**Roll No:** 20PH20014
**Name:** Jessica John Britto
**Date:** 25/08/2021

# Basic Electronics Laboratory

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| **Name:** | Jessica John Britto |
| **Roll Number:** | 20PH20014 |

## EXPERIMENT-1

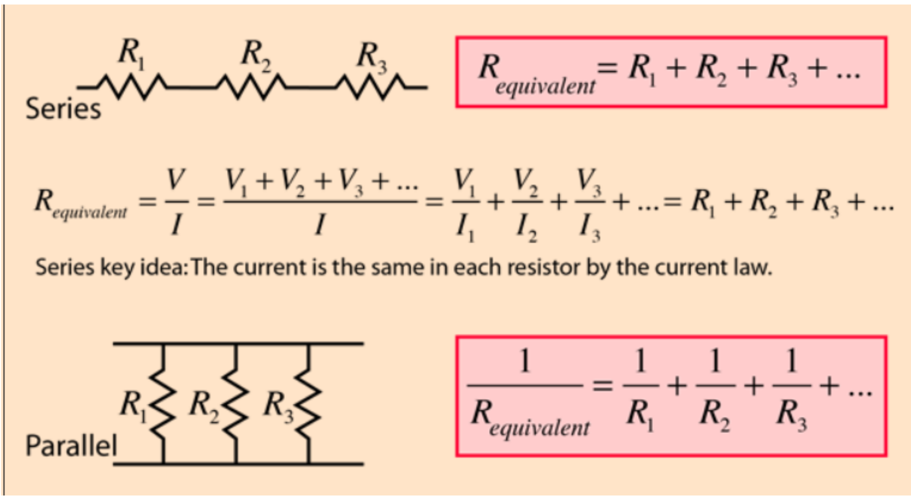
**Aim:**

1. Familiarisation of Resistor
2. Familiarisation of Capacitor
3. Familiarisation of Inductor
4. Verification of Ohm's Law
5. Voltage divider circuit diagram and Thevenin Model of Voltage Divider
6. Active Devices

### Ⅰ. Familiarisation of Resistor

**Tools Used:** Basic Electronics Virtual Lab
**Background Knowledge (Brief):**

1. Types of resistors:
    1. Fixed- The value of resistance is constant and specified. It's of two types- Linear and Non-Linear. In linear resistors, there's a linear relationship between resistance and temperature while in non-linear, there's a non-linear relationship between resistance and temperature. For eg- Carbon film, Metal film, wire wound resistors.
    2. Variable- The value of resistance is variable and can be changed by rotating the wiper. For eg- Semi fixed, potentiometer.
2. Calculating Equivalent Resistance in Series and Parallel Combinations:




3. Reading the value of fixed resistors:

    Resistors are colour coded in 4 or 5 colours as they are too small for value to be written on them.

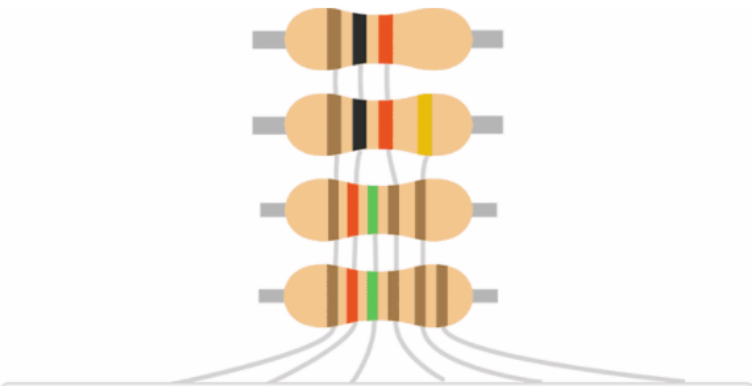
    1. $1^{st}$ band - represents the first digit

2. $2^{nd}$ band - represents the second digit
3. $3^{rd}$ band - represents a multiplier
4. $4^{th}$ band – represents tolerance

In the case of 5 band coding, an extra band is present before the multiplier which represents the third digit.

The tolerance of a resistor is the deviation that a resistor may vary from its nominal value resistance, measured at 25°C with no load applied. Lower per cent tolerances equal more precision (less variance) in resistance values.

| Number of Coloured Bands | 3 Coloured Bands (E6 Series) | 4 Coloured Bands (E12 Series) | 5 Coloured Bands (E48 Series) | 6 Coloured Bands (E96 Series) |
|---|---|---|---|---|
| $1^{st}$ Band | $1^{st}$ Digit | $1^{st}$ Digit | $1^{st}$ Digit | $1^{st}$ Digit |
| $2^{nd}$ Band | $2^{nd}$ Digit | $2^{nd}$ Digit | $2^{nd}$ Digit | $2^{nd}$ Digit |
| $3^{rd}$ Band | Multiplier | Multiplier | $3^{rd}$ Digit | $3^{rd}$ Digit |
| $4^{th}$ Band | – | Tolerance | Multiplier | Multiplier |
| $5^{th}$ Band | – | – | Tolerance | Tolerance |
| $6^{th}$ Band | – | – | – | Temperature Coefficient |



| | 1st Digit | 2nd Digit | 3rd Digit | Multiplier | Tolerance | Temp. Coeff. |
|---|---|---|---|---|---|---|
| Black | 0 | 0 | 0 | x $10^0$ | | 250 (U) |
| Brown | 1 | 1 | 1 | x $10^1$ | ±1% | 100 (S) |
| Red | 2 | 2 | 2 | x $10^2$ | | 50 (R) |
| Orange | 3 | 3 | 3 | x $10^3$ | | 15 (P) |
| Yellow | 4 | 4 | 4 | x $10^4$ | | 25 (Q) |
| Green | 5 | 5 | 5 | x $10^5$ | | 20 (Z) |
| Blue | 6 | 6 | 6 | x $10^6$ | | 10 (Z) |
| Violet | 7 | 7 | 7 | x $10^7$ | | 5 (M) |
| Grey | 8 | 8 | 8 | x $10^8$ | | 1 (K) |
| White | 9 | 9 | 9 | x $10^9$ | | |
| Gold | - | - | - | x $10^{-1}$ | | |
| Silver | - | - | - | x $10^{-2}$ | | |

4. Resistors are classified on the basis of material they are made up of
    a. Carbon Film Resistor: A type of fixed value resistor. They are constructed out of a ceramic carrier with a thin pure carbon film around them. They are cheap and general-purpose resistors and are electrically noisy.
    b. Metal Film Resistor: A thin metal layer as a resistive element on a non-conducting body. They are among the most common types of axial resistors. They are used when higher tolerance is needed.
    c. Wire Wound Resistor: The conductive wire can be made of varying alloys and thicknesses to control the resistance value. Wire wound resistors are typically used in high power and industrial applications such as circuit breakers and fuses. Wire wound resistors in a ceramic case are called ceramic resistors.

**Graphs (Image/Screenshots):**

Quiz on Virtual Basic Electronics Lab-

1.

Enter the resistance value: 47 KOhm

Enter the tolerance : +/- 5 %

Correct Resistance Value
Correct Unit Value
Correct Tolerance Value

check

2.

Enter the resistance value: 5.2 Ohm

Enter the tolerance : +/- 10 %

Correct Resistance Value
Correct Unit
Correct Tolerance Value

check

3.

Enter the resistance value: 97 Ohm

Enter the tolerance : +/- 20 %

Correct Resistance Value
Correct Unit
Correct Tolerance Value
check

4.

Enter the resistance value: 3.3 KOhm

Enter the tolerance : +/- 0.1 %

Correct Resistance Value
Correct Unit
Correct Tolerance Value
check

5.

Enter the resistance value: 1.58 Ohm

Enter the tolerance : +/- 2 %

Correct Resistance Value
Correct Unit
Correct Tolerance Value
check

6.

Enter the resistance value: 6.15 Ohm

Enter the tolerance : +/- 0.25 %

Correct Resistance Value
Correct Unit
Correct Tolerance Value
check

**Conclusion:**

During this experiment on the virtual lab, the resistance values of resistors were calculated by matching the band colours with their values based on the chart given on the Basic Electronics Virtual Lab. The 4-, 5- and 6- coloured bands have tolerance band and the 6-coloured bands have temperature coefficient band. The basics of resistors which also include their types of resistors and their significance in electronics were studied thoroughly. Resistors are one of the basic elements in any electronic circuit.

**Discussions:**

1. Nearly all electronic circuits consist of various types of resistors, so it is important to get a complete idea about them such as determining resistance by looking at the colour codes of the resistors and knowing the significance and use of different types of resistors is essential in order to choose an appropriate type of resistor for a specific requirement such as Metal Film Resistors are used when high tolerance is needed.
2. Resistors perform passive control of voltage and current, are used as voltage dividers. A transistor needs a small base voltage to make a large voltage flow through its collector/ emitter terminals. But its base is vulnerable to high currents, so a resistor is used to limit the current and provide a safe biasing voltage.
3. Resistors along with capacitors are used in timing components (which are used in timer and oscillator). They are effectively used to control the charging and

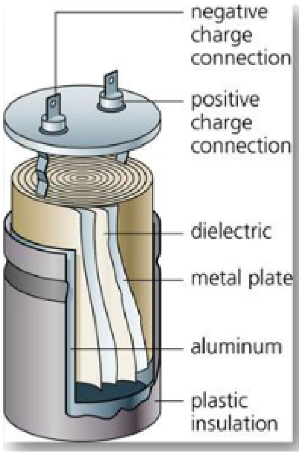
discharging processes of the capacitor and its value is varied to obtain different time intervals.

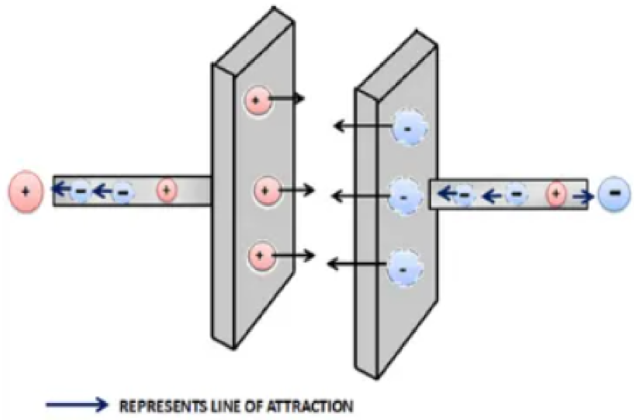
4. I learnt the basics of resistors such as to find the resistance based on the color codes and also learnt that resistors have a wide range of applications such as dividing voltages, biasing voltage and heavily used in control systems engineering as part of tuning the response.
5. Due to the virtual nature of the experiment, errors like the heating effect of resistors were not observed. The parts of the circuit grounded had the same effect if they were grounded at different terminals as compared to if they were grounded at the same point.

## ＩＩ. Familiarisation of Capacitor

**Tools Used:** Basic Electronics Virtual Lab
**Background Knowledge (Brief):**

1. It is used to store charge in the form of the electric field. It's a passive component. It is made of two parallel plates separated by a dielectric material. Real capacitors are made by taking thin strips of metal foil and the appropriate dielectric material and sandwiching them together. They attain a large area by putting a dielectric between two layers of metal foil and rolling it up.




2. Capacitance is the electrical capacity of the body measured in Farads.

$$C=Q/V$$

3. Capacitors are classified as
   a. Polarized: They have positive and negative electrodes, such as tantalum, super and electrolytic capacitors.
   b. Unpolarized: They don't have positive and negative electrodes. For eg- Ceramic, Polyester, Polystyrene film capacitors.
4. Capacitors in series:

When multiple capacitors are connected in series net equivalent capacitance is equal to

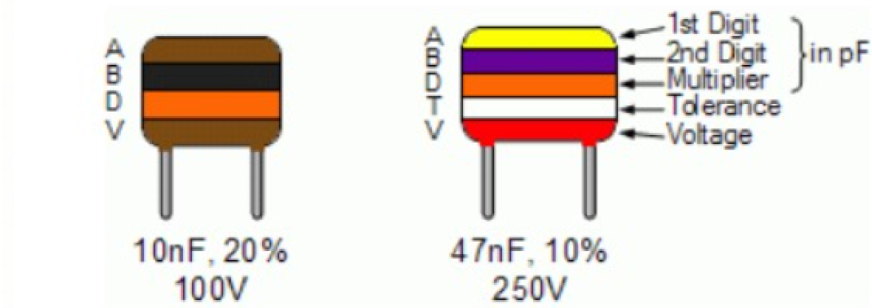
$$1/C_{eq}=1/C_1+ 1/C_2+.............\ 1/C_n$$

5. Capacitors in parallel:

   When multiple capacitors are connected in parallel then equivalent capacitance is equal to

$$C_{eq}= C_1+C_2 +......C_n$$

6. **<u>Reading the value of capacitance:</u>**
   a. Capacitors are colour coded in 4 or 5 colours:
      i. $1^{st}$ band - represents the first digit
      ii. $2^{nd}$ band - represents the second digit
      iii. $3^{rd}$ band - represents a multiplier
      iv. $4^{th}$ band – represents tolerance. If the capacitor is a 4 banded colour coded, then the $4^{th}$ band is voltage.
      v. $5^{th}$ band- represents the voltage if the $5^{th}$ band is present.



| Band Colour | Digit A | Digit B | Multiplier D | Tolerance (T) > 10pf | Tolerance (T) < 10pf | Temperature Coefficient (TC) |
|---|---|---|---|---|---|---|
| Black | 0 | 0 | x1 | ± 20% | ± 2.0pF | |
| Brown | 1 | 1 | x10 | ± 1% | ± 0.1pF | $-33\times10^{-6}$ |
| Red | 2 | 2 | x100 | ± 2% | ± 0.25pF | $-75\times10^{-6}$ |
| Orange | 3 | 3 | x1,000 | ± 3% | | $-150\times10^{-6}$ |
| Yellow | 4 | 4 | x10,000 | ± 4% | | $-220\times10^{-6}$ |
| Green | 5 | 5 | x100,000 | ± 5% | ± 0.5pF | $-330\times10^{-6}$ |
| Blue | 6 | 6 | x1,000,000 | | | $-470\times10^{-6}$ |
| Violet | 7 | 7 | | | | $-750\times10^{-6}$ |
| Grey | 8 | 8 | x0.01 | +80%,-20% | | |
| White | 9 | 9 | x0.1 | ± 10% | ± 1.0pF | |
| Gold | | | x0.1 | ± 5% | | |
| Silver | | | x0.01 | ± 10% | | |

