NUZVID POLYTECHNIC

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Venkatadripuram (V), Annavaram (Post), Nuzvid (M), Eluru (Dt), A.P-521201.

As per C-23

AC CIRCUITS AND TRANSFORMERS &EE-303

Material

Prepared by

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IMPORTANT NOTE

Q.No.	Target Date	Submission Date	Faculty signature		Q.No.	Target Date	Submission Date	Faculty signature
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SHORT ANSWER QUESTIONS:-

1. **Derive the relationship among Pole, Speed and Frequency.**

Ans: Let P= No. of poles
N= Rotor speed in rpm
F= Frequency in Hz

No. of cycles per revolution $= \frac{P}{2}$

No. of revolution per second $= \frac{N}{60}$

$$\text{Frequency} = \frac{\text{No.of Cycles}}{\text{Second}}$$
$$= \frac{\text{No.of Cycles}}{\text{Revolution}} \times \frac{\text{No.of Revolution}}{\text{Second}}$$
$$= \frac{P}{2} \times \frac{N}{60}$$
$$\boxed{F = \frac{PN}{120}} \text{ Hz}$$

2. **Define the terms Cycle, Time period and Frequency.**

Ans:

Cycle: One complete set of positive and negative values of an alternating quantity is known as "Cycle".
Time Period: The time taken to complete one cycle of an alternating quantity is called "Time Period".
Frequency: The no. of cycles per second by an alternating quantity is called "Frequency".

3. **Define instantaneous value, maximum value, average value and RMS value.**

Ans:

Instantaneous value: The value of an alternating quantity at any instant of time is called "Instantaneous value".
Maximum value: The height value attained by an alternating quantity is called "Maximum Value".
Average value: It is defined as the arithmetic mean of all the values of over one complete cycle is called as "Average Value".
RMS value: Is is defined as square root of the mean of the instantaneous values of an alternating quantity is called "RMS value".

4. **Define form factor and peak factor.**

Ans:

Form factor: The ratio between RMS value to the average value of an alternating quantity is called "Form Factor".

$$\boxed{\text{Form Factor}, K_f = \frac{\text{RMS Value}}{\text{Average Value}}}$$

Peak Factor: The ratio between Maximum value to the RMS value of an alternating quantity is known as "Peak Factor".

$$\boxed{\text{Peak Factor}, K_p = \frac{\text{Max. Value}}{\text{RMS Value}}}$$

5. **Define phase and phase difference.**

Ans: Phase: The angle turned by an alternating quantity from a given instant is known as "Phase".

Phase Difference: The angular displacement between two alternating quantities is called "Phase Difference".

6. Derive an expression for RMS value of half wave rectified sine wave.

Ans: Let instantaneous value, $v = V_m \sin \omega t$

RMS value, $V_{rms} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} v^2 d\omega t}$

$$= \sqrt{\frac{1}{2\pi}\left(\int_0^{\pi} V_m^2 \sin^2(\omega t)\, d\omega t + \int_{\pi}^{2\pi} 0\, d\omega t\right)}$$

Here $\cos 2\theta = 1\text{-}2\sin^2(\theta)$

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

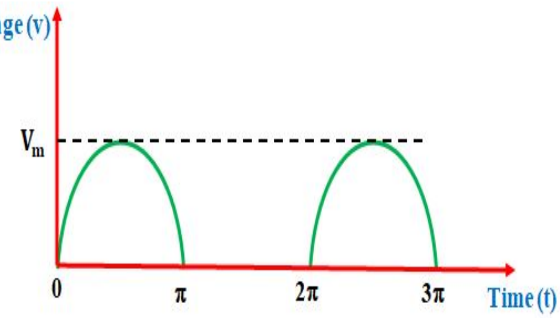
$$= \sqrt{\frac{V_m^2}{4\pi}\left([\omega t]_0^{\pi} - \left[\frac{\sin 2\omega t}{2}\right]_0^{\pi}\right)}$$

$$= \sqrt{\frac{V_m^2}{4\pi}\left([\pi - 0] - \frac{\sin 2(\pi)}{2} + \frac{\sin 2(0)}{2}\right)}$$

$$= \sqrt{\frac{V_m^2}{4\pi}\pi}$$

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

$$\boxed{V_{rms} = 0.5\ V_m} \text{ Volts}$$



Half wave rectified sine wave

7. Derive an expression average value of half wave rectified sine wave.

Ans: Let instantaneous value, $v = V_m \sin \omega t$

Average value, $V_{avg} = \frac{1}{2\pi}\int_0^{2\pi} v\, d\omega t$

$$= \frac{1}{2\pi}\left(\int_0^{\pi} V_m \sin \omega t\, d\omega t + \int_{\pi}^{2\pi} 0\, d\omega t\right)$$

