LIST OF EXPERIMENTS

EXPERIMENT NO. 1

Safety Precautions and Handling of Measuring Instruments

Experiment No: 1
Safety precautions and handling of measuring instruments

Aim: To study safety precautions while working on electrical systems, handling of various equipment's such as multimeter, ammeters, voltmeters, wattmeters, resistors, inductors and capacitors.

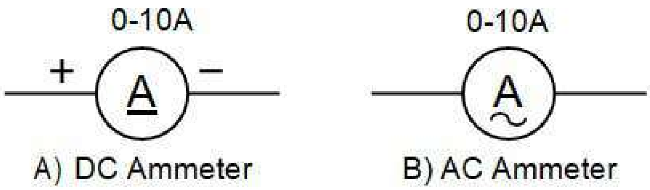
Theory:

1. Safety Precautions:
   While working on electrical installations, it is necessary to observe and follow safety precautions. Following are some of "safety precautions" to be observed while working on electrical installations.
   (a) Insulation of the conductors must be proper and in good condition. If it is not so, the current in the conductors may find an alternative path through the body of the person coming in contact with such conductors resulting into an electric shock.
   (b) Megger tests should be carried out for checking insulation resistance. With the help of a megger, all the tests such as insulation test with respect to earth, insulation test between two conductors, continuity test, test for earth resistance and polarity test for single pole switches must be performed on the new wiring before energizing it for use.
   (c) Earth connection should always be maintained in proper condition.
   (d) Supply from mains must be switched off and the fuses must be removed before starting repair or maintenance work on any installation.
   (e) Fuses must have correct ratings.
   (f) Rubber or plastic-soled shoes or chappals must be used while working on an electrical installation. Using a wooden support under the feet is advisable as it avoids the contact with the earth.
   (g) Rubber gloves of appropriate voltage rating should be used while touching the terminals or while removing insulation layer from a conductor.
   (h) A line tester should be used to check whether a terminal is 'live' i.e. holds any potential. More appropriate method is to use a test lamp.
   (i) Insulated screwdrivers, pliers, line testers etc. should be used.
   (j) Two different terminals should not be touched at the same time.
   (k) The plug should never be removed by pulling the wires connected to it.
   (l) The sockets should be fixed at a height beyond the reach of the children.
2. Measuring Instruments:
   (a) Ammeter:
   Ammeter is used to measure current in an electrical circuit and is required to be connected always in series.
   Classification or Types of Ammeter-
      i. Permanent Magnet Moving Coil (PMMC) ammeter.
      ii. Moving Iron (MI) Ammeter.
      iii. Electrodynamometer type Ammeter.

iv. Induction Type Ammeter.
v. Digital Ammeter (DAM).

Depending on type of supply i.e. AC or DC , ammeter is selected. DC Ammeter are mainly PMMC instruments, MI can measure both AC and DC currents, also Electrodynamometer type thermal instrument can measure DC and AC, induction meters are not generally used for ammeter construction due to their higher cost, inaccuracy in measurement.

Symbol



(b) Voltmeter:
Voltmeter is employed to measure the potential difference (Voltage) across any two points of a circuit. It is connected in the parallel across any element in the circuit. Classification or Types of Voltmeter

i. Permanent Magnet Moving coil (PMMC) Voltmeter.
ii. Moving Iron (MI) Voltmeter.
iii. Electro Dynamometer Type Voltmeter.
iv. Induction Type Voltmeter.
v. Electrostatic Type Voltmeter.
vi. Digital Voltmeter (DVM).

Depending upon type of electric supply voltmeter is selected for voltage measurements. For DC voltmeters PMMC instruments are used, MI instrument can measure both AC and DC voltages, electrodynamometer type, thermal instrument can measure DC and AC voltages as well. Induction meters are not used because of their high cost, inaccuracy in measurement. Rectifier type voltmeter, electrostatic type and also digital voltmeter (DVM) can measure both AC and DC voltages.

Symbol

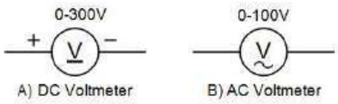


Figure 1: Voltmeter

Figure 2: Analog Voltmeter

(c) Wattmeter: - The wattmeter is an instrument for measuring the electric power in watts of any given circuit. It consists of two coils i.e. pressure coil (parallel) and current coil (series). As the current coil is connected in series with load, it measures the load current and whereas the pressure coil is connected across the load is used to measure the voltage across the load. Mainly electro- dynamic type of wattmeter is used.

(d) Digital Multimeters A digital multimeter is a test tool used to measure two or more electrical values—principally voltage (V), current (A) and resistance (Ω). It is a standard diagnostic tool for technicians in the electrical/electronic industries.Digital multimeters long ago replaced pointer-based analog meters due to their ability to measure with greater accuracy, reliability and increased impedance. Digital multimeters combine the testing capabilities of single-task meters—the voltmeter (for measuring volts), ammeter (amps) and ohmmeter (ohms). Often, they include several additional specialized features or advanced options. Technicians with specific needs, therefore, can seek out a model targeted to meet their needs.

Symbol:

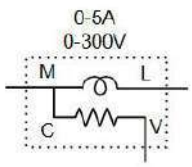


Figure 3: Wattmeter

Figure 4: Multimeter

3. Electrical Parameters

(a) Resistance: Variable resistors (rheostats) are made up of high resistivity material such as nickel- chromium iron alloy closely wound over a circular tube. These are available both in single tube and double tube. Inter-turn insulation is provided to avoid short circuiting of turns. The tube of rheostat is made of insulating material, like asbestos. These are employed at places where resistance of a circuit is to be varied without breaking the circuit.

Images of resistances and Symbol:

Figure 5: Resistance and Rheostat

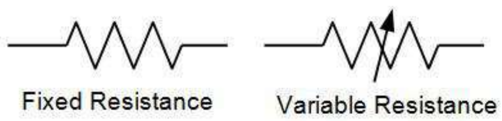


Figure 6: Symbol of Resistance

(b) Inductance: - An inductor is an element which can store energy in the form of magnetic field. The function of an inductor is to provide opposition to a changing or varying current.

Images of Inductor and Symbol:

Figure 7: Inductor

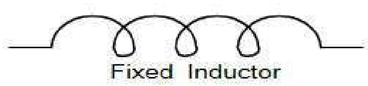


Figure 8: Symbol of Inductor

(c) Capacitance: - A capacitor is a passive electrical component consisting of a pair of conductors separated by a dielectric. Capacitance is measure of the ability to store the charge. Capacitance also depends on the dielectric constant of the dielectric material separating the plates.

Images of Capacitor and Symbol:

Figure 9: Capacitor

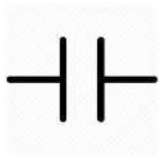


Figure 10: Symbol of Capacitor

Conclusion:

EXPERIMENT NO. 2

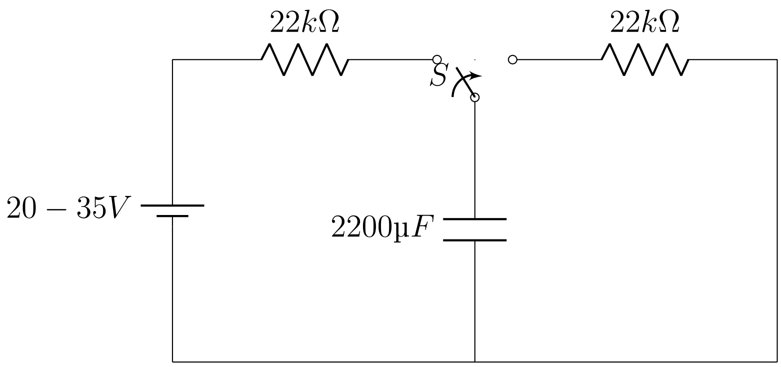
Capacitor Charging and Discharging

Experiment No: 2
Capacitor Charging and Discharging

Aim: To calculate and measure charging and discharging voltage of capacitor.
Apparatus:

Apparatus	Rating	Quantity
DC Ameter	0-250 mA	1
DC Voltmeter	0-150 V	1
DC Voltage Source	0-35 V	1
Resistance	22kΩ	2
Capacitor	22 μF	1

Circuit Diagram:



Theory:

1. **Charging of Capacitor**

   Consider a capacitor C is in series with the resistance R. The capacitor has initially no charge and no voltage across it.

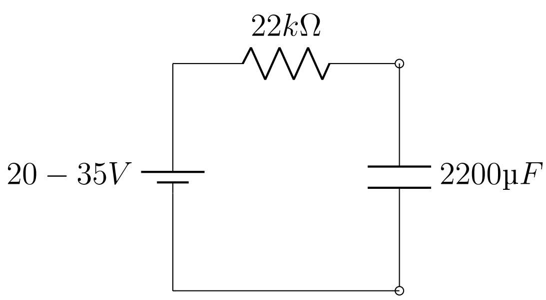
   When switch S is closed at t = 0, the R-C series circuit will get connected to supply voltage V. When the switch 'S' is in OFF condition:

   $$\text{Current through capacitor i} = 0 \quad \text{Voltage across capacitor } V_c = 0$$

   At t = 0^-: when switch 'S' is in ON condition:

   $$\text{Current through capacitor } i_{max} = \frac{V}{R} \quad \text{Voltage across capacitor } V_c = 0$$

   At t = ∞



Current through capacitor i = 0   Voltage across capacitor V_c = V

The voltage and current equation during charging is given by

$V_c = V(1 - e^{-\frac{t}{\tau}})$

$i = Ie^{-\frac{t}{\tau}}$

Time constant: The term τ in above in equation is called as time constant of the R-C charging circuit and is measured in sec. $\tau = CR$ Time constant in R-C circuit can be defined as time required by the capacitor voltage to rise from zero to 0.632 of its final steady state value during charging. OR Time constant is the time required for the charging current of capacitor to fall to 0.368 of its initial value, starting from its maximum value.

Procedure:

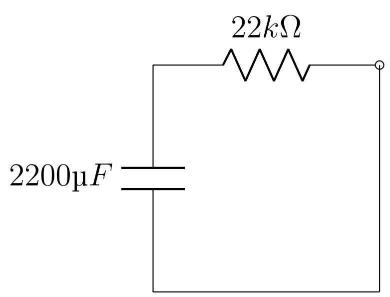
(a) Connect the circuit diagram as shown in Figure
(b) Switch ON the power supply.
(c) Set the required input voltage
(d) Switch on RC series circuit
(e) Note down the voltage across capacitor and current through capacitor at regular time intervals.
(f) Note down these readings at the time equal to five times time constant.

Observation Table:

Sr. No.	Time in seconds	V_c	i	Sr. No.	Time in seconds	V_c	i
1	10			10	100		
2	20			11	120		
3	30			12	140		
4	40			13	160		
5	50			14	180		
6	60			15	200		
7	70			16	220		
8	80			17	240		
9	90			18	260		

2. **Capacitor Discharging:**

Now consider the capacitor C is being discharged through resistance R by closing switch S at t = 0. Let capacitor be fully charged to V volt.



When switch 'S' is in OFF condition:

Current through capacitor i = 0 Voltage across capacitor V_c = V

At t = 0^-, when switch 'S' is in ON condition:

Current through capacitor i = $i_{max} = -\frac{V}{R}$

Voltage across capacitor V_c = V

At t=∞:

Current through capacitor i = 0 Voltage across capacitor V_c = 0

The voltage and current equation during discharging is given by

$V_c = Ve^{-\frac{t}{\tau}}$

$i = Ie^{-\frac{t}{\tau}}$

Time Constant: Time constant in R-C circuit can be defined as time required by the capacitor voltage to fall to 0.368 of its initial maximum value during discharging. OR Time constant is the time required for the charging current of capacitor to fall to 0.368 of its initial value, starting from its initial value.

Procedure:

(a) Let the capacitor be fully charged. Note down its voltage.

(b) Close the RC circuit through switch.

(c) Note down the voltage across capacitor and current through capacitor at regular time intervals.

(d) Note down these readings at the time equal to five times time constant.

Observation Table:

Sr. No.	Time in seconds	V_c	$-i$	Sr. No.	Time in seconds	V_c	$-i$
1	10			10	100		
2	20			11	120		
3	30			12	140		
4	40			13	160		
5	50			14	180		
6	60			15	200		
7	70			16	220		
8	80			17	240		
9	90			18	260		

Plot the graphs of

(a) Charging voltage and discharging voltage (on Y axis) against time (on X axis)

(b) Charging current and discharging current (on Y axis) against time (on X axis)

Comparison of results with theoretical values:

Capacitor Charging:

1. At time equal to time constant
   Expected value of $V_c =$ Observed value of $V_c =$
2. At time equal to time constant
   Expected value of $i =$ Observed value of $i =$
3. Theoretical value of Initial charging current $I = \frac{V}{R} =$
4. Observed value of initial charging current $I = \frac{V}{R} =$

Capacitor Discharging:

1. At time equal to time constant
   Expected value of $V_c =$ Observed value of $V_c =$
2. At time equal to time constant
   Expected value of $i =$ Observed value of $i =$
3. Theoretical value of Initial charging current $I = -\frac{V}{R} =$
4. Observed value of initial charging current $I = \frac{V}{R} =$

Conclusion:

EXPERIMENT NO. 3

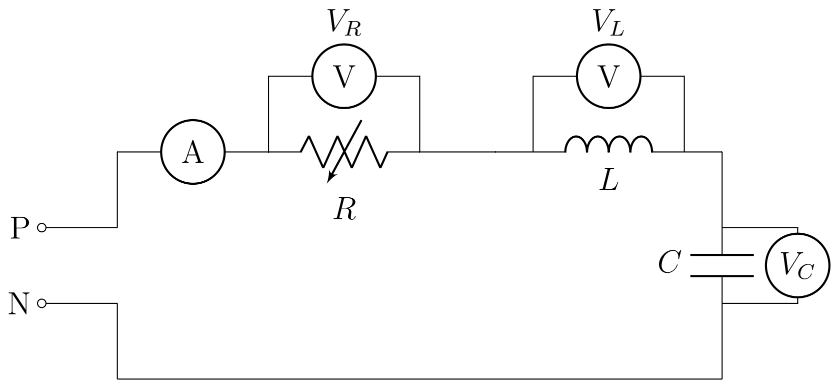
RL and RC Series Circuit

Experiment No: 3
RL and RC Series Circuit

Aim: To measure the steady-state response of series RL and RC circuits on AC.
Apparatus:

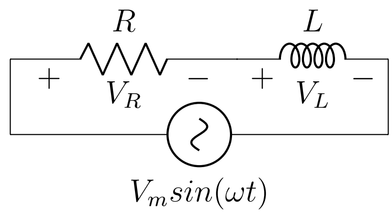
Apparatus	Rating	Quantity
A.C. Ameter	0-1/5/10 A	1
A.C. Voltmeter	0-300 V	1
Experimental Kit	-	1
Multimeter	-	1
Rheostat	570 Ω, 1.2 A	1

Circuit Diagram:



Theory:

1. **Series RL Circuit:** Let a single-phase AC supply $v = V_m sin(\omega t)$ is applied across a series circuit of resistance R Ω , inductance L Henry as shown in the following figure:



If the frequency $f(Hz)$ is then inductive reactance is given by $X_L = 2\pi f L$

$Z = R + jX_L \qquad |Z|\underline{/\phi}$

Where, $|Z| = \sqrt{R^2 + jX_L^2} \qquad \phi = tan^{-1}\left(\frac{X_L}{R}\right)$

Thus, in RL series circuit the current lags behind voltage by ϕ i.e. voltage leads current by ϕ. Instantaneous voltage and current are given by

$v = V_m sin(\omega t); \qquad i = I_m sin(\omega t - \phi) = \frac{V_m}{Z} sin(\omega t - \phi)$

The instantaneous power is given by

$$p = vi = \frac{V_m I_m}{2} cos\phi - \frac{V_m I_m}{2} cos(2\omega t - \phi)$$

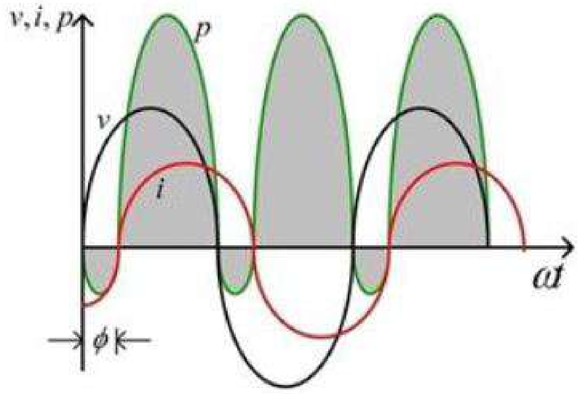
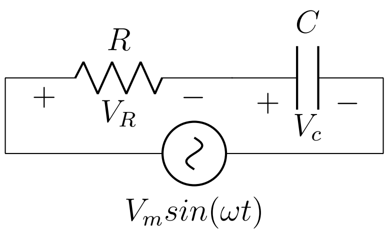


Figure 1: Voltage, Current and Power waveforms

2. **Series RC circuits:**

Let a single-phase AC supply $v = V_m sin(\omega t)$ is applied across a series circuit of resistance R, capacitance C as shown in the following figure:



If the frequency is f then capacitive reactance is given by $X_C = \dfrac{1}{2\pi fc}$

The opposition offered by R-C series circuit to ac current is Z (Impedance)

$Z = R - jX_c$ $\qquad |Z|\underline{/-\phi}$

Where, $|Z| = \sqrt{R^2 + jX_L^2}$ $\qquad \phi = tan^{-1}\left(\dfrac{X_c}{R}\right)$

It indicates in RC series circuit, current leads voltage by ϕ i.e. voltage lags current by ϕ
Instantaneous voltage and current are given by

$v = V_m sin(\omega t);$ $\qquad i = I_m sin(\omega t + \phi) = \dfrac{V_m}{Z} sin(\omega t + \phi)$

The instantaneous power is given by,

$p = vi = \dfrac{V_m I_m}{2} cos\phi - \dfrac{V_m I_m}{2} cos(2\omega t + \phi)$

Powers in R-L and R-C series circuit:

(a) Active/real Power (P) [Watt]: It is the power consumed by the circuit. It is the multiplication of RMS values of voltage, current and power factor.

(b) Reactive Power (Q) [VAr]: It is the multiplication of RMS values of voltage, current, and sine of the angle of between voltage and current.

(c) Apparent Power (S) [VA]: It is the multiplication of RMS values of voltage, current.

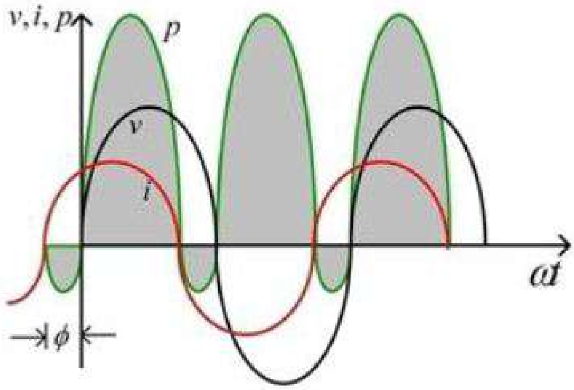


Figure 2: Voltage, Current and Power waveforms

Procedure:

(a) Connect the circuit diagram as shown in Figure

(b) Switch ON the power supply. Apply single phase input voltage to the circuit.

(c) Note down the ammeter reading (I), and voltmeter readings V, VR, VL / VC (which indicate input voltage, voltage across the resistance and voltage across the inductor/capacitor).

(d) Take a few readings while changing the resistance value.

Observation Table 1:

(a) R-L series circuit

Sr. No.	Applied Voltage	Voltage across R	Voltage across L	I
1				

Calculations:

From Phasor diagram $\phi_L =$

$R = \frac{V_R}{I}$ $Z_L = \frac{V_L}{I}$ $cos\phi_L$ $r_L = Z_L cos(\phi_L)$ $X_L = Z_L sin\phi_L$ $L = \frac{X_L}{2\pi f}$

$R = \frac{V}{I}$ $cos\phi = \frac{R}{Z}$ ϕ $P = VIcos\phi$ $Q = VIsin\phi$ $S = VI$

Result Table 1:

R	Z_L	$cos\phi_L$	r_L	X_L	L	Z	$cos\phi$	ϕ	P	Q	S

Observation Table 2:

(b) R-C series circuit

Calculations:

Sr. No.	Applied Voltage	Voltage across R	Voltage across C	I
1				

$R = \frac{V_R}{I}$ $X_C = \frac{V_C}{I}$ $|Z| = \sqrt{R^2 + X_C^2}$ $C = \frac{1}{2\pi f X_C}$ $cos\phi = \frac{R}{Z}$

ϕ $P = VIcos\phi$ $Q = VIsin\phi$ $S = VI$

R	X_C	Z	C	$cos\phi$	ϕ	P	Q	S

Conclusion:

EXPERIMENT NO. 4

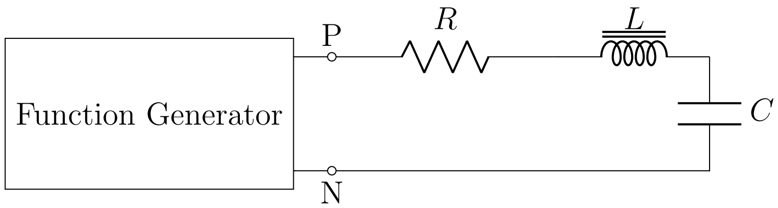
R-L-C Series Resonance Circuit

Experiment No: 4
R-L-C Series Resonance Circuit

Aim: To derive resonance frequency and analyze resonance in series RLC circuit.
Apparatus:

1. RLC series kit
2. Function Generator
3. Multi-meter
4. Patch cords

Circuit Diagram:



Theory: Resistance, Inductance and capacitance are properties of circuit elements that depend on the geometry of the conductors and insulators of which they are composed. The units for resistance R, capacitance C and for inductance L are Ohm, Farad, and Henry respectively. An inductor is manufactured by winding a wire into a coil shape. The wire itself has some resistance, and therefore the inductor possesses not only an L, but also an R. Capacitors and inductors both can pass AC currents. The effect either has on an AC current flow is called reactance (X). These reactive components not only limit the AC current flowing in a circuit, but also affect the time or phase relationships between the current and the various voltages present across the components. Therefore, in AC circuits the rules for combining these reactance's must take into account both magnitudes and phase angles. The reactance possessed by inductance is known as Inductive reactance and reactance possessed by capacitance is called as capacitive reactance. The equivalent AC resistance (the quantity relating voltage and current) of a circuit containing reactance's and resistances is called impedance (Z). Comparison of the phase of the voltage and current in resistors, capacitors, and inductors:

1. Resistor: The voltage across a resistor's terminals is at each instant directly proportional to the current through it. The voltage and current are said to be in phase with one another.

2. Capacitor: The voltage and current are 90° (1/4 cycle) out of phase. The current through a capacitor depends on the time-rate-of-change of the voltage across the capacitor. The voltage lags the current by 90°. That is, if the current is a maximum at a certain instant, the voltage doesn't reach a maximum until a quarter period later.

3. Inductor: The voltage and current are 90° out of phase, but in the opposite way, as compared to a capacitor. The voltage across an inductor's terminals depends upon the time-rate-of-change of the current through it. The voltage leads the current by 90°.

Series Resonance: To get the series resonance, the resistance, inductance and capacitance must be connected in series across the AC supply with certain frequency. The inductive reactance increases as the frequency increased and the capacitive reactance decreases as frequency increased.

Inductive reactance $X_L = 2\pi L = \omega L$

Capacitive reactance $X_C = \dfrac{1}{2\pi fC}$

From this we can say that there must be a frequency at which X_L equals X_C. This property at equal and opposite reactance is called resonance. The frequency at which $X_C = X_L$ is called as resonant frequency and is given by f_r

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

In a series AC circuit, inductive reactance leads by 90°, while capacitive reactance lags by 90°. So X_L and X_C are 180° out of phase.

Procedure:

1. Connect the circuit as shown in circuit diagram.
2. Vary the frequency applied to the circuit by using function generator.
3. Observe the change in frequency from function generator and record value of current by using ammeter or multi-meter.

Observation Table:

Sr. No.	Frequency (Hz)	Current (A)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		

Calculation:

$X_L = 2\pi fL$ $\qquad$ $X_C = \dfrac{1}{2\pi fC}$

$|Z| = \sqrt{R^2 + (X_L - X_C)^2}$ $\qquad$ $cos\phi = \dfrac{R}{Z}$

Result Table:

Sr. No.	X_L	X_C	Z	I	cosϕ	f (Hz)	
						Observed	Calculated

Plot the graph of 1) XL Vs frequency
2) XC Vs frequency
3) I Vs frequency
4) Z Vs frequency
5) Cosϕ Vs frequency

Conclusion:

EXPERIMENT NO. 5

Star and Delta Connection

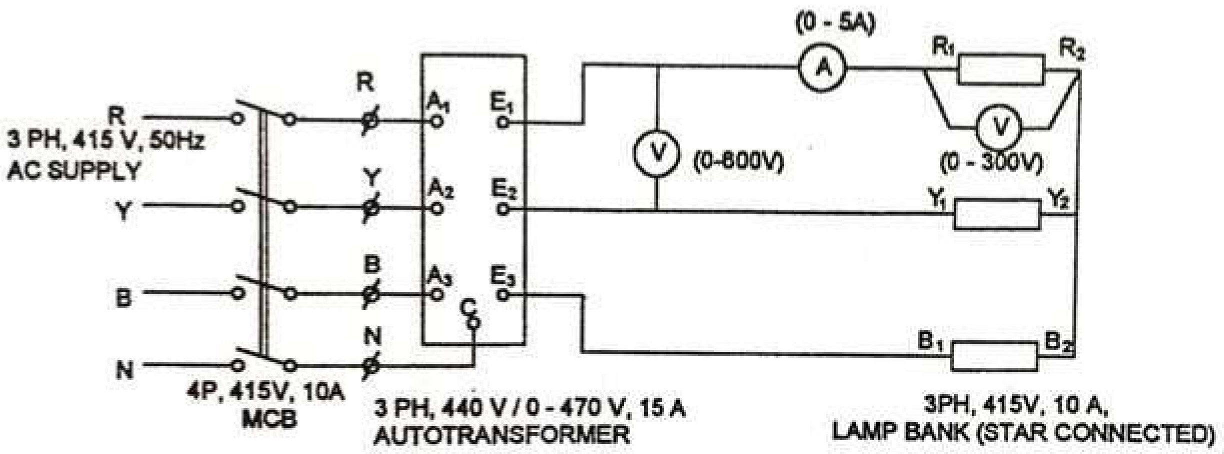
Experiment No: 5
Star and Delta Connection

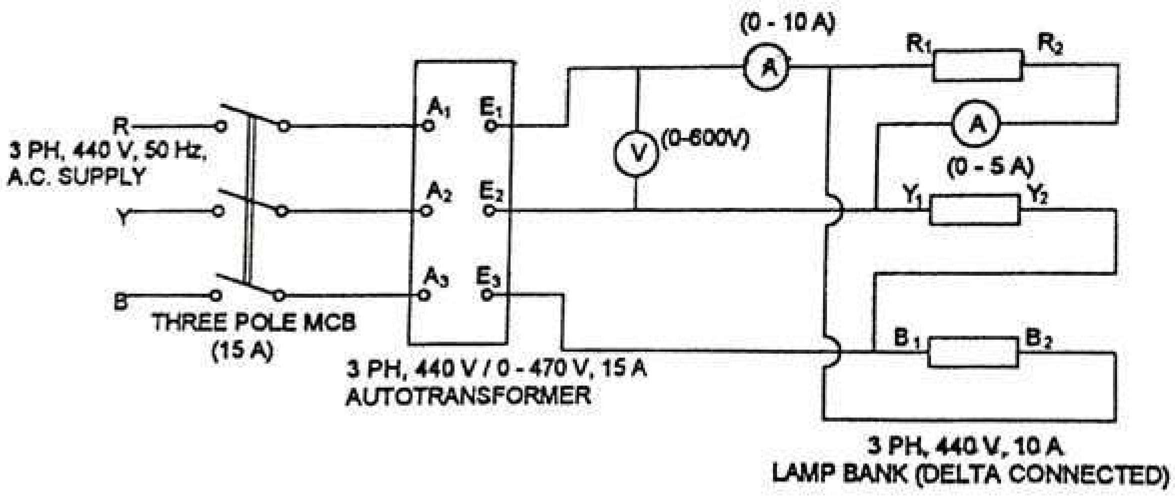
Aim: To verify the relation between phase and line quantities in three phase balanced star delta connections of load.

Apparatus:

Equipment	Rating	Quantity
Three phase lamp load	(440V, 10 A)	1
A.C. Voltmeter	(0-300V-600V)	1
A.C. Ammeter	(0-5A)	1
A.C. Ammeter	(0-10A)	1

Circuit diagram:





Theory:

A balanced three phase system is one in which the voltages in all phases are equal in magnitude and differ in phase from one another by equal angle i.e.120 degree (electrical). A three phase balanced load is that in which the loads connected across three phases are identical in nature and magnitude.

Star Connection:

In this type of interconnection, one of the ends of each load impedances are joined together to form a common point called as star or neutral point. The potential difference between line and neutral is called as phase voltage and between two lines is called line voltage. Hence,V_{RN}, V_{YN}, V_{BN} (Each equal to V_{PH}) are the three phase voltages.

We have, as phasor relations:

$$\overline{V}_{RY} = \overline{V}_{RN} - \overline{V}_{NY} = \overline{V}_Y - \overline{V}_R$$
$$\overline{V}_{YB} = \overline{V}_{YN} - \overline{V}_{NB} = \overline{V}_B - \overline{V}_Y$$
$$\overline{V}_{BR} = \overline{V}_{BN} - \overline{V}_{NR} = \overline{V}_R - \overline{V}_B$$

From phasor diagram,
$V_{RY} = 2 * V_{RN} * cos30 = \sqrt{3}V_{RN}$
i.e $V_L = \sqrt{3}V_{ph}$
Also IR, IY, IB are the three line currents, as well as the three phase currents i.e. $I_L = I_{PH}$

Delta Connection: In this type of interconnection, the end of first load impedance is connected to start of second load impedance, the end of second load impedance is connected to start of third load impedance and end of third is connected to start of first. In this way a closed loop of three impedances is formed. Three-phase supply is given to the three junctions in the closed loop of the impedances.

Current flowing through any line is called line current (i.e., $I_R = I_Y = I_B = I_L$) and current through any single load impedance is called as phase current (i.e.$I_{RY} = I_{YB} = I_{BR} = I_{PH}$). The line voltages V_{RY}, V_{YB} and V_{BR} are phase voltages as well as line voltages.

We have, as phasor relations,

$$\bar{I}_R = \bar{I}_{RY} - \bar{I}_{BR}$$
$$\bar{I}_Y = \bar{I}_{YB} - \bar{I}_{RY}$$
$$\bar{I}_B = \bar{I}_{BR} - \bar{I}_{YB}$$

From phasor diagram, $I_R = 2 * I_{RY} * cos30 = \sqrt{3}I_{RY}$
i.e $I_L = \sqrt{3}I_{ph}$

Procedure:

1. onnect the given lamp load in STAR,
2. Make it balance by switching appropriate number of lamps in each phase.
3. Measure the line and phase voltages as well as line and phase currents
4. Repeat the same procedure by connecting the load in DELTA.

Observation table:

Connection	Phase Voltage	Phase Current	Line Voltage	Line Current
Star				
Delta				

Calculation:

Star Connection	Delta Connection

Conclusion:

EXPERIMENT NO. 6

Performance of Single Phase Transformer

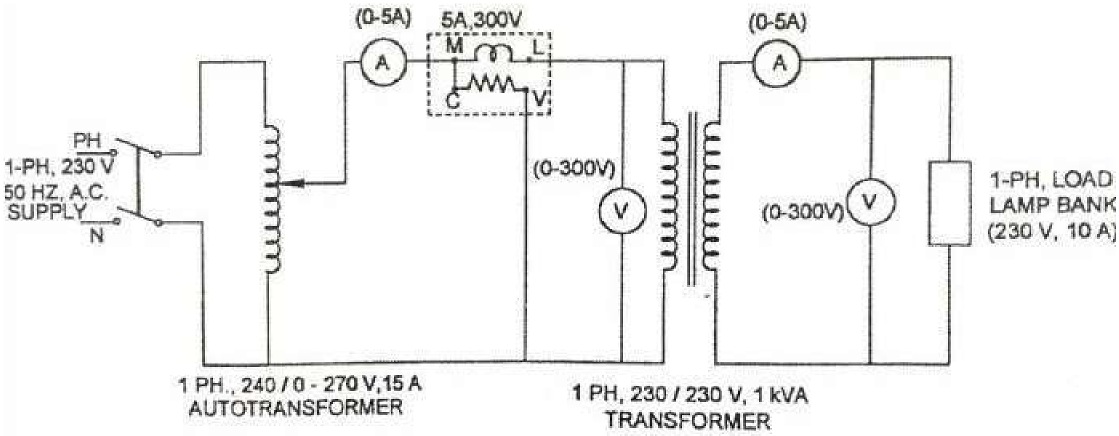
Experiment No: 6
Performance of Single Phase Transformer

Aim: To determine efficiency and regulation of Single Phase Transformer by Direct Loading test.

Apparatus:

Apparatus	Rating	Quantity
Transformer	1 kVA, 230/230 V	1
AC Ameter	0-5A 0-10A	1
AC Voltmeter	0-300 V	1
Dimmerstat	230V/0-270V, 15A V	1
Resistive load bank (Single Phase)	230V, 10A	1
Wattmeter	300 V, 10 A	1

Circuit Diagram:



Theory:

Transformer transforms electrical energy from one circuit to another. By keeping primary side voltage constant if load on secondary side is increased, then terminal voltage V_2 across the load changes. For a resistive or inductive type of load this change is on negative side, i.e., the terminal voltage drops. With the further increase in load it drops further because the load current increases and hence the voltage drops in resistance and leakage reactance of the secondary winding also increases.

Voltage Regulation: The change in secondary voltage from no load to full load expressed as the fraction of no load secondary voltage is defined as the voltage regulation of transformer.

Losses: There are two types of losses in transformer

1. Copper losses or Winding losses (Variable Losses).

2. Iron losses or Core losses (Constant losses) Due to various losses, the power output of the transformer is always less than the corresponding power input. So for same input, higher the value of power output i.e. lesser the losses, more efficient is the transformer.

Efficiency:

Efficiency of the transformer is defined as the ratio of output power to the input power. When expressed in percentage;

$$\%\eta = \frac{Output Power}{Input Power} x100.$$

Procedure:

1. Connect the circuit as shown in diagram.
2. Initially keep all the lamps off and keep the dimmerstat at zero position.
3. Switch on the supply and by varying the dimmerstat, apply rated voltage to primary.
4. Note down the readings of currents, voltages and power. The secondary voltmeter reading is obviously the no load secondary voltage$V_{2(0)}$.
5. Now keeping primary voltage constant, increase the load on secondary side in steps by switching the lamps on. Note down various quantities $V_1, I_1, W_1, V_2 and I_2$ at each step.
6. Repeat the procedure till full load current flows on secondary side.

Observation Table:

Sr. No.	Primary Voltage	Primary Current	Secondary Voltage	Secondary Current
1				
2				
3				
4				
5				
6				
7				
8				

Calculation:

1. Full load Seconddary Current $= \dfrac{kVArating \times 1000}{I_2}$
2. Output Power $W_2 = V_2 \times I_2$
3. Efficiency $\eta = \dfrac{W_2}{W_1} \times 100$
4. Voltage Regulation $= \dfrac{V_{2(0)} - V_2}{V_{2(0)}}$

Result Table:

Sr. No.	W_2	% Efficiency	% Voltage Regulation
1			
2			
3			
4			
5			
6			
7			
8			

Conclusion:

EXPERIMENT NO. 7

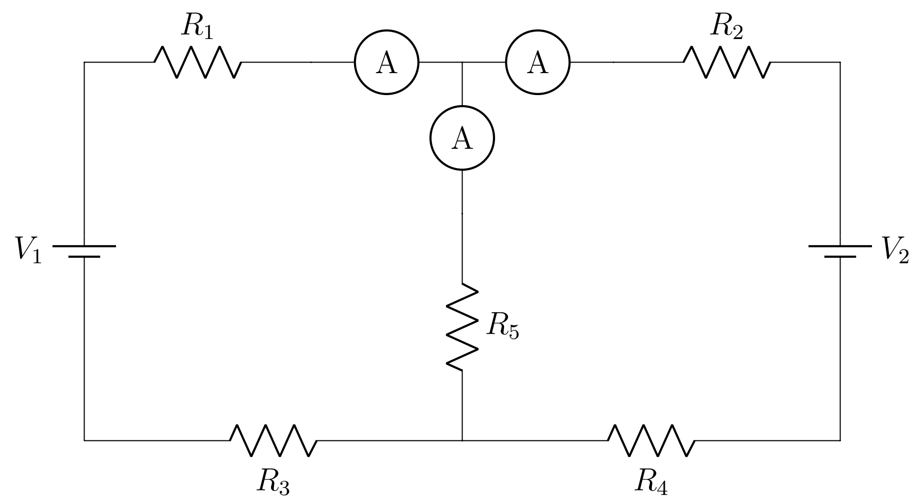
KVL & Superposition Theorem

Experiment No: 7
KVL & Superposition Theorem

Aim: To verify KVL and Superposition theorem.
Apparatus:

1. Experimental kit.
2. Dual power supply (0-30 V D.C., 2 A, CC/CV)
3. D.C. milliammeter (0-250/500mA)- 3 Nos
4. Multimeter
5. Connecting wires

Circuit Diagram:



Theory:
Part A: Verification of Kirchoff's Law
Statement: Algebraic sum of the branch voltages in any closed loop is always equal to zero.

$$\sum V = 0$$

Solution of the given network by Mesh Analysis

In the given network all the circulating loop currents are assumed to be flowing in the same direction i.e clockwise. This is not necessary essential as the choice of direction can be arbitrarily for any loop current. The equation for different loops will always be of the generalized form given below:

$$R_{11}I_1 + R_{12}I_2 + ... + R_{1n}I_n = V_1$$
$$R_{21}I_1 + R_{22}I_2 + ... + R_{2n}I_n = V_2$$
$$-.-$$
$$R_{n1}I_1 + R_{n2}I_2 + ... + R_{nn}I_n = V_n$$

Where, V_1= the Algebraic sum of the source voltage in loop-1 in the direction of I_1 V_2= the Algebraic sum of the source voltage in loop-1 in the direction of I_2 R_{11}= Sum of all resistances in Loop-1 $R_{12} = R_{21}$=Total resistance common to loop 1 & 2 Hence it is important to note that the resistance elements (or the coefficient) R_{11}, R_{22} etc respectively represent the total resistance values on the contours of the loops 1, 2 etc always positive sign. In other words it means that equation derived for a particular loop ,the term which loops own circulating current is always positive e.g. the term $R_{11}I_1$ is always positive in the equation of first loop, the term $R_{22}I_2$ is always positive in the equation of second loop and so on, On the other hand all other resistance elements like R_{12}, R_{21} , etc representing the resistance common to two loops carry a positive sign if the two assumed loop currents through the flow in the same direction and a minus sign if these loop currents flow in opposite direction With these rules in mind it is possible to write the equation necessary for the solution of any method merely by inspecting that network without the necessity for collecting terms with the same coefficient

For loop 1: $R_{11}I_1 + R_{12}I_2 = V_1$ For loop 2:$R_{21}I_1 + R_{22}I_2 = V_2$

Solve the given equation by simultaneous method or matrix method or by Euler method

Procedure:

1. Apply suitable voltage using DC dual power supply on both sides
2. Measure currents using milli-ammeter.

Observation Table:

$R_1 =$ $R_2 =$ $R_3 =$ $R_4 =$ $R_5 =$

V_1	V_2	V_{R1}	V_{R5}	V_{R3}

Calculation:

Voltage	Practical Values	Calculated Values
V_1		
V_{R1}		
V_{R5}		
V_{R3}		

Part B: Verification of Superposition Theorem

Statement: Superposition theorem states that in a linear bilateral network containing constant resistance and several source, the resultant current in any branch is a algebraic sum of the currents that would be produce in that branch by each source acting separately, when all the remaining source are replaced by their respective internal resistances.

Procedure:

1. Apply suitable voltage V_1 using DC power supply and replace second source (V_2) by its internal resistance
2. Measure current through respective branch using milli-ammeter.
3. Repeat the process considering second source voltage V_2
4. Measure current through respective branch when both the voltage sources are present

Observation Table:

$R_1 =$ $R_2 =$ $R_3 =$ $R_4 =$ $R_5 =$

$V_1 =$ $V_2 =$

Current When V_1 acting alone I'	Current When V_1 acting alone I"	When V_1 &V_2 are acting Simultaneously (I)

Calculation:

Current	Practical Values	Calculated Values
I'		
I"		
I		

Conclusion:

EXPERIMENT NO. 8

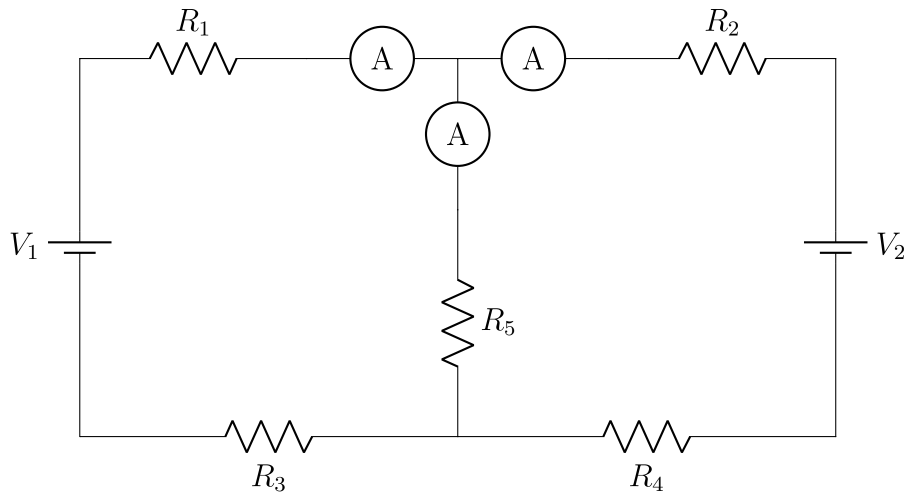
Thevenin's Theorem

Experiment No: 8
Thevenin's Theorem

Aim: To verify Thevenin's theorem.
Apparatus:

1. Experimental kit.
2. Dual power supply (0-30 V D.C., 2 A, CC/CV)
3. D.C. milliammeter (0-500mA)
4. Multimeter
5. Connecting wires

Circuit Diagram:



Theory:
Thevenin's theorem states that, any linear, two port circuit consisting of voltage sources and resistances can be replaced by an equivalent two port circuit consisting of a single voltage source (V_{TH}) in series with a single resistance (R_{TH}), where, the value of 'V_{TH}' is equal to the open circuit voltage across the two ports and the value of 'R_{TH}' is equal to the net resistance of the entire circuit across the same two ports.

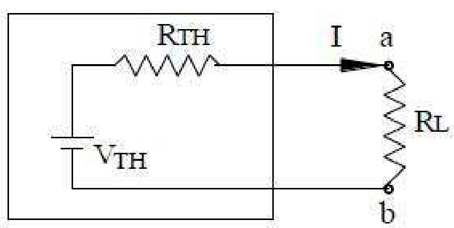


Figure 1: Thevenin's Equivalent Circuit

'V_{TH}' and 'R_{TH}' are called as Thevenin's equivalent voltage and resistance respectively. This idea can be used to find current in any circuit element (or to find voltage across any circuit element) say, a resistor. Let us find the current in a certain resistor in the given circuit. We call this resistor as the 'load resistor (R_L)'. First, we assume that this resistor is removed from its place. The remaining circuit will be a twoport circuit as shown to left hand side in above diagram. Then we measure the voltage between the two ports and also the effective resistance of the entire circuit across the same two ports with suitable methods. Finally we represent the given circuit with Thevenin's equivalent circuit as shown to right hand side in the above diagram. When we replace the load resistor across the same two ports, the given circuit will be equivalent to a circuit as shown in the adjacent diagram. Hence, the current in the load resistor will be;

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

Procedure:

1. Apply certain voltages from the two voltage sources. Observe and note down the current in the load resistor (as shown by the ammeter connected in series with it. This reading is required to compare the results i.e., for verification of Thevenin's theorem).
2. Now, remove the load resistor (R_L) through which the current is to be determined.
3. Measure the voltage between the two terminals from where the load resistance has been removed. This is the value of Thevenin voltage 'V_{TH}'.
4. Now, short-circuit the voltage sources (assuming the voltage sources to be ideal). Measure the resistance of the whole network between the same two terminals with the help of multimeter. This is the value of Thevenin resistance 'R_{TH}'.
5. Repeat the procedure for a different set of source voltages and record all the observations as before.

Observation Table:

$R_1 =$ $R_2 =$ $R_3 =$ $R_4 =$ $R_L =$

V_1	V_2	R_L	I_L	V_{TH}	I_{TH}

Calculations:

1. Thevenins Equivalent Voltage, VTH
2. Thevenins Equivalent Resistance, RTH
3. Current in load resistor by Thevenin's Theorem $I_L = \frac{V_{TH}}{R_{TH}+R_L}$

Result table:

By Observation			By Calculation		
V_{TH}	R_{TH}	I_L	V_{TH}	R_{TH}	I_L

Conclusion:

EXPERIMENT NO. 9

Measurement of Insulation Resistance

Experiment No: 9
Measurement of Insulation Resistance

Aim: To measure the insulation resistance of electrical equipment/cable using Megger.
Apparatus: Megger
Theory:

Every electric wire in your plant – whether it's in a motor, generator, cable, switch, transformer, etc. – is carefully covered with some form of electrical insulation. The wire itself is usually copper or aluminum, which is known to be a good conductor of the electric current that powers your equipment. The insulation must be just the opposite from a conductor: it should resist current and keep the current in its path along the conductor. To understand insulation testing you really don't need to go into the mathematics of electricity, but one simple equation – Ohm's law – can be very helpful in appreciating many aspects. Even if you've been exposed to this law before, it may be a good idea to review it in the light of insulation testing. Essentially, "good insulation" means relatively high resistance to current. Used to describe an insulation material, "good" would also mean "the ability to keep a high resistance." So, a suitable way of measuring resistance can tell you how "good" the insulation is. Also, if you take measurements at regular periods, you can check trends toward its deterioration When your plant electrical system and equipment are new, the electrical insulation should be in top-notch shape. Furthermore, manufacturers of wire, cable, motors, and soon have continually improved their insulations for services in the industry. Nevertheless, even today, insulation is subject to many effects which can cause it to fail – mechanical damage, vibration, excessive heat or cold, dirt, oil, corrosive vapors, moisture from processes, or just the humidity on a muggy day.

Measurement of Insulation Resistance:

You have seen that good insulation has high resistance, and poor insulation has relatively low resistance. The actual resistance values can be higher or lower, depending on factors such as temperature or moisture content of the insulation (resistance decreases in temperature or moisture). With a little record-keeping and common sense, however, you can get a good picture of the insulation condition from values that are only relative.

The Megger insulation tester is a small, portable instrument that gives you a direct reading of insulation resistance in ohms or mega ohms. For good insulation, the resistance usually reads in the mega ohm range. The Megger insulation tester is essentially a high-range resistance meter (ohmmeter) with a built-in direct-current generator. This meter is of special construction with current and voltage coils, enabling true ohms to be read directly, independent of the actual voltage applied. This method is nondestructive; that is, it does not cause deterioration of the insulation.

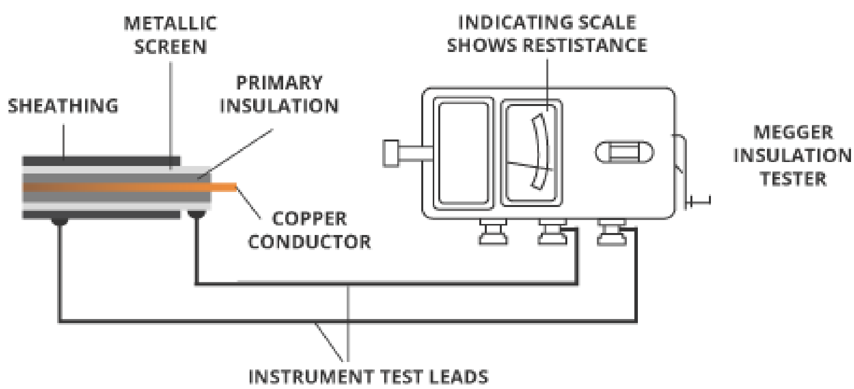


Figure 1: Insulation resistance measurement with Megger

Testing insulation resistance: For testing insulation of the installation, we have to check insulation resistance between earth & conductor and the insulation resistance between conductors.

1. **Insulation resistance between earth & conductor:** For the purpose of safety, it is necessary to ensure that there is no leakage current through the insulation used. This test gives the value of the insulation resistance between earth & conductor. Insulation resistance can be measured with the help of 500 V megger using the procedure as given below.
   (a) Keep all fuse links, all switches and lamps in position. The main switch should be off.
   (b) Connect the line terminal of megger to either of the main leads (phase or neutral) and earth terminal to any point on the earth continuity conductor of the system.
   (c) Rotate the handle of megger with hand and note down insulation resistance between conductor and earth. This resistance should not be less than 50 M-Ohm divided by the number of outlets.
2. **Insulation resistance between conductors:**
   (a) In this test, keep all the switches and fuse links in position. Keep the main switch in off position. Remove all the lamps and appliances from supply.
   (b) Now connect the megger terminals between two conductors (phase & neutral).
   (c) Rotate the handle of megger with hand & note down insulation resistance between conductors. This resistance should be less than specified in previous test.
3. **Insulation Test on machine:**
   (a) Keep all the switches and fuse links in position. Keep the main switch in off position.
   (b) Now connect the megger terminals between machine winding and the frame, also between the two windings.
   (c) Rotate the handle of the megger with hand and note down the insulation resistance between windings and frame and between the two windings

Observation Table:

Insulation resistance between earth and Conductor	Insulation resistance between conductors
Insulation resistance between winding and motor frame	Insulation resistance between two winding of motor

EXPERIMENT NO. 10

Electrical Protection Equipments

Experiment No: 10
Electrical Protection Equipments

Aim: To demonstrate different types of electrical protection equipment such as fuses, MCB, MCCB, ELCB.

Theory:

The need for Protection: Electrical power system operates at various voltage levels from a 230V single phase, 415 V to 765 kV three-phase or even more. Electrical apparatus used may be enclosed (e.g., motors) or placed in open (e.g., transmission lines). All such equipment undergoes abnormalities in their lifetime due to various reasons. It is necessary to avoid these abnormal operating regions for the safety of the equipment.

Even more important is the safety of the human person which may be endangered due to exposure to live parts under fault or abnormal operating conditions. A small current of the order of 50 mA is sufficient to be fatal! Whenever human security is sacrificed or there exists the possibility of equipment damage, it is necessary to isolate and de-energize the equipment. Designing electrical equipment from a safety perspective is also a crucial design issue which will not be addressed here. To conclude, every electrical equipment has to be monitored to protect it and provide human safety under abnormal operating conditions. This job is assigned to electrical protection systems. It encompasses apparatus protection and system protection. This is generally carried out by using switchgear and protection.

Switchgear is a generic term which includes all the switching devices associated with power system protection. It also includes all devices associated with control, metering and regulating of electrical power systems. Assembly of such devices in a logical manner forms switchgear. In other words, systems used for switching, controlling and protecting the electrical power circuits and different types of electrical equipment are known as switchgear. The switchgear has to perform the function of carrying, making and breaking the normal load current like a switch and it has to perform the function of clearing the fault in the power system. In addition to that, it also has the provision of metering and regulating the various parameters of electrical power systems. Thus the switchgear includes circuit breakers, current transformers, voltage transformers, protection relays, measuring instruments, electrical switches, electrical fuses, miniature circuit breaker, lightning arresters or surge arresters, electrical isolators and other associated piece of equipment.

Following are the major protective equipment used in household electrical appliances:

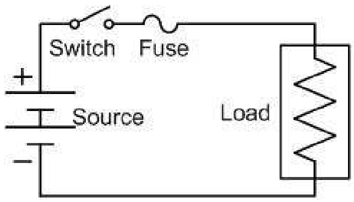
1. Fuse
2. Miniature Circuit Breaker (MCB)
3. Earth Leakage Circuit Breaker (ELCB)
4. Molded Case Circuit Breaker (MCCB)

FUSE:

1. Types of Fuses and Applications In the field of electronics or electrical, a fuse is an essential device used in various electrical circuits which gives the protection from the overcurrent. It comprises a strip or a metal wire that dissolves when the heavy flow of current supplies through it. Once this device has functioned in an open circuit, it ought to rewire or changed based on the type of fuse. A fuse is an automatic disconnection of supply which is frequently shortened to ADS. The alternative of the fuse is a stabilizer or circuit breaker, but they have many different characteristics.

2. Why do we require Fuse?: These are used to prevent the home appliances from the high current or overload damage. If we use a fuse in the homes, the electrical faults cannot happen in the wiring and it doesn't damage the appliances from the fire of wire burning. When the fuse gets break or damage, then an abrupt sparkle happens which may direct to damage your home appliances. That is the reason we require different types of fuses to guard our home-appliances against damage.

3. Working Principle of Fuse The working principle of the fuse is "heating consequence of the current". It is fabricated with a lean strip or thread of metallic wire. The connection of the Fuse in an electrical circuit is always in series. When the too much current is produced due to the heavy flow of current in the electrical circuit, the fuse gets soften and it opens the circuit. The extreme flow of current may direct to the collapse of the wire and prevents the supply.The fuse can be changed by the new fuse with an appropriate rating. It can be designed with the elements like Cu (copper), Zn (zinc), Al (aluminum) and Ag (silver). They also perform like a circuit breaker for breaking the circuit while the abrupt fault happens in the circuit. This works like a safety measure or protector for humans from risks. Like this, the fuse works.



$$\text{Fuse Rating} = \frac{Power(W)}{Voltage(V)} \times 1.25$$

Figure 1: Fuse

The selection of a fuse can be done by calculating the fuse rating by using the above formula.

• Write down the voltage (volts) and power (watts) of the appliance.

• Calculate the fuse rating.

• After the result, use the maximum fuse rating. For instance, if the calculated fuse rating is the maximum fuse rating. For example, if the calculated fuse rating is 7.689 amps, you can use an 8 amp fuse.

4. **Applications of Fuse:** The different types of fuses and their uses have discussed are essential components in all the electrical circuits. Some of the main applications of fuses in the Electrical and Electronics field include the following. • Power Transformers, Electrical Appliances, like ACs (Air Conditioners), TV, Washing Machines, Music Systems, and many more, Electrical Cabling in Home, Mobile Phones, Motor starters, Laptops, Power Chargers, Cameras, Scanners, Printers, and Photocopiers, Automobiles, electronic devices and Gaming's

5. **Advantages of an Electrical Fuse**

   (a) It is the cheapest form of protection, and it does need any maintenance.

   (b) Its operation is completely automatic and requires less time as compared to circuit breakers.

   (c) The smaller sizes of fuse element impose a current limiting effect under short-circuit conditions.

   (d) Its inverse time-current characteristic enables its use for overload protection.

6. **Disadvantages of an Electrical Fuse**

   (a) Considerable time is required in replacing a fuse after the operation.

   (b) The current-time characteristic of a fuse cannot always be correlated with that of the protective device.

7. **Different Types of Fuses:** The fuses are classified into several types based on the application namely AC type fuse and DC type fuse. Again these fuses are classified into several types. The following diagram illustrates the electrical fuse types chart based on the AC fuse and DC fuse.

DC Fuse: DC fuses are available superior in size, and DC supply has a stable value over 0 volts. So it is tough to remove and deactivate the circuit. There will be a chance of generation of an electric Arc between dissolved wires. To conquer this, electrodes located at better distances. For this reason, the size of the DC fuse gets amplified.

AC Fuses: The AC fuse is slighter in size and oscillated 50 to 60 times in each and every sec from least to highest. As a result, there is no scope for Arc generation between the dissolved wires. For this reason, they can be crammed in a small size. Further, AC fuses are classified into two parts namely HV fuses and LV fuses. Here LV & HV indicates the low voltage and high voltage. LV Fuses: The low voltage fuses are divided into five types such as a rewirable, cartridge, drop out, striker and switch fuses.

Rewirable Fuses: Rewirable fuses are LV fuses, which are almost used in small applications like wiring in the house, small-scale industries, and other tiny current applications. These types of fuses include two essential parts such as a fuse base, which has two terminals like in and out. In general, this element is fabricated with Porcelain. Another part of this fuse is a fuse carrier, which grips the fuse element. This element is fabricated with aluminum, tinned copper and lead. The main advantage of a fuse carrier is, we can simply plug and remove from the base of the fuse without the risk of shock. As the fuse is damaged due to heavy current, then we can simply eliminate the Fuse Carrier as well as put back the fuse wire.

Cartridge type Fuses: The cartridge type of fuses has entirely closed containers and the metal contact as well. The applications of this fuse mainly include low voltage (LV), high voltage (HV), and small fuses. Again, these types of fuses are classified into two types, they are D-type and Link-type fuses.

D-type Cartridge Fuse: This type of fuse is composed with the cartridge, base of the fuse, adapter ring, and cap. The base of the fuse includes a fuse cap, which is packed with the fuse ingredient by cartridge using an adapter ring. It is composed of the cartridge, fuse base, cap & adapter ring. The fuse base has the fuse cap, which is fitted with the fuse element with a cartridge through the adapter ring. The connection of the circuit is finished when the tilt of the cartridge builds contact through the conductor.

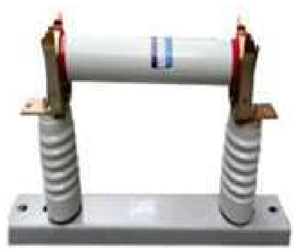
High Rupturing Capacity or Link Type Fuse: The link type fuse is also known as high rupturing capacity (HRC) or BS type fuse. In this sort of fuse, the current flow with fuse element is specified under standard condition.In this BS type fuse, the flow of current by fuse element is given under normal condition. The arc which is generated by the fuse blown is controlled is fabricated with porcelain, ceramic, and silver. The container of the fuse element is packed with silica sand. This type of fuse is again categorized into two parts includes a blade type and bolted type.

Blade and Bolted Type Fuses: The knife type fuse or plug-in type of fuses is designed with plastic. This type of fuse can be simply changeable in the electric circuit exclusive of any load.In bolted type fuse, plates of this fuse are conducting are set to the base of the fuse.

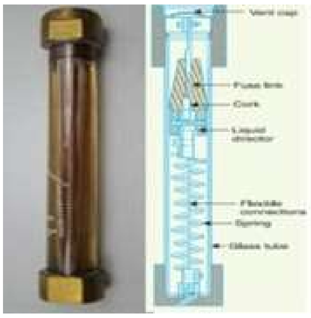
Striker type Fuse: The striker type of fuse is employed for tripping and closing the electrical circuit. These fuses are having plenty of force as well as displacement.

Switch type Fuse: Basically, the switch type fuse is enclosed with a metal switch and also a fuse. These fuses are mainly used in low and intermediate voltage levels.

HV (High Voltage) Fuses: Generally, HV fuses are used to protect the transformers like instrument transformers, small power transformer and also used in power systems. These fuses are normally charged for voltages over 1500V to 138000V. The fuse part in HV fuses are fabricated with either copper, silver or in some cases Tin is used, in order to offer consistent and steady performance. These fuses are classified into three types which include the following.

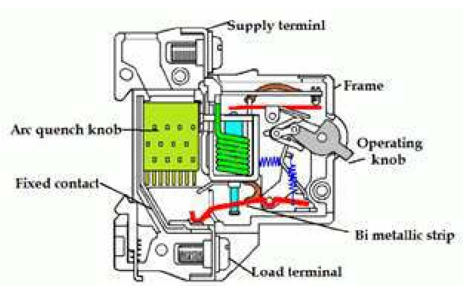


Cartridge Type HRC Fuse: The fuse component of the HRC is cut in the helix form which evades the effect of the corona at the upper voltages. It includes two fused elements namely low resistance and high resistance, and that are located parallel by each other. The low-resistance wires take the usual current which is blown-out as well as decreases the short-circuit current throughout the fault state.



Liquid Type HRC Fuse: This type of fuse is packed with carbon tetrachloride also preserved at both the tops of the caps. Once the error occurs when the flowing current surpasses away from the allowable limit, and the element of the fuse is blown-out. The fluid of the fuse performs as an arc extinguishing standard for the HRC fuse types. They may be used to protect the transformer as well as the support protection to the breaker circuit.

Expulsion Type HV Fuse: These types of fuses are extensively used to protect the feeders as well as transformer due to they're low-priced. It is designed for 11kV; also their cracking capability is up to 250 MVA. This type of fuse includes an unfilled open-finished cylinder designed with synthetic resin-bonded paper. The elements of the fuse are positioned in the cylinder, and the tops of the tubes are linked to appropriate equipment at every finish. The arc generating is blown off in the inside covering of the cylinder, and the gases thus shaped destroys the arc.



Miniature Circuit Breakers (MCB): are electromechanical devices which areused to protect electrical equipment from an overcurrent.MCB is a mechanical switching device which is capable of making, carrying and breaking currents under normal circuit conditions and also making, carrying for a specified time and automatically breaking currents under specified abnormal circuit conditions such as those of short circuit. In short, MCB is a device for overload and short circuit protection. A) Construction: The construction of Miniature Circuit Breakers(MCB) is very simple, robust and maintenance-free. MCB is replaced by a new one when it is failing because MCB is not repaired or maintained.there are three parts of Miniature Circuit Breakers(MCB) in construction-
1) Frame:the frame is a rigid, strong, insulated housing in which the other components are mounted. it is a molded case.

2) Trip Unit: For the proper working of the miniature circuit breaker trip unit is responsible. Two main types of trip mechanism are provided in Miniature Circuit Breakers(MCB). A bimetallic strip provides protection against overload current and an electromagnet provides protection against short-circuit current. trip unit is the main part of the MCB.

3) Operating Mechanism: The operating mechanism of MCB provides with the manual operation for closing and opening operation of the miniature circuit breaker. It has three-positions "ON," "OFF," and "TRIPPED".By observing the positions of the switching latch one can determine the condition of MCB whether it is closed, tripped or manually switched off. If the MCB is tripped due to over-current or overheating, The external switching latch in the "TRIPPED" position. When manually switch off the miniature circuit breaker, the switching latch will be in "OFF" position. the switch is positioned at "ON", In a closed condition of the miniature circuit breaker.

- **Working:**

The principal of operation is simple. functions of Miniature Circuit Breakers(MCB) is interrupting the continuity of electrical flow through the circuit once a fault is detected. In simple terms of MCB is a switch, which automatically turns off when the overcurrent flowing through it.Generally, MCB is designed to protect against overcurrent and over-temperature faults. There are two contacts one is fixed and the other movable. When the current exceeds the predefined limit a solenoid forces the movable contact to open (i.e., disconnect from the fixed contact) and the MCB getting off thereby stopping the current to flow in the circuit.The MCB is manually turned on to restart the flow of current. This mechanism is used to protect from the faults arising due to over current.To protect against fault arising due to overheating or increase in temperature a bi-metallic strip is used. MCBs are generally designed to trip within 2.5 milliseconds when an overcurrent fault arises. In case of temperature rise or overheating it may take 2 seconds to 2 minutes for the MCB to trip. If the circuit is overloaded for a long time, the bimetallic strip becomes overheated and deformed. This deformation of bimetallic strip causes, displacement of latch point.The moving contact of the MCB is so arranged by means of spring pressure, with this latch point, that a little displacement of latch causes, release of spring and makes the moving contact to move for opening the MCB. The current coil or trip coil is placed such a manner, that during short circuit fault the MMF of that coil causes its plunger to hit the same latch point and make the latch to be displaced. Hence the MCB will open in the same manner. And it protects the circuit from the overcurrent or overloading.

- **Advantages :**

1. With a miniature circuit breaker, it is very simple to resume to the supply. You just need to push the knob of MCB back to on position. But in case of fuse, the entire fuse wire needs to be replaced.
2. A miniature circuit breaker is more sensitive to current than a fuse. It detects any abnormality in the current flow and automatically switches off the electrical circuit.
3. A miniature circuit breaker is reusable and hence has less maintenance and replacement cost. Whereas a fuse needs to be replaced whenever it goes faulty.
4. In the case of a miniature circuit breaker, the faulty zone of an electrical circuit can be easily identified.

- **Types of MCB** There are three standard characteristics are available for domestic as well as commercial MCBs and are given by B, C and D. Each type has its own function.

Type B MCBs: are mainly used where switching surges are small or non-exist and are generally suitable for domestic applications and light commercial applications. There are no devices with long high starting current in domestic applications and hence the best suited MCB is type B. These are designed to trip at fault currents in the range of 3 to 5 times the rated current. Suppose if the rated current is 10 A, then the MCB trips at 30-50 A.

Figure 1: Type B

Figure 2: Type C

Figure 3: Type D

Type C MCBs: are designed for high inductive circuits where surge currents are expected. These are generally used for commercial and industrial applications where a number of fluorescent lamps being turned ON or starting of small motors may give high surge currents. These are less sensitive than type B MCBs and causes reduced nuisance trips. Type C MCBs are designed to operate or trip at the fault currents of 5-10 times that of rated current. For 10 A type C MCB, the operating current range is 50-100 A.

Type D MCBs: are designed for heavy industrial applications where normal surge currents are very high. These are ideal for electric welders and site transformers where frequent high surge currents are expected. The most common applications of type D MCBs include motors, UPS systems, X-ray machines, transformers and battery charging systems. These are designed to trip at 10-20 times the rated current. For 10 A type D MCB, the operating current range is 100-200 A.

The settings or characteristics of an MCB are fixed in the factory itself by the manufacturer and they are not adjustable at the user end or at the site. Tripping currents for operation at 0.1 Sec or less of different MCBs are given below.

Type B	3-5 Times Rated Current
Type C	5-10 Times Rated Current
Type D	10-20 Times Rated Current

Earth Leakage Circuit Breaker (ELCB): An ECLB is one kind of safety device used for installing an electrical device with high earth impedance to avoid shock. These devices identify small stray voltages of the electrical device on the metal enclosures and intrude the circuit if a dangerous voltage is identified. The main purpose of Earth leakage circuit breaker (ECLB) is to stop damage to humans & animals due to electric shock.Earth Leakage Circuit Breaker (ELCB) is a device used to directly detect currents leaking to earth from an installation and cut the power and mainly used in TT earthing systems. There are two types of ELCBs:

1. Voltage Earth Leakage Circuit Breaker (voltage-ELCB)
2. Current Earth Leakage Current Earth Leakage Circuit Breaker (Current-ELCB).

Voltage-ELCBs have first introduced about sixty years ago and CurrentELCB was first introduced about forty years ago. For many years, the voltage-operated ELCB and the differential current operated ELCB wereboth referred to as ELCBs because it was a simpler name to remember.But the use of a common name for two different devices gave rise to considerable confusion in the electrical industry.If the wrong type was used on an installation, the level of protectiongiven could be substantially less than that intended.To ignore this confusion, IEC decided to apply the term Residual CurrentDevice (RCD) to differential current operated ELCBs. Residualcurrent refers to any current over and above the load current.

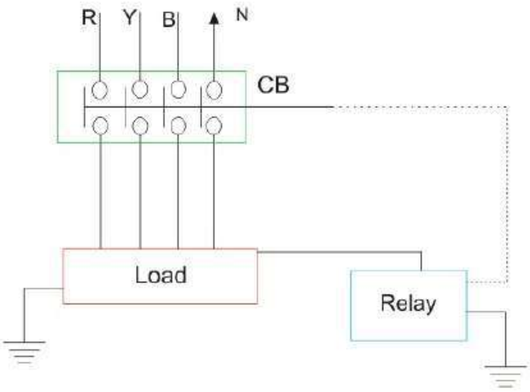


Figure 4: ELCB

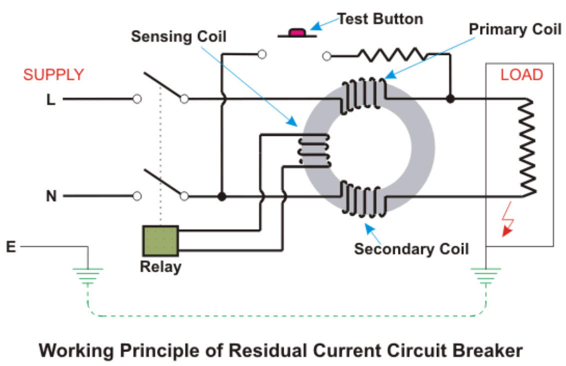


Figure 5: ELCB Internal Structure

Working Principle of Voltage ELCB: Voltage ELCB is a voltage operated device. It has a coil and if the voltage across the coil exceeds a predetermined value such as 50 V, the current through the coil will be sufficient enough to trip the circuit.Voltage ELCB is connected in between the metallic part of equipment and the Earth. If we take an example of insulation failure, then the voltage across the coil of Voltage ELCB will drive enough current to cut the power supply till the manually reset.The way to identify an ELCB is by looking for green or green and yellow earth wires entering the device. They rely on voltage returning to the trip via the earth wire during a fault and afford only limited protection to the installation and no personal protection at all. You should use plugin 30mA RCD's for any appliances and extension leads that may be used outside as a minimum. Advantages of Voltage Operated ELCB

• ELCBs are less sensitive to fault conditions and have few nuisance trips.

• While current and voltage on the ground line generally fault current from a live wire, this is not continuously the case, therefore there are conditions in which an ELCB can annoyance trip.

• When installation of the electrical instrument has two contacts to earth, a near high current lightning attack will root a voltage gradient in the earth, offering the ELCB sense coil with sufficient voltage to source it to a trip.

• If either of the soil wires become detached from the ELCB, it will no longer install will frequently no longer be correctly earthed.

• These ELCBs are the necessity for a second connection and the opportunity that any extra connection to ground on the threatened system can inactivate the detector.

Disadvantages of Voltage Operated ELCB:

• They do not sense errors that don't permit current through the CPC to the ground rod.

• They do not permit an only building system to be simply divided into many sections with independent error protection because earthing systems are typically used mutual earth, Rod.

• They may be skipped by outside voltages from something associated with the earthing system like as metal pipes, a TN-C-S or a TN-S earth mutual neutral and earth.

• As electrical leaky utilizations like washing machines, some water heaters and cookers might source the ELCB to trip.

• ELCBs present an extra resistance & an extra point of failure in the earthing system.

Working Principle of Current ELCB:

The working of Current ELCB is quite interesting but easy. Current operated ELCB is also known as Residual Current Device, RCD. A Residual Current Device (RCD) has a toroidal iron core over which phase and neutral windings are wound. A search coil is also wound on the same iron core which in turn is connected to the trip coil. Figure below shows the constructional detail of RCD or Current ELCB.Under normal operating condition, the current through the phase winding and neutral winding are same but both the windings are wound in such a manner to oppose the mmfs of each other, therefore net mmf in the toroidal iron core will be zero.Let us consider a condition where earth leakage current exists in the load side. In this case the current through the phase and neutral will no longer be equal rather phase current will be more than the neutral current.Thus mmf produced by phase winding will be more than the mmf produced by neutral winding because of which a net mmf will exist in the toroidal iron core.

$$\text{Net mmf in Core} = \text{mmf by phase winding} - \text{mmf by neutral winding}$$

This net mmf in the core will link with the Search Coil and as the mmf is changing in nature (current is AC), an emf will be induced across the terminals of the Search Coil. This emf will in turn drive a current through the Trip Coil which will pull (because of current flow through the Trip Coil, it will behave as an electromagnet and hence will pull the lever to open contact) the supply contacts to isolate the power supply. Notice that Current ELCB works on Residual Current that is the reason it is also called Residual Current Device.A RCD / Current ELCB is also provided with test button to check the healthiness of the safety device. If you carefully observe the figure, you will notice that, when we press the Test Button, Load and phase winding are bypassed due to which only mmf because of neutral winding will exist in the core (as there is no opposing mmf as was the case with both the windings in service) which will cause RCD to trip to isolate the supply.

Molded Case Circuit Breaker:

Moulded Case Circuit Breakers are electromechanical devices which protect a circuit from Overcurrent and Short Circuit. They provide Overcurrent and Short Circuit Protection for circuits ranging from 63 Amps up to 3000 Amps.Their primary functions are to provide a means to manually open a circuit and automatically open a circuit under overload or short circuit conditions. The overcurrent, in an electrical circuit, may result from short circuit, overload or faulty design.

Unlike fuse, anMCCB can be easily reset after a fault and offers improved operational safety and convenience without incurring operating cost. Moulded case circuit breakers generally have a Thermal element for overcurrent and Magnetic element for short circuit release which has to operate faster. MCCBs are manufactured such that end user will not have access to internal workings of the over-current protection device. Generally constructed of two pieces of heavy-duty electrically insulated plastic, these two halves are riveted together to form the whole. Inside the plastic shell is a series of thermal elements and a Spring-loaded trigger. When the thermal element gets too warm, from an overcurrent situation, the spring trips, which in turn will shut off the electrical circuit.

Sizing the MCCB: MCCBs in an electrical circuit should be sized according to the circuit's expected operating current and possible fault currents.

Types of MCCB:

Type of MCCB	Operating Current	Operating Time	Application	Suitability	Surge Current	Installation Location
Type B	Trips between 3 and 5 times rated current (In)	0.04-13 seconds	Domestic applications (lighting and resistive elements)	Resistive load application	Low	Sub feeder of Distribution board
Type C	Trips between 5 and 10 times rated current (In)	0.04-5 seconds	Commercial or industrial applications	Inductive load applications	Moderate	At incoming/outgoing of Distribution Board
Type D	Trips between 10 and 20 times rated current (In)	0.04-3 seconds	Commercial or industrial applications	Inductive capacitive load applications (Pumps, motor, large winding motors etc.)	High	At incoming of Distribution Board/Panels
Type K	Trips between8 and 12 times rated current (In)	0.04-5 seconds	Industrial applications	Inductive and motor loads with high inrush currents.	High	At incoming of Distribution Board/Panels
Type Z	Trips between 2 and 3 times rated current (In)	0.04-5 seconds	Highly sensitive to short circuit and are used for protection of highly sensitive devices such as semiconductor devices	Medical instruments	Very low	At sub feeder of Distribution board for IT equipment.

Conclusion: