BEE Viva

D.C. Circuits :-

Q1. Differentiate between active and passive elements.

Ans.

- The element which supply energy to the network are called active elements.
- The active elements may be constant voltage source or constant current source.
- The elements which receive energy from the network are called passive elements.
- The passive elements may be resistor, inductor or capacitor.

Q2. State two types of Active elements.

Ans. The two types of active elements are : 1.Voltage controlled and
2. Current controlled sources

Q3. State 3 types of DC Circuits.

Ans. Three types of DC Circuits are :-

1. Series DC Circuit:
    - The circuit in which DC Series Source and the number of resistors are connected end to end so that the same current flows through them is called a DC Series Circuit.

2. Parallel DC Circuit:
    - The circuit which has DC Source and one end of all the resistors joined to a common junction and the other end are also joined to another common junction so that current flows through them is called a DC Parallel Circuit.

3. DC Series-Parallel Circuit:
    - The circuit in which series and parallel circuit are connected in series is called a series parallel circuit.

Q4. Define R,L,C,X_L & X_C along with their units:

Ans. Resistance(R) is the property of a material due to which it opposes the flow of electric current through it.

SI unit of Resistance is ohm and is represented by the symbol Ω.

Inductance(L) is the tendency of an electrical conductor to oppose a change in the electric current flowing through it. The flow of electric current creates a magnetic field around the conductor.

SI unit of Inductance is henry and is represented by H.

Capacitance is the ratio of the amount of electric charge stored on a conductor to a difference in electric potential.

SI unit of capacitance in farad and is represented by F.

X_c is the capacitive reactance and its unit is ohm.

Formula = $1/\omega C$

X_L is the inductive reactance and its unit is ohm.

Formula = ωL

Q5. State the Ohm's Law for D.C. Circuits.

Ans. Current flowing through the conductor is directly proportional to the potential difference applied to the conductor, provided that there is no change in temperature.

Equation :- $V=IR$

Where V is voltage,

I is current flowing through the conductor,

R is the resistance of conductor

Q6. State the Ohm's Law for A.C. Circuits.

Ans. The rules and equations for DC circuits apply to AC circuits only when the circuits contain resistance alone, as in the case of lamps and heating elements. In order to use effective values of voltage and current in AC circuits, the effect of inductance and capacitance with resistance must be considered.

The combined effects of resistance, inductive reactance and capacitive reactance make up the total opposition to current flow in an AC circuit. The total opposition is called impedance and is represented by the letter Z. The unit for measurement of impedance is the ohm.

Q7. State KCL & KVL for D.C. Circuits.

Ans. Kirchhoff's Current Law (KCL): The algebraic sum of currents meeting at a junction or node in an electric circuit is zero.

OR

The sum of currents flowing towards any junction in an electric circuit is equal to the sum of currents flowing away from the junction.

Kirchhoff's Voltage Law (KVL): The algebraic sum of all the voltages in any closed circuit or mesh or loop is zero.

OR

The sum of EMFs and the sum of voltage drops or rises in a closed loop circuit is zero.

Q8. State the difference between Mesh & Nodal Analysis.

Ans. Mesh analysis is basically writing mesh equation with the help of KVL in terms of unknown mesh currents. Mesh is an elementary form of a loop.

Nodal analysis is based of Kirchhoff's current law which states that the algebraic sum of currents meeting at a point is zero. Every junction where two or more branches meet is regarded as a node. One of the nodes in the network is taken as *reference node* or *datum node*. If there are *n* nodes in any network, the number of simultaneous equations to be solved will be (n-1).

Q9. What are limitations/disadvantages of Mesh Analysis?

Ans. 1. We can use this method only when the circuit is planar, otherwise the method is not useful.

2. If the network is large then the number of meshes will be large, hence, the total number of equations will be more so it will become inconvenient to use in such cases.

Q10. What do you mean by linear elements? State their 3 types.

Ans. These are elements in which the constituent relation, the relation between voltage and current, is a linear function. They obey the superposition principle. Examples of linear elements are resistances, capacitances, inductances, and linear dependent sources.

Q11.State & explain the Superposition, Thevinin’s, M.P.T.T & Norton’s Theorems.

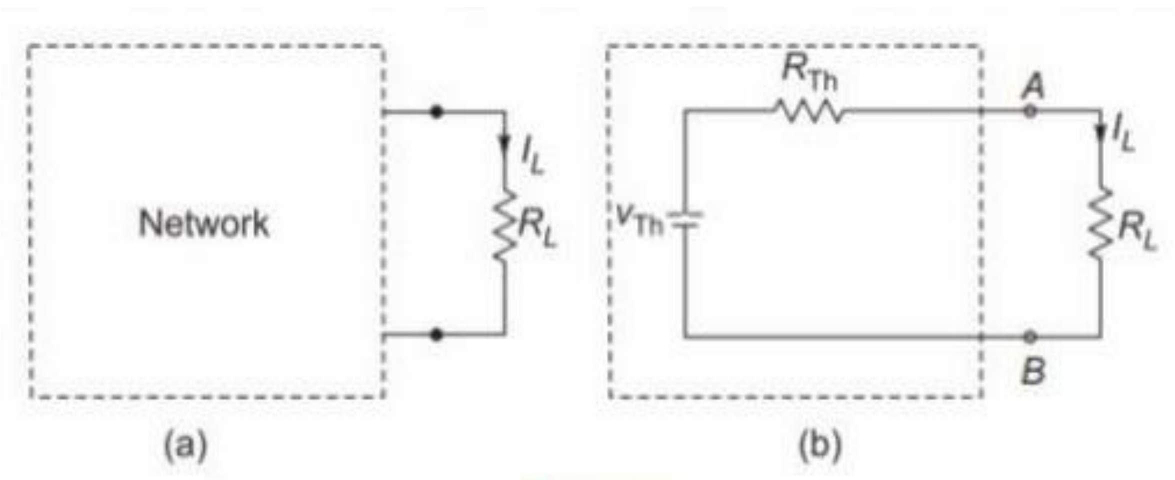
Ans. <u>Superposition Theorem</u>: It states that ‘*in a linear network containing more than one independent source, the resultant current in any element is the algebraic sum of the currents that would be produced by each independent source acting alone, all the other independent sources being represented meanwhile by their respective internal resistances.*’

The independent voltage sources are represented by their internal resistances if given or simply with zero resistances, i.e., short circuits if internal resistances are not mentioned.

The independent current sources are represented by infinite resistances, i.e., open circuits.

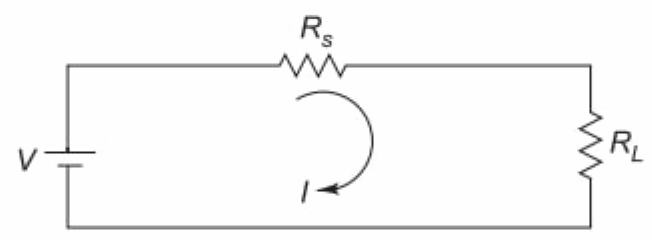
A linear network is one whose parameters are constant, i.e., they do not change with voltage and current.

Thevinin’s Theorem: It states that ‘*any two terminals of a network can be replaced by an equivalent voltage source and an equivalent series resistance. The voltage source is the voltage across the two terminals with load, if any, removed. The series resistance is the resistance of the network measured between two terminals with load removed and constant voltage source being replaced by its internal resistance (zero resistance if not mentioned, i.e., short circuit) and constant current source replaced by infinite resistance, i.e., open circuit.*’

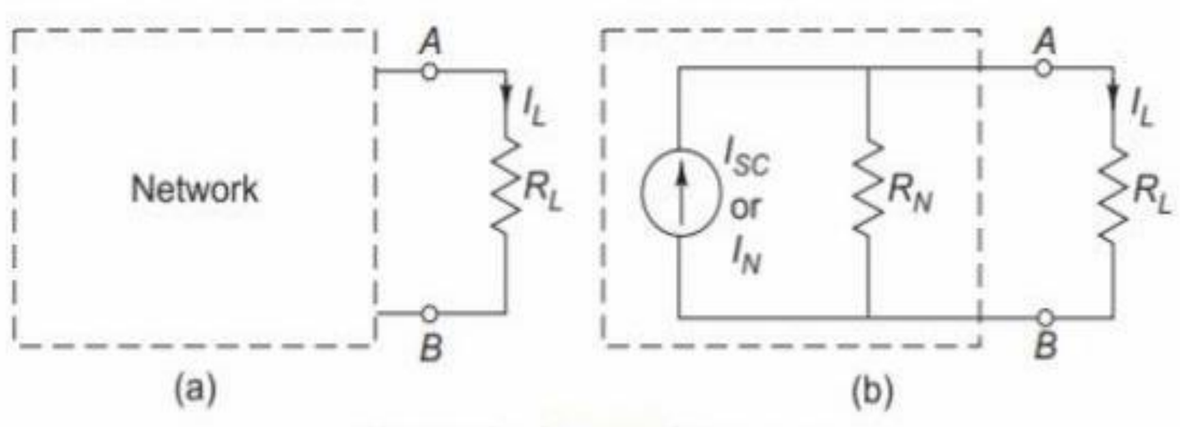


Maximum Power Transfer Theorem: It states that '*the maximum power is delivered from a source to a load when the load resistance is equal to the source resistance*.'

$$I = \frac{V}{R_S + R_L}$$



Norton's Theorem: It states that '*any two terminals of a network can be replaced by an equivalent current source and an equivalent parallel resistance. The constant current is equal to the current which would flow in a short circuit paced across the terminals. The parallel resistance is the resistance of the network when viewed from these open-circuited terminals after all voltage and current sources have been removed and replaced by internal resistances*.'



Q12.What is the application of M.P.T.T? (Public Address System)

Why is it not used for electrical machines like transformer?

Ans. MPTT is applied in Radio communications, where the power amplifier transmits the maximum amount of signal to the antenna if and only if load impedance in the circuit is equal to the source impedance.

It is also applied in audio systems, where the voice is to be transmitted to the speaker. The amplifier amplifies the maximum amount of voice when the load impedance is equal to the source impedance.

Since a transformer is not a source of energy or power, it is a passive device which transforms power between two systems at differing voltage level to allow for more effective transmission and distribution; MPTT is not used in it.

Q13. Give/Write the proof of M.P.T.T.

Ans. Proof of M.P.T.T.:

To determine the value of R_L for maximum power to be transferred to the load,

$$\frac{dP}{dR_L} = 0$$

$$\frac{dP}{dR_L} = \frac{d}{dR_L} \frac{V^2}{(R_S + R_L)^2} R_L$$

$$= \frac{V^2[(R_S + R_L)^2 - (2R_L)(R_S + R_L)]}{(R_S + R_L)^4}$$

$$(R_S + R_L)^2 - 2\,R_L\,(R_S + R_L) = 0$$

$$R_S^2 + R_L^2 + 2R_S\,R_L - 2R_L\,R_S - 2R_L^2 = 0$$

$$R_L = R_S$$

Hence, the maximum power will be transferred to the load when load resistance is equal to the source resistance.

Q14. State the 2 types of electrical faults.

Ans. 1. Short Circuit: When two terminals of a circuit are connected by a wire, they are said to be short circuited. A short circuit has following features:

- Zero resistance.
- Current through it is very large.
- No voltage across it.

2. Open Circuit: When two terminals of a circuit have no direct connection between them, they are said to be open circuited. An open circuit has the following features:

- Infinite resistance.
- Zero current.
- Entire voltage appears across it.

Q15. Why X_L & X_C are not considered in D.C. Circuits?

Ans. Formula for $X_L = \omega L$

$= 2\pi fL$

And since, for D.C. Circuit, $f = 0$

Therefore, $X_L = 0$

Formula for $X_C = 1/\omega C$

$= 1/2\pi fC$

And since, for D.C. Circuit, $f = 0$

Therefore, X_C = Infinite

Therefore, X_L & X_C are not considered for D.C. Circuits.

<u>A.C. Circuits: -</u>

Q1. Prove that pure L & C do not consume any power.

Ans. If Current and Voltage are 90 degrees out of phase, then the power will be zero since power in single phase AC Circuits is given by:

$$P= V\ I \cos \theta$$

Where;
P = Power in Watts
V = Voltage in Volts
I = Current in Amperes
Cos θ = Power factor of the circuit i.e. phase difference between current and voltage waves.

We know that in pure capacitive circuit, current is leading by 90 degrees from voltage and in pure inductive circuit, current is lagging by 90 degrees from voltage.

Therefore, if angle between current and Voltage are 90° ($\theta = 90$),
then Power = P = V I Cos (90°) = 0 → [Cos (90°) = 0]

Q2. Define Average & RMS values, Form & Peak Factors.

Ans. Average value of an alternating quantity is defined as the arithmetic mean of all the values over one complete cycle.

RMS or effective value of alternating current is defined as that value of steady current (direct current) which will do the same amount of work in the same time or would produce the same heating effect as when the alternating current is applied for the same time.

Form Factor is defined as the ratio of RMS value to the average value of the given quantity.

$$\text{Form factor}(k_f) = \frac{\text{RMS Value}}{\text{Average value}}$$

Peak factor is the ratio of peak value to the RMS value of a given quantity.

$$\text{Peak factor}(k_p) = \frac{\text{Peak Value}}{\text{RMS Value}}$$

Q3. Define cycle, frequency & time period.

Ans. Cycle: One complete set of positive and negative values of an alternating current is termed a cycle.

Frequency: The number of cycles per second of an alternating quantity is known as its frequency. It is denoted by f and measured in hertz(Hz) or cycles per second (c/s).

Time period: The time taken by an alternating quantity to complete one cycle is called its time period. It is denoted by T and is measured in seconds.

$$T = 1/f$$

Q4. For an A.C., prove that RMS Value > A.V. Value.

Ans.

For RMS value of sinusoidal A.C.

$$v = V_m \sin\theta \qquad 0 < \theta < 2\pi$$

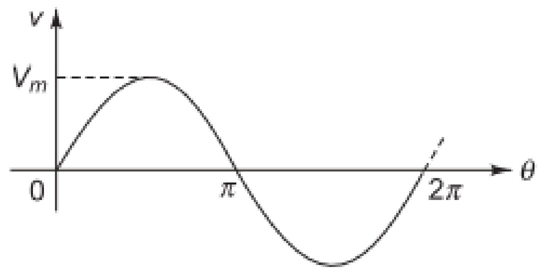


Fig. 3.6 Sinusoidal waveform

$$V_{\text{rms}} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} v^2(\theta)\,d\theta}$$

$$= \sqrt{\frac{1}{2\pi}\int_0^{2\pi} V_m^2 \sin^2\theta\,d\theta}$$

$$= \sqrt{\frac{V_m^2}{2\pi}\int_0^{2\pi} \sin^2\theta\,d\theta}$$

$$= \sqrt{\frac{V_m^2}{2\pi}\int_0^{2\pi}\left(\frac{1-\cos 2\theta}{2}\right)d\theta}$$

$$= \sqrt{\frac{V_m^2}{2\pi}\left[\frac{\theta}{2}-\frac{\sin 2\theta}{4}\right]_0^{2\pi}}$$

$$= \sqrt{\frac{V_m^2}{2\pi}\left[\frac{2\pi}{2}-0-0+0\right]}$$

$$= \sqrt{\frac{V_m^2}{2}}$$

$$= \frac{V_m}{\sqrt{2}}$$

$= 0.707V_m$

For average value of Sinusoidal A.C.