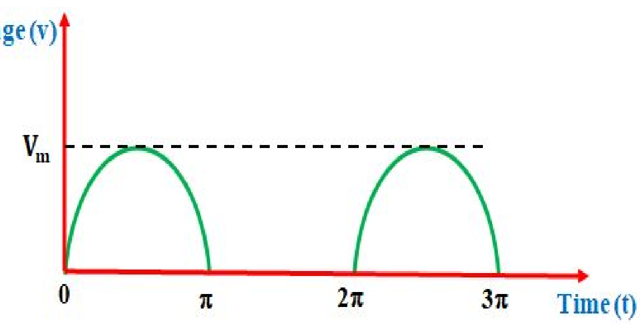
$$= \frac{V_m}{2\pi}[-\cos \omega t]_0^{2\pi}$$

$$= \frac{V_m}{2\pi}(-\cos 2\pi + \cos 0)$$

$$= \frac{V_m}{2\pi}(1+1)$$

$$= \frac{V_m}{\pi}$$

$$\boxed{V_{avg} = 0.31826\ V_m} \text{ Volts}$$



Half wave rectified sine wave

8. Derive an expression for RMS value of full wave rectified sine wave.

Ans: Let instantaneous value, $v = V_m \sin \omega t$

RMS value, $V_{rms} = \sqrt{\frac{1}{\pi}\int_0^{\pi} v^2 d\omega t}$

$$= \sqrt{\frac{1}{\pi}\int_0^{\pi} V_m^2 \sin^2(\omega t)\, d\omega t}$$

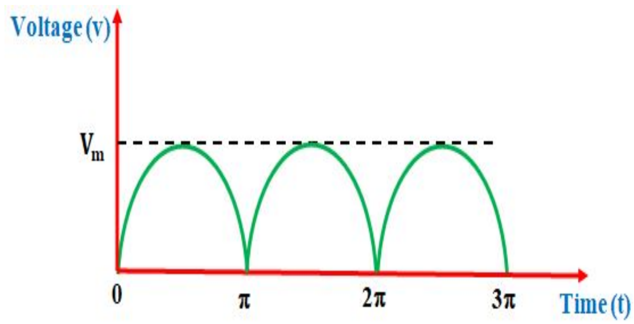
Here $\cos 2\theta = 1\text{-}2\sin^2(\theta)$

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

$$= \sqrt{\frac{V_m^2}{2\pi}\left([\omega t]_0^{\pi} - \left[\frac{\sin 2\omega}{2}\right]_0^{\pi}\right)}$$

$$= \sqrt{\frac{V_m^2}{2\pi}(\pi - 0)}$$

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



Full wave rectified sine wave

$$\boxed{V_{rms} = 0.707\, V_m} \text{ Volts}$$

9. Convert 3-j6 into polar form.

Ans: 3-j6 is converted into polar form

$$|A| = \sqrt{(3)^2 + (-6)^2}$$
$$= \sqrt{45}$$
$$= 6.708$$
$$\theta = \tan^{-1}\left(\frac{-6}{3}\right)$$
$$= -63.43$$

$$\therefore \quad \boxed{3\text{-}j6 = 6.708\angle\text{-}63.43}$$

10. Convert $100\angle 45^0$ into rectangular form.

Ans: $100\angle 45^0$ is converted into rectangular form

$$|A|\cos\theta + j\,|A|\sin\theta = 100\cos 45 + j\,100\sin 45$$
$$= 70.71 + j70.71$$

$$\therefore \quad \boxed{100\angle 45^0 = 70.71 + j70.71}$$

11. Define Q-factor of series resonance circuit.

Ans: It is defined as the ratio between reactive power to the average power.

$$\boxed{\text{Q-factor} = \frac{\text{Reactive Power}}{\text{Average Power}}}$$

12. Define conductance, susceptance &admittance and mention its units.

Ans:

Conductance: The reciprocal of resistance is nothing but "Conductance". The unit for conductance is mho.