*Capacitor Color Code*

| Band Colour | Voltage Rating (V) | | | | |
|---|---|---|---|---|---|
| | Type J | Type K | Type L | Type M | Type N |
| Black | 4 | 100 | | 10 | 10 |
| Brown | 6 | 200 | 100 | 1.6 | |
| Red | 10 | 300 | 250 | 4 | 35 |
| Orange | 15 | 400 | | 40 | |
| Yellow | 20 | 500 | 400 | 6.3 | 6 |
| Green | 25 | 600 | | 16 | 15 |
| Blue | 35 | 700 | 630 | | 20 |
| Violet | 50 | 800 | | | |
| Grey | | 900 | | 25 | 25 |
| White | 3 | 1000 | | 2.5 | 3 |
| Gold | | 2000 | | | |
| Silver | | | | | |

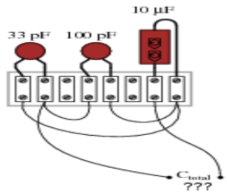
*Capacitor Voltage Color Code*

## Graphs (Image/Screenshots):

✓ 1. Two 33 µF capacitors are connected in series with each other. What will their combined capacitance be in Farads?

- ◉ 16.5 µF
- ○ 120 µF
- ○ 66 µF
- ○ 200 µF

✓ 2. Calculate the total capacitance in this collection of capacitors, as measured between the two wires:




Calculate total capacitance given the values of inductors C1, C2, and C3

- ○ 130.990 pF
- ○ 200.8 pF
- ○ 130 pF
- ◉ 132.998 pF

✓ 3. A 10µF capacitor is charged to a voltage of 20 volts.How many coulombs of electric charge are stored in this capacitor?

- ○ 20µC of charge
- ○ 120µC of charge
- ○ 20mC of charge
- ◉ 200µC of charge

✓ 4. Two 470µF capacitors connected in series are subjected to a total applied voltage that changes at a rate of 200 volts per sec. How much current will there be through these capacitors?
(Hint :The total voltage is divided evenly between the two capacitors.)

- ◉ 47 mA
- ○ 470 mA
- ○ 94 mA
- ○ 940 mA

✓ 5. Two capacitors 470µF capacitors connected in parallel are subjected to a total applied voltage that changes at a rate of 200 volts per sec.How much total current will there be through these capacitors?

- ○ 47 mA
- ○ 18 mA
- ◉ 188 mA
- ○ 18.8 mA

bmit

## Conclusion:

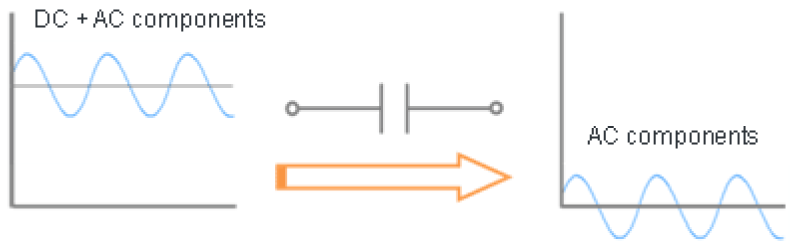
During this experiment on the virtual lab, the effective capacitances of series and parallel combinations of capacitors were found using appropriate formulae given on the Basic Electronics Virtual Lab. The basics of capacitors which also include their types of capacitors and their significance in electronics were studied thoroughly. Capacitors are one of the basic elements in any electronic circuits. Applications of capacitors include in timers, coupling and decoupling applications, microcontrollers.

## Discussions:

1. Nearly all electronic circuits consist of various types of capacitors, so it is important to get a complete idea about them such as determining capacitance by looking at the capacitor colour codes and capacitor voltage colour codes charts and knowing the

significance and uses of different types of capacitors is essential to choose an appropriate type of capacitor for a specific requirement such as for coupling and decoupling applications, ceramic, tantalum capacitors are used.

2. Ceramic capacitors are used for  coupling, decoupling, smoothing, and filtering.




<Capacitors for coupling>

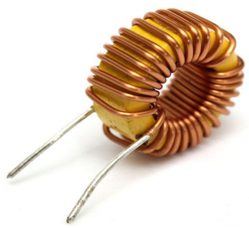
3. Decoupling capacitors are extensively used in microcontrollers. If the input voltage drops, the decoupling capacitor provides power to an IC to keep the voltage stable and if the voltage increases, it absorbs the excess energy trying to flow to the IC, to keep the voltage stable.
4. I've learnt the physics behind the charging and discharging processes of the capacitors, to find the effective capacitance to simplify circuits, importance and uses of capacitors in microcontrollers, in timers, coupling, decoupling, filtering and smoothing applications, and different types of capacitors and their usages.

## Ⅰ Ⅰ Ⅰ. Familiarisation of Inductor

**Tools Used:** Basic Electronics Virtual Lab

**Background Knowledge (Brief):**

1. Inductor only affects currents when thy are changing in value, unlike resistors which affect the current uniformly at all times. Inductance is the tendency to oppose the change in electric current.



2. The power associated with inductive current is stored as energy in the inductor's magnetic field.

3. Calculating effective inductance in series and parallel

Equivalent Inductance ($L_{eq}$) :

for series connection :

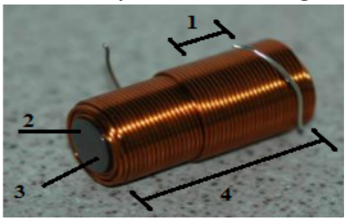
$$L_{eq} = L_1 + L_2 + L_3$$

for parallel connection :

$$\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3}$$

4. $V = L \cdot \dfrac{dl}{dt}$

   Where L is the inductance and is measured in henry.
   Putting a voltage across an inductor causes the current to rise as a ramp
   1 volt across 1 henry produces a current that increases at 1 amp per second
5. Types of inductors such as Air core inductorss, high frequency inductors, etc.
6. The amount of inductance is affected by the following factors



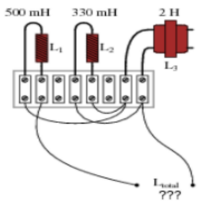

1. No of turns of wire wound around the coil
2. Cross sectional area of the coil
3. The material type of the coil
4. The Length of the coil

## Graphs (Image/Screenshots):

✓ 1. . Two 50 mH inductors are connected in parallel with each other. What will their combined inductance be in Henrys?

- 200 mH
- 50 mH
- 100 mH
- 25 mH

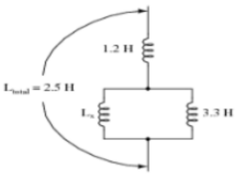
✓ 2. Calculate the total inductance in this collection of inductors, as measured between the two wires:




calculates total inductance given the values of inductors L1, L2, and L3.

- 700 mH
- 783.26 mH
- 689.09 mH
- 583.26 mH

✓ 3. How large must Inductor Lx be in order to provide a total inductance of 2.5 H in this network of inductors?




- 214.5 H
- 2.145 H
- 1.245 H
- 12.45 H

✓ 4. Two 5 H inductors connected in series are subjected to an electric current that changes at a rate of 4.5 amps per sec.How much voltage will be dropped across the series combination?

- 45 V
- 22.5 V
- 11.25 V
- 90 V

✓ 5. Two 5 H inductors connected in parallel are subjected to an electric current that changes at a rate of 4.5 amps per sec.How much voltage will be dropped across the series combination?(Hint: The total current is divided evenly between the two inductors).

- 45 V
- 22.5 V
- 11.25 V
- 90 V

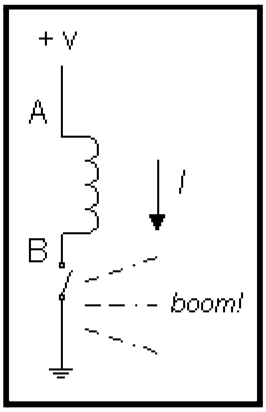
omit

## Conclusion:

During this experiment on the virtual lab, the effective inductances of series and parallel combinations of inductors were found using appropriate formulae. The basics of inductors which also include their types of inductors and their significance in electronics were studied thoroughly. Mother device that controls the current is the inductor. Applications of inductors include tuning circuits, filtering, relays, chokes, as energy storage devices in switched-mode power devices to produce DC current and many more. Inductors are used in transformers. Inductors are one of the basic elements in any electronic circuits.

**Discussions:**

1. Nearly all electronic circuits consist of various types of inductors, so it is important to get a complete idea about them such as determining effective inductance by using appropriate formulae and knowing the significance and uses of different types of capacitors is essential to choose an appropriate type of inductor for a specific requirement such as for Onboard charger for Electric Vehicles, line and noise filter, laminated core inductors are used.
2. Inductive Kick- It is capable of producing a momentary voltage that is much higher than the voltage of the power source that supplied the current to create its magnetic field . This temporary voltage is called an inductive kick.



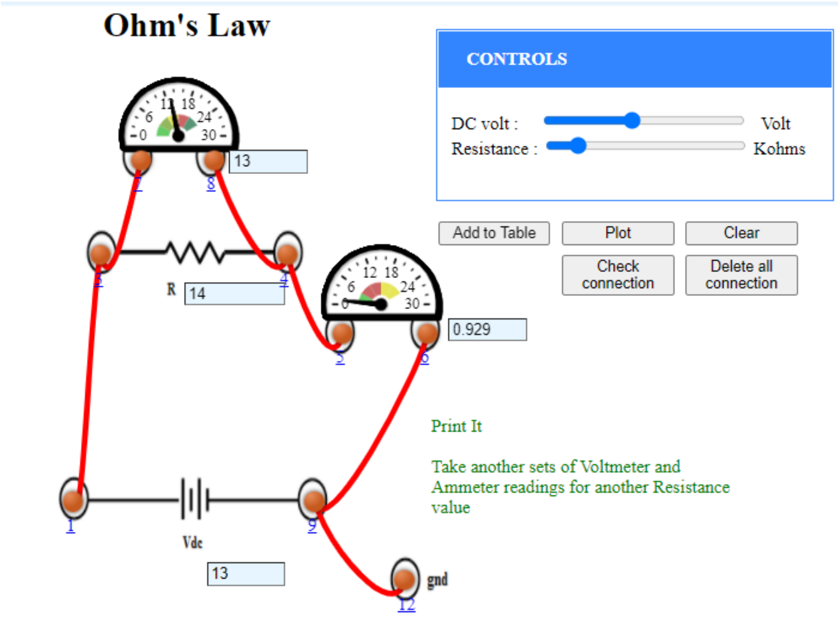

Example of applications of inductive devices to provide an inductive kick is a Combustion Engine ignition system that creates the spark across the gap of the spark plug.

3. Unlike the resistor that affects the current uniformly at all times, the inductor only affects currents when they are changing in value.
4. Inductors are used in transformers. A transformer is a device made of two or more inductors, one of which is powered by AC, inducing an AC voltage across the second inductor. If the second inductor is connected to a load, power will be electromagnetically coupled from the first inductor's power source to that load.
5. I have learnt to find effective inductane in series and parallel combination, importance and uses of inductors in power electronics, filtering and smoothing applications, and different types of inductors and their usages.

## IV. Verification of Ohm’s Law

**Tools Used:** Basic Electronics Virtual Lab

**Circuit (hand drawn/image):**



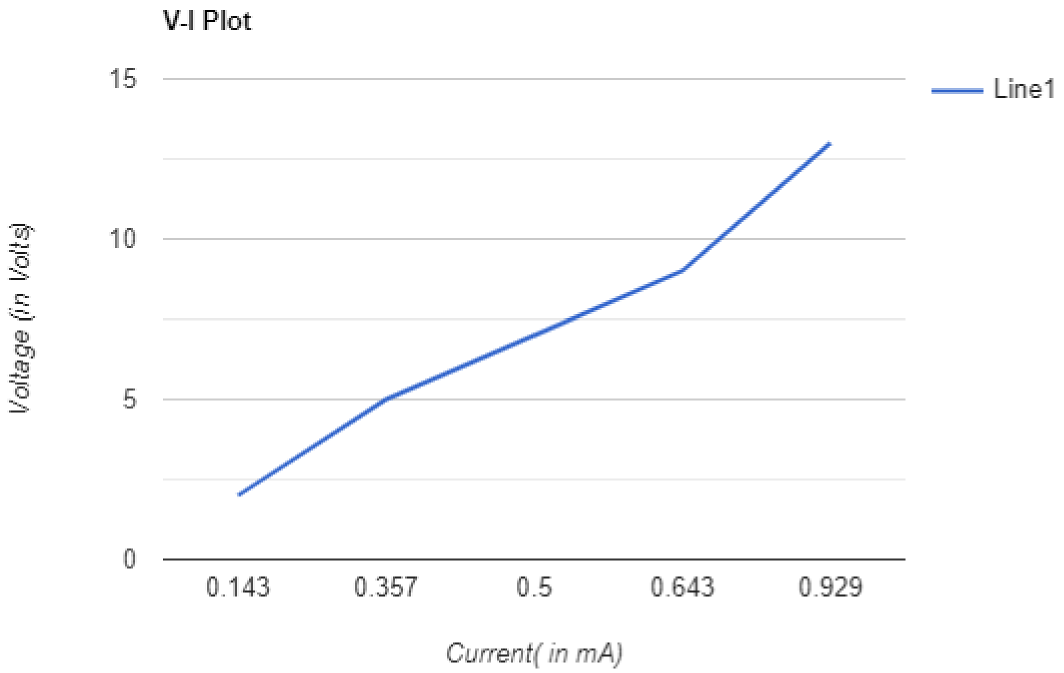

**Measurement Data (Tabular form):**

**EXPERIMENTAL TABLE**

Resistance: 14 KΩ

| Serial No. | Voltage(Volt) V | Current(milliAmpere) mA |
|---|---|---|
| 1 | 2 | 0.143 |
| 2 | 5 | 0.357 |
| 3 | 7 | 0.500 |
| 4 | 9 | 0.643 |
| 5 | 13 | 0.929 |

**Graphs (Image/Screenshots):**




**Conclusion:**

Clearly, a straight line is obtained when V-I is plotted. The slope of the V-I graph gives R (resistance). Hence, the ohm's law is verified.

**Discussion:**

For linear circuits, ohm's law is valid. The switch must be opened after sometimes taking the readings, as due to heating effect, we may get incorrect readings while performing this experiment in the actual lab, and hence ohm's law will not be verified.

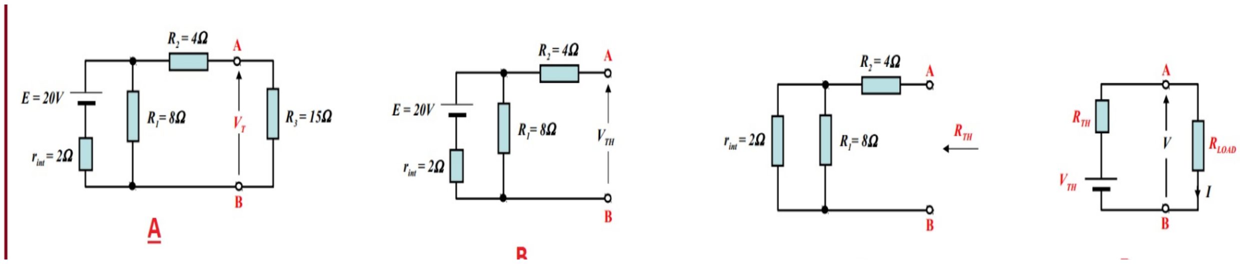
**<u>Ⅴ. Voltage divider circuit diagram and Thevenin Model of Voltage Divider</u>**

**Tools Used:** Circuit Simulator Applet (Falstad)
**Background Knowledge (Brief):**

1. A voltage divider in its simplest form consists of a pair of resistors connected in series, whereby the total voltage across the two of them is divided into two parts.
2. The current and voltage in each part of the circuit are calculated as in any other series or parallel circuit using Kirchhoff's laws.
3. When there is no load on the divider, the portions of the voltage can vary between 0 volts and the total voltage, depending on the individual resistors. There is a marked

difference, however, when the circuit is loaded with very small loads. Then the voltage across the part of the circuit including the load will be very small regardless of the resistors in the divider.

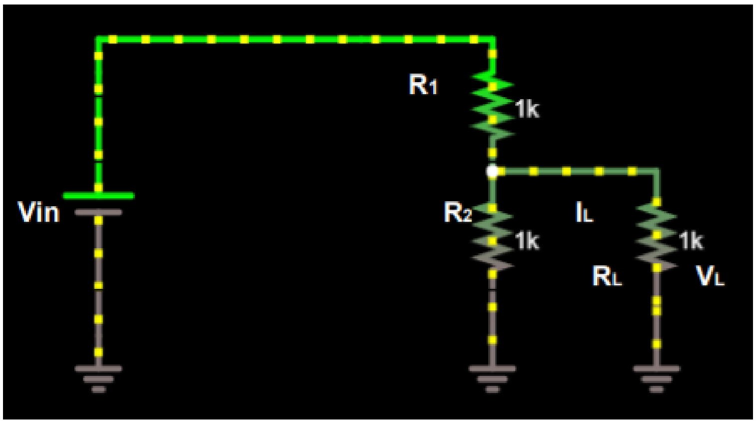
4. Thevenin’s Theorem-
   Any linear circuit containing several voltages and resistances can be replaced by just one single voltage in series with a single resistance connected across the load.



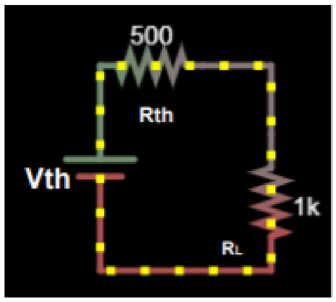

Any linear two-terminal network can be replaced by an equivalent network consisting of a voltage source Vth in series with a resistance (Rth).
Vth = Open circuit voltage at load terminals.
Rth = Equivalent resistance at load terminals when sources are made inoperative.

**Circuit (hand drawn/image):**

**Circuit-1**



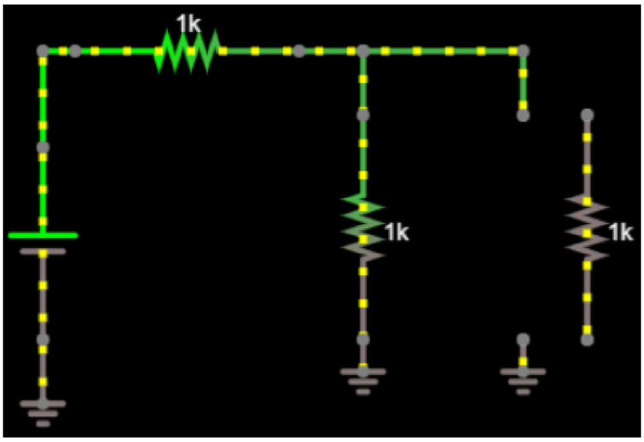

**Circuit-2**




**Thevenin’s equivalent circuit**

Circuit-2 is the Thevenin’s equivalent circuit of circuit-2.

**Circuit-3: Making the load resistance inoperative to find Thevenin voltage and resistance**




## Measurement Data(Tabular Form):

Observation Table for Circuit-1:

Since the experiment is being performed on the Circuit Simulator Applet (Falstad), observed $V_{out}$ and $V_{out}$ calculated are same and $R_{in}$ observed and $R_{in}$ calculated are same due to the absence of heating effect, human error in measuring the readings, parallax error and instrumental error.

| Sl No. | $R_1$ (in Ω) | $R_2$ (in Ω) | $V_{in}$ (in Volts) | $V_{out} = V_{in} \cdot \frac{R_2}{(R_1 + R_2)} (V)$ | I (mA) | Observed $R_{in}$ = Calculated $R_{in}$ (in Ω) |
|---|---|---|---|---|---|---|
| 1 | 1000 | 1000 | 5 | 2.5 | 6 | 833.33 |
| 2 | 500 | 1000 | 5 | 3.33 | 3.33 | 1500 |
| 3 | 1000 | 500 | 5 | 1.67 | 3.75 | 1333.33 |

Observation Table for Circuits-2 and -3:

$\mathbf{I_L^1}$ is the calculated current from circuit-3 and $\mathbf{I_L^2}$ is the current observed flowing through $\mathbf{R_L}$ in circuit-2. Since this experiment is performed on the Circuit Simulator Applet (Falstad), errors due to heating effect, human error in measuring the readings, parallax error and instrumental error, are avoided. Hence, $\mathbf{I_L^1}$ and $\mathbf{I_L^2}$ have the same value.

| $R_1$ (in Ω) | $R_2$ (in Ω) | $R_L$(in Ω) | $V_{in}$ (in Volts) | $V_{out}$=$V_{th}$ (V) | I (mA) | $R_{th}$ = $R_1$ \|\| $R_2$ (Ω) | $I_L^1 = I_L^2$ (in mA) |
|---|---|---|---|---|---|---|---|
| 1000 | 1000 | 1000 | 5 | 2.5 | 6 | 500 | 1.67 |
| 1000 | 500 | 500 | 5 | 1.67 | 3.33 | 333.33 | 2.00 |
| 500 | 1000 | 500 | 5 | 3.33 | 3.75 | 333.33 | 3.99 |

**Conclusion:**

Clearly, Thevenin's theorem is verified. Any linear circuit, irrespective of its complexity can be reduced to an equivalent circuit with just a single voltage source and series resistance connected to the load. By observing the values from the Circuit Simulator Applet (Falstad), we get $V_{out}$=$V_{th}$ . The basics of how a voltage is dropped across a resistor were studied. By performing the experiment, I can observe that the greater is the resistance, the greater will be the voltage drop across it.

**Discussions:**

1. Nearly all electronic circuits make use of the concept of the voltage divider and Thevenin's theorem, so it is important to get a complete idea about them such as determining resistance while using a multimeter and using the voltage drop concept and with an ammeter, Ohm's Law verification can be done.
2. I have learnt to use Circuit Simulator Applet (Falstad).

## VI. **Active Devices**

**Tools Used:** The experiment was performed in the live class in online mode

**Background Knowledge(brief):**

1. A diode is a two-terminal electronic component that conducts current primarily in one direction; it has low resistance in one direction, and high resistance in the other.
2. Active devices include transistors and diodes.

**Conclusion:**

A diode is one of the active devices. Potential drops across the two diodes were measured using a multimeter. Silicon diode has a voltage drop of 0.577V and the Germanium diode has a potential drop of 0.28V. Silicon diode is dark in colour while Germanium diode has a light colour.

**Discussion:**

1. Germanium diodes have higher electron and hole mobility and because of this Ge devices can function up to a higher frequency than Si devices.
2. The germanium diode is also superior to silicon diode in terms of energy loss, current loss, etc. The Ge diode loses only 0.3-0.4 a volt while a silicon diode loses about 0.6-0.7 volts.
3. Identification of Diodes: cathode terminal can be identified by observing the side with a band, i.e, the cathode terminal is on the side with a band, hence, the black probe of the multimeter must be connected to the cathode terminal and the red probe of the multimeter must be connected to anode terminal.
4. Silicon diode has a voltage drop of 0.577V and the Germanium diode has a potential drop of 0.28V. Silicon diode is dark in colour while Germanium diode has a light colour.
5. Zener diodes are used for voltage regulation.