$$v - V_m \sin\theta \qquad 0 < \theta < 2\pi$$

Since this is a symmetrical waveform, the average value is calculated over half the cycle.

$$\begin{aligned}
V_{\text{avg}} &= \frac{1}{\pi}\int_0^{\pi} v(\theta)\,d\theta \\
&= \frac{1}{\pi}\int_0^{\pi} V_m \sin\theta\; d\theta \\
&= \frac{V_m}{\pi}\int_0^{\pi} \sin\theta\; d\theta \\
&= \frac{V_m}{\pi}[-\cos\theta]_0^{\pi} \\
&= \frac{V_m}{\pi}[1+1] \\
&= \frac{2V_m}{\pi} \\
&= 0.637\ V_m
\end{aligned}$$

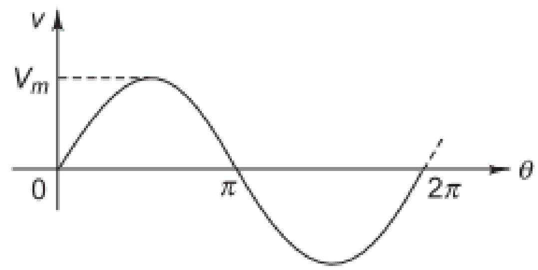


Fig. 3.7 *Sinusoidal waveform*

$\therefore$ For an A.C., RMS Value > A.V. Value.

Q5. For an A.C., prove that Peak Factor > Form Factor.

Ans. For an A.C.

Peak factor (k_p) = Maximum value/ RMS value

$= V_m / 0.707V_m$

$= 1.414$

Form factor (k_f) = RMS value/ Average value

$= 0.707V_m / 0.637V_m$

$= 1.109$

∴ For an A.C., Peak Factor > Form Factor.

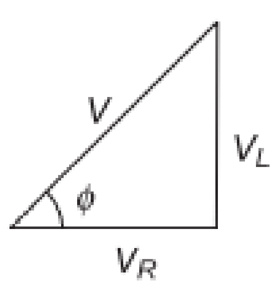
Q6. Draw labelled V-Δ, Z-Δ & P-Δ for R-L, R-C, R-L-C (with $X_L > X_C$)

Ans. Voltage Triangles:

1. R-L circuit:

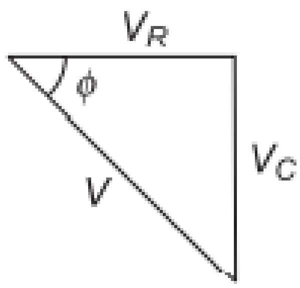
$\overline{V_T} = \sqrt{(V_R^2+V_L^2)} \quad \angle \tan^{-1}(V_L/V_R)$

$= V_R + jV_L$



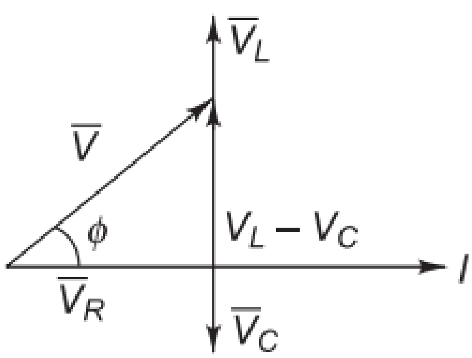
2. R-C circuit:

$$\overline{V_T} = \sqrt{(V_R^2+V_C^2)} \quad \angle\tan^{-1}(V_C/V_R)$$
$$= V_R - jV_C$$

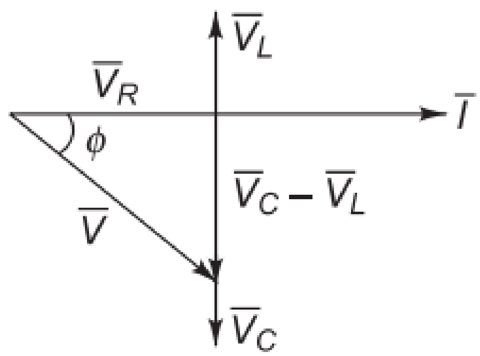


3. R-L-C circuit:

$$\overline{V_T} = \sqrt{(V_R^2+(V_L-V_C)^2)} \quad \angle\tan^{-1}[(V_L-V_C)/V_R]$$
$$= V_R + j(V_L-V_C)$$