$$\boxed{\text{Conductance, } G = \frac{1}{R}} \; ℧$$

Susceptance: The reciprocal of reactance is nothing but "Susceptance". The unit for susceptance is mho.

$$\boxed{\text{Susceptance, } B = \frac{1}{X}} \; ℧$$

Admittance: The reciprocal of impedance is nothing but "Admittance". The unit for admittance is mho.

$$\text{Admittance, } Y = \frac{1}{Z} \ \mho$$

13. Draw the impedance and power triangles.

Ans:

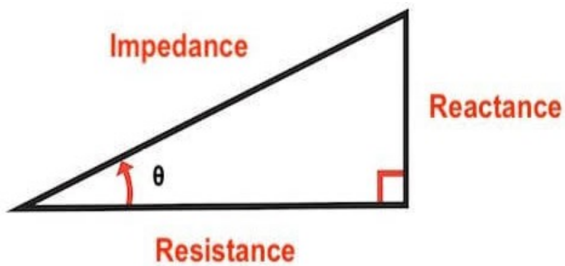


Fig.1 Impedance triangle for RL-Load

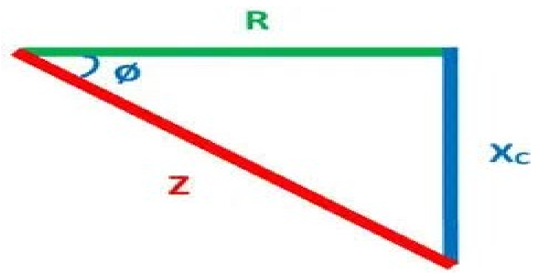


Fig.2 Impedance triangle for RC-Load

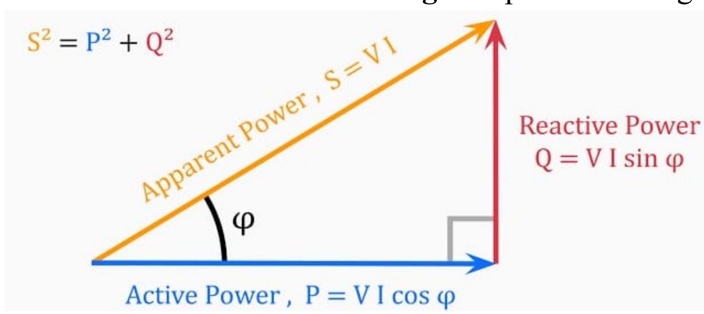


Fig.3 Power Triangle

14. Find the resonant frequency of RLC series circuit having resistance 10Ω, inductance 20mH and capacitance 100μF.

Ans:

Given Data

Resistance, R= 10Ω,
Inductance, L= 20mH
Capacitance, C= 100μF

Require Data

Resonant Frequency=?

$$\text{Resonant Frequency, } F_r = \frac{1}{2\pi\sqrt{LC}}$$

$$= \frac{1}{2\pi\sqrt{20 \text{ X } 10^{-3} \text{X } 100 \text{ X } 10^{-6}}}$$

$$F_r = 112.53953 \text{ Hz}$$

15. Define active, reactive and apparent powers.

Ans:

Active Power: The power which is consumed by the consumer is called "Active Power".

$$\text{Active Power, } P = VI\cos\emptyset \ \text{Watts}$$

Reactive Power: The power which is flows from load to source is called "Reactive Power".

$$\text{Reactive Power, } Q = VI\sin\emptyset \ \text{VAR}$$

Apparent Power: The product of voltage and current is nothing but "Apparent Power".

$$\text{Apparent Power, } S = VI \ \text{VA}$$

16. What are the methods used to solve the parallel circuits.

Ans:

- Vector method
- Admittance method
- J-notation method

17. Define poly phase and phase sequence.

Ans: <u>Poly-Phase</u>: Poly means many and Phase means windings. Poly-phase system is a combination of two or more then two voltages having same magnitude and frequency but displaced from each other by an equal electrical angle.

<u>Phase Sequence</u>: The order in which the three phases reach their maximum value is known as "Phase Sequence".

18. Define Line voltage, Phase voltage, Line current and Phase current.

Ans:

<u>Line Voltage</u>: The voltage between any two phases from 3-ϕ is called "Line Voltage".

<u>Phase Voltage</u>: The voltage between any of the phase from 3-ϕ system to neutral is known as "Phase