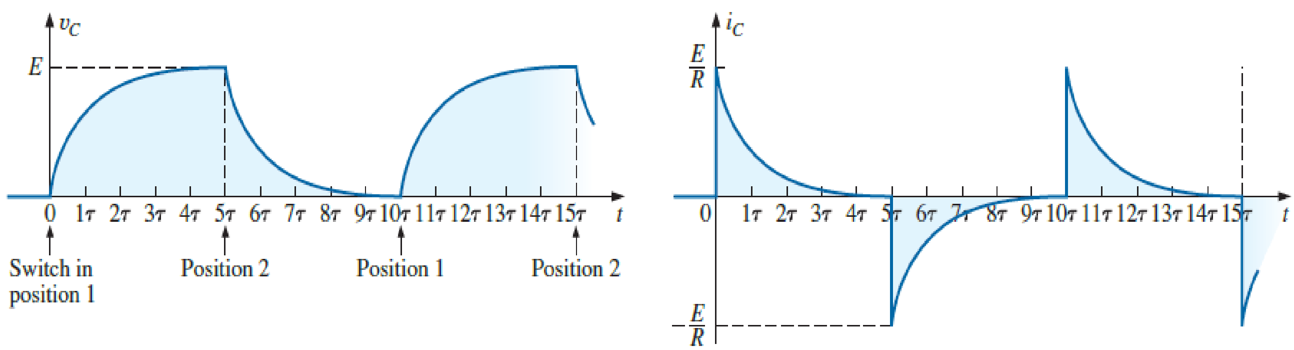
Generally, the transient response of RC network has two phases, the charging phase and the discharging phase, these phases can be clarified by the following network configurations:



(a) Charging network



(b) discharging configuration.



Where:

$$v_C = E(1 - e^{-t/\tau})$$ charging

$$v_C = Ee^{-t/\tau}$$ discharging

$$i_C = \frac{E}{R}e^{-t/\tau}$$

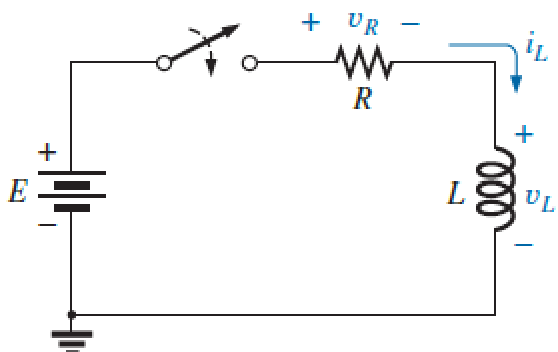
$$\tau = RC$$

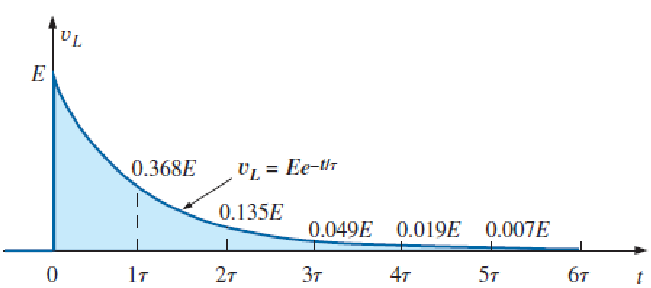
The **inductor is** a coil of wire, with or without a core, establishes a magnetic field through and surrounding the unit. Its **inductance** level determines the strength of the magnetic field around the coil due to an applied current. The level of inductance has similar construction sensitivities in that it is dependent on the area within the coil, the length of the unit, and the permeability of the core material. It is also sensitive to the number of turns of wire in the coil as dictated by the following equation

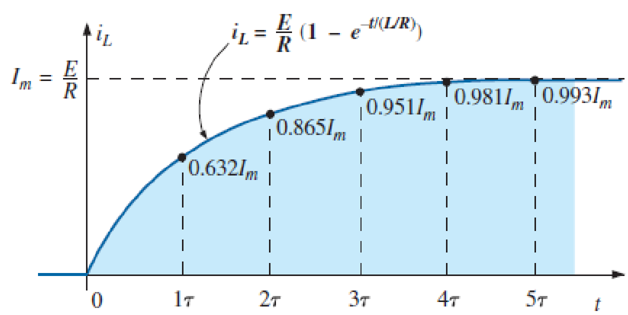
$$L = \frac{\mu N^2 A}{l}$$

Where
μ= permeability (Wb/Am)
N = number of turns (t)
A = area (m^2)
l = length (m)
L = henries (H)

Generally, the transient response of RL network has two phases, the storage phase and the release phase, the storage phase can be clarified by the following network configurations:







Where

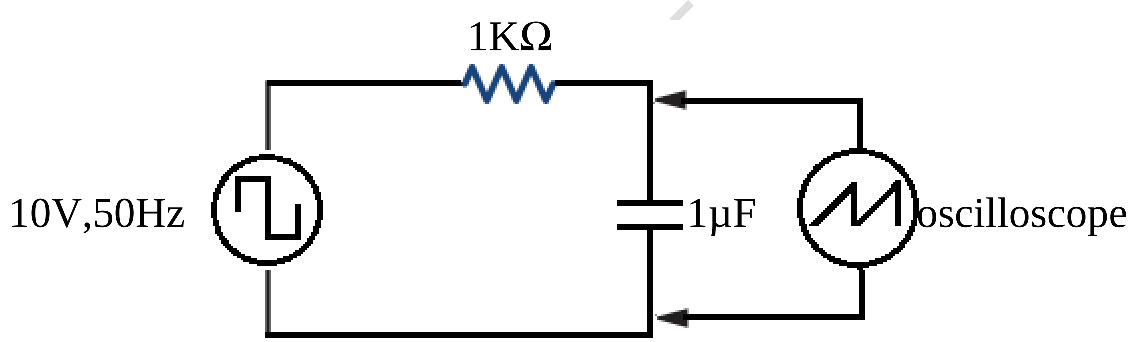
$$v_L = Ee^{-t/\tau} \quad \text{(volts, V)}$$

$$i_L = \frac{E}{R}(1 - e^{-t/\tau}) \quad \text{(amperes, A)}$$

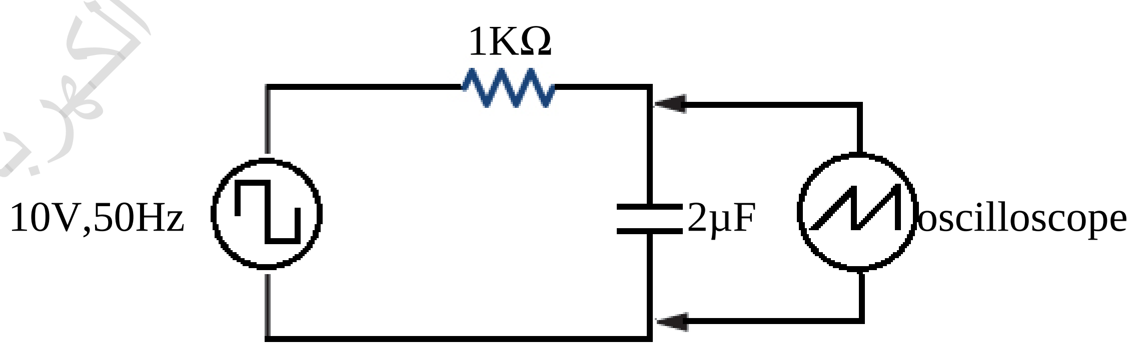
$$\tau = \frac{L}{R} \quad \text{(seconds, s)}$$

Procedure:

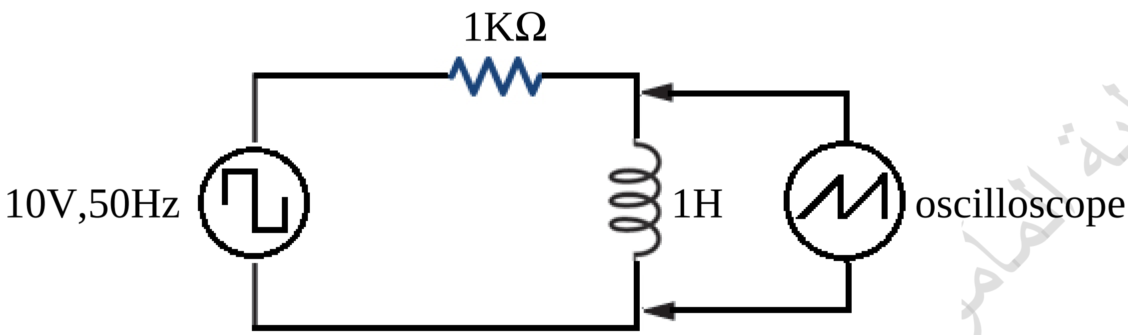
1- Connect the circuit as shown in figure below and draw the oscilloscope output:



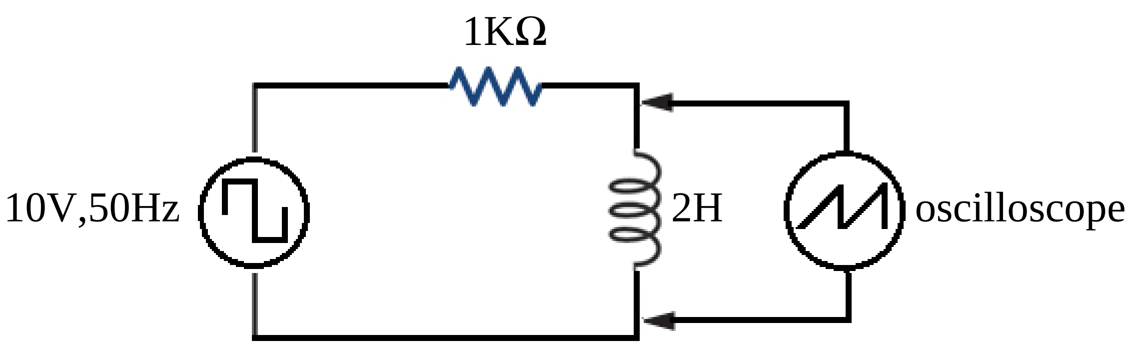
2- Connect the circuit as shown in figure below and draw the oscilloscope output:



3- Connect the circuit as shown in figure below and draw the oscilloscope output:



4- Connect the circuit as shown in figure below and draw the oscilloscope output:



Discussion:

1- From the output of oscilloscope in procedure, what is the relation of I_c,V_c in charging phase and I_L, V_L in storage phase?

2- What is the effect of increasing the value of resistor on the response of the circuit in step (1) of the procedure?

3- What is the effect of increasing the value of resistor on the response of the circuit in step (3) of the procedure?