$V_L > V_C$

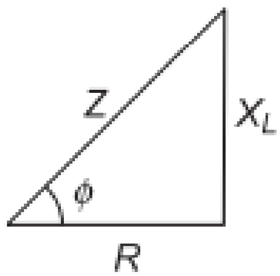


$V_C > V_L$

Impedance Triangles:

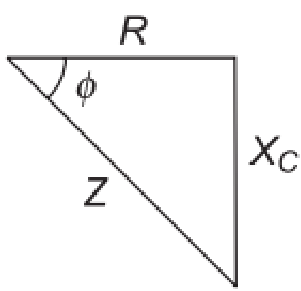
1. R-L circuit:

$\overline{Z} = Z\angle\Phi$
$= \sqrt{}(R^2 + X_L^2)\ \angle\tan^{-1}(X_L/R)$
$= R + jX_L$



2. R-C circuit:

$\overline{Z} = Z\angle\Phi$
$= \sqrt{}(R^2 + X_C^2)\ \angle\tan^{-1}(X_C/R)$
$= R - jX_C$

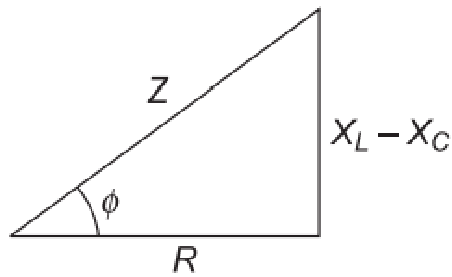


3. R-L-C circuit:

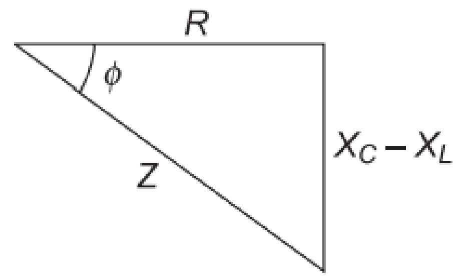
$\overline{Z} = Z\angle\Phi$

$= \sqrt{(R^2 + (X_L - X_C)^2)}\ \angle\tan^{-1}[(X_L - X_C)/R]$

$= R + j(X_L - X_C)$



$X_L > X_C$



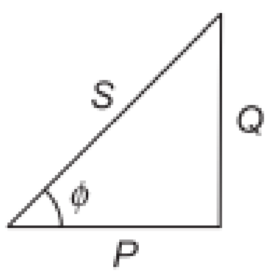
$X_C > X_L$

Power Triangles:

1. R-L circuit:

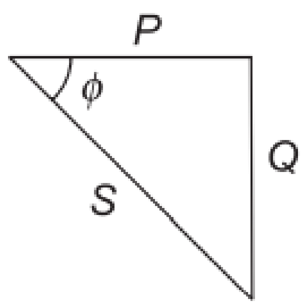
$\overline{S} = \sqrt{(P^2 + Q^2)}\ \angle\tan^{-1}(Q/P)$

$= P + jQ$



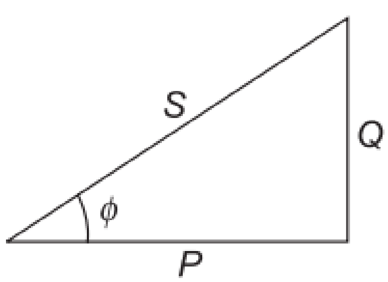
2. R-C circuit:

$$\overline{S} = \sqrt{(P^2 + Q^2)}\ \angle -\tan^{-1}(Q/P)$$
$$= P - jQ$$

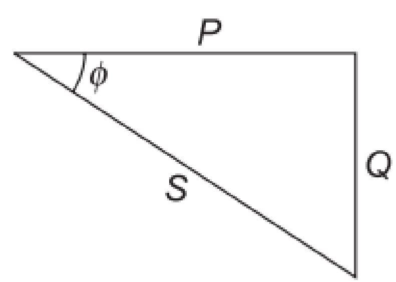


3. R-L-C circuit:

$$\overline{S} = \sqrt{(P^2 + Q^2)}\ \angle \tan^{-1}(Q/P)$$
$$= P \pm jQ$$



$X_L > X_C$



$X_C > X_L$

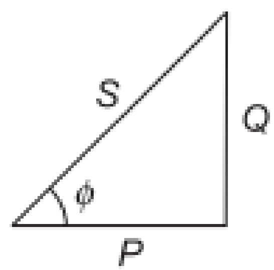
Q7. ______________

Q8. Draw a neat labelled P-Δ for R-L/R-C circuit. Mark on its sides the names, expressions & practical units of the respective powers.

Ans. Power Triangles:

R-L circuit:

$\overline{S} = \sqrt{(P^2 + Q^2)}\ \angle\tan^{-1}(Q/P)$
$= P + jQ$



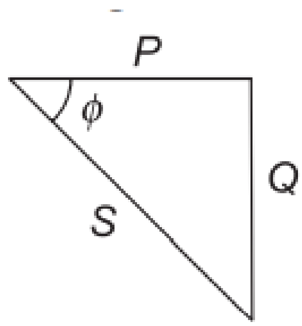
$S = I^2Z = VI$ (Apparent power)

$Q = I^2X_L = VI \sin \Phi$ (Reactive/Quadrature power)

$P = I^2R = VI \cos \Phi$ (Active/Consumed/Absorbed power)

R-C circuit:

$\overline{S} = \sqrt{(P^2 + Q^2)}\ \angle-\tan^{-1}(Q/P)$
$= P - jQ$



$S = I^2Z = VI$ (Apparent power)

$Q = I^2X_C = VI \sin \Phi$ (Reactive/Quadrature power)

$P = I^2R = VI \cos \Phi$ (Active/Consumed/Absorbed power)

Q9. Define Y, G & B along with their mathematical expressions.

Ans. (Y) represents the admittance of the circuit and is defined as the reciprocal of Impedance.

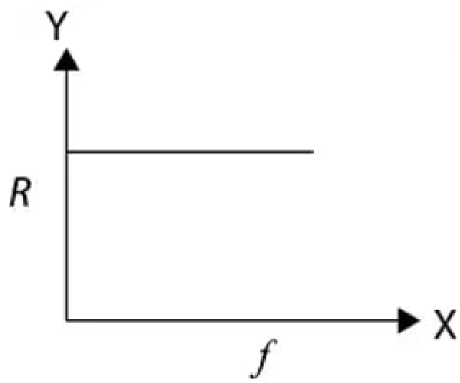
The real part of admittance is called conductance (G), and the imaginary part of admittance is called susceptance (B), and these are measured in mhos (℧) or siemens (S).

$$\frac{1}{\overline{Z}} = \frac{1}{\overline{Z}_1} + \frac{1}{\overline{Z}_2}$$

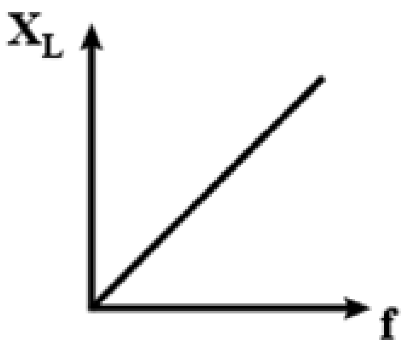
$$\overline{Y} = \overline{Y}_1 + \overline{Y}_2$$

Q10. Sketch the graphs of R v/s *f*, X_L v/s *f*, X_C v/s *f*, Z v/s *f*, I v/s *f*.

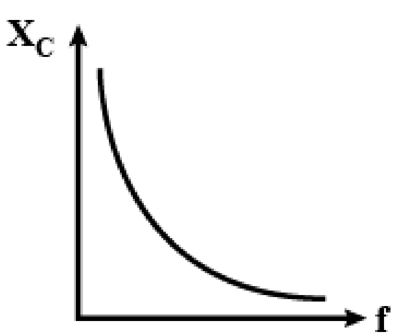
Ans. R v/s *f*



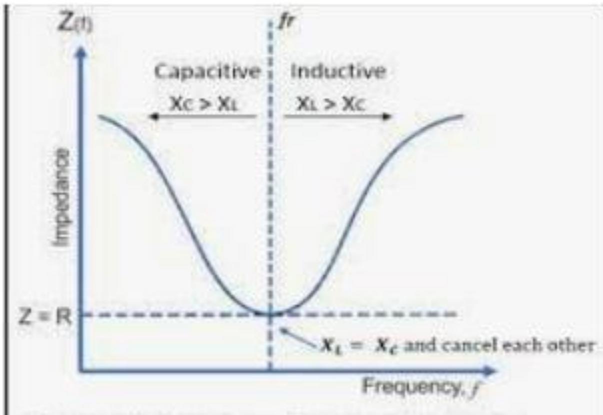
X_L v/s *f*



X_C v/s *f*

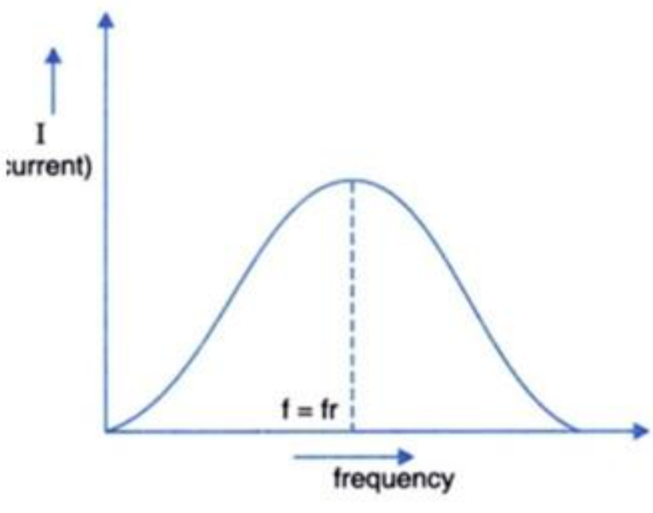


Z v/s *f*



Series Resonance – Impedance vs. Frequency.

I v/s *f*



Q11. Compare between Series & Parallel resonance.

Ans.

Parameter	Series Circuit	Parallel Circuit
Current at resonance	I=V/R and is maximum	I=VCR/L and is minimum
Impedance at resonance	Z=R and is minimum	Z=L/CR and is maximum
Power factor at resonance	Unity	Unity
Resonant frequency	$f_0 = \frac{1}{2\pi\sqrt{LC}}$	$f_0 = \frac{1}{2\pi}\sqrt{\left(\frac{1}{LC} - \frac{R^2}{L^2}\right)}$
Quality Factor	$Q = \frac{2\pi f_0 L}{R}$	$Q = \frac{2\pi f_0 L}{R}$
Magnification	Voltage across L and C	Current through L and C

Q12. Define dynamic impedance parallel resonance circuit.

Ans. At resonance, the circuit is purely resistive. The real part of admittance is $[R/(R^2+ X_L^2)]$. Hence, the dynamic impedance at resonance is given by

$$Z_D = \frac{R^2 + X_L^2}{R}$$

At resonance,

$$R^2 + X_L^2 = X_L X_C = L/C$$

$$Z_D = L/CR$$

Q13. Define Q-factor & Bandwidth. State their expressions.

Ans. Bandwidth of a resonant circuit is defined as the range of frequencies for which the power delivered to R is greater than or equal to $P_0/2$ where, P_0 is the power delivered to R at resonance.

From the shape of resonance curve, it is clear that there are two frequencies for which the power delivered to R is half the power at resonance. For this reason, these frequencies are referred as those corresponding to the half-power points. The magnitude of the current at each half-power point is the same.

Hence, $$I_1^2R = \frac{I_0^2R}{2} = I_2^2R$$

Therefore, $$I_1 = I_2 = \frac{I_0}{\sqrt{2}} = 0.707I_0$$

Quality Factor is the measure of current magnification in a parallel resonant circuit.

$$Q_O = \frac{\text{Current through inductor or capacitor}}{\text{Current at resonance}} = \frac{I_{C0}}{I_0}$$

Three Phase Circuits: -

Q1. Advantages of 3-Φ circuits.

Ans.

1. In a single-phase system, the instantaneous power is fluctuating in nature. However, in a three-phase system, it is constant at all times.

2. The output of a three-phase system is greater than that of a single-phase system.

3. Transmission and distribution of a three-phase system is cheaper than that of a single-phase system.

4. Three-phase motors are more efficient and have higher power factors than single-phase motors of the same frequency.

5. Three-phase motors are self-starting whereas single-phase motors are not self-starting.

6. Reduced number of wires in the circuit.

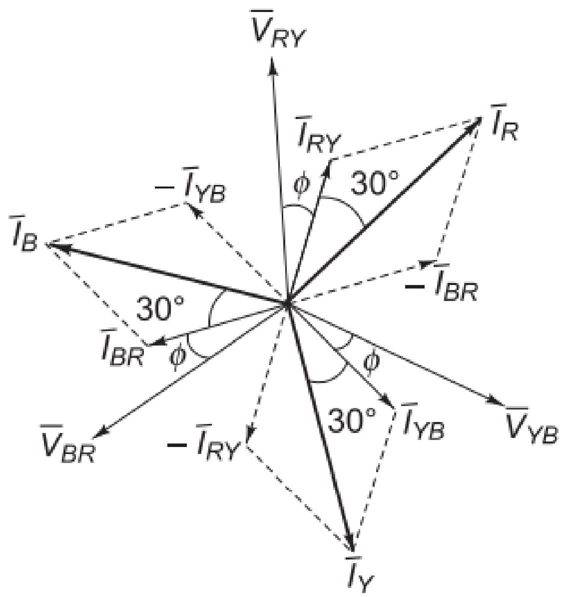
Q2. Compare between 3-Φ Y & Δ connections.

Ans.

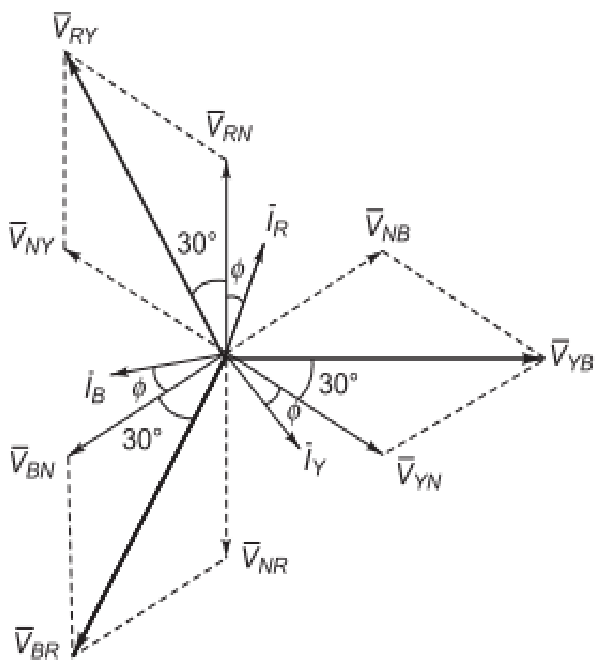
Star Connection	***Delta Connection***
1. $V_L = \sqrt{3}\ V_{ph}$	1. $V_L = V_{ph}$
2. $I_L = I_{ph}$	2. $I_L = \sqrt{3}\ I_{ph}$
3. Line voltage leads the respective phase voltage by 30°.	3. Line current lags behind the respective phase current by 30°.
4. Power in star connection is one-third of power in delta connection.	4. Power in delta connection is 3 times of the power in star connection.
5. Three-phase, three-wire and three-phase, four-wire systems are possible.	5. Only three-phase, three-wire system is possible.
6. The phasor sum of all the phase currents is zero.	6. The phasor sum of all the phase voltages is zero.

Q3. Draw typical phasor diagrams for Y & Δ connections.

Ans. Phasor diagram for Delta Connection:



Phasor diagram for Star Connection:



Q4. State uses/applications of Y & Δ connections.

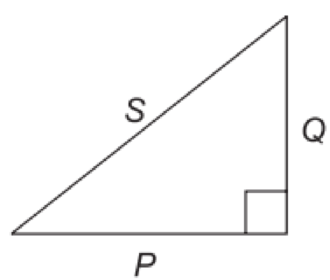
Ans.

Usually, Star connection is used in both transmission and distribution networks (with either single phase supply or three phase supply)	Delta connection is generally used in distribution networks.
Since insulation required is less, Star Connection can be used for long distances.	Delta connection are used for shorter distances.
Star Connections are often used in application which require less starting current.	Delta connections are often used in applications which require high starting torque.

Q5. Draw a labelled total power Δ for 3-Φ system.

Ans. Since, Total reactive power $Q = 3V_{ph}I_{ph}\sin\Phi$

$$= \sqrt{3}V_L I_L \sin\Phi$$



Total apparent power $S = 3V_{ph}I_{ph} = \sqrt{3}V_L I_L$

Q6. Advantages of 2 watt-meter method.

OR

How can we measure power in 3-Φ circuit with 2 watt-meters?

Ans. Merits of 2 watt-meter method:

- It can be used for balanced as well as unbalanced loads.
- The two wattmeter can be simply connected between the two lines externally without disturbing the 3-Φ system.
- It does not require the neutral wire. Therefore, it can be used for star or delta connected system.
- Apart from providing the total true power consumed = (W_1+W_2), it also furnishes additional information in case of a balanced system:
  - The p.f. can be indirectly found as

    $$\tan \Phi_{ph} = \pm \frac{\sqrt{3}(W_1-W_2)}{(W_1+W_2)} \quad \text{for lagging p.f.}$$

  - Total reactive power = $\pm \sqrt{3}(W_1-W_2)$; +ve for lagging p.f. and –ve for leading p.f.
  - Merely from the two wattmeter reading W_1 and W_2 we can know the nature of the load e.g. if $W_1 = W_2$ then $\tan \Phi_{ph} = 0$

    Therefore, $\Phi_{ph} = 0$; $\cos \Phi_{ph} = 1$

Q7. Why a single 3-Φ system is more economical than three separate 1-Φ systems? Explain in brief.

Ans. Three phase power supply requires less conducting materials to transmit & distribute electrical power. Hence, it becomes more beneficial from an economical standpoint.

Q8. State the expressions for total power P_T, Total reactive power Q_T, p.f. in terms of the 2 watt-meter readings W_1 & W_2.

Ans. $W_1+W_2 = P_T = \sqrt{3}V_LI_L\cos\Phi$

$W_1-W_2 = Q_T = \sqrt{3}V_LI_L\sin\Phi$

Power factor (lagging) = p.f. = $\cos\Phi$

$= \cos[\tan^{-1}(\sqrt{3}(W_1-W_2)/(W_1+W_2))]$

Power factor (leading) = p.f. = $\cos\Phi$

$= \cos[\tan^{-1}(-\sqrt{3}(W_1-W_2)/(W_1+W_2))]$

Therefore, $W_1 = V_LI_L \cos(30° - \Phi)$

$W_2 = V_LI_L \cos(30° + \Phi)$

Q9. What precautions will you take if one of the two watt-meters, say W_1 starts reading –ve?

Ans. The readings can be converted to positive by interchanging either current coil or voltage coil.

Q10. How can you decide the nature of the 3-Φ load from the readings W_1 & W_2 of the 2 watt-meters?

Ans. If W_1 is greater than W_2 then load is inductive and

when W_1 is smaller than W_2 then load is capacitive

if $W_1 = W_2$ then the load is resistive

$$\tan\varphi = \sqrt{3}\,\frac{W_1 - W_2}{W_1 + W_2}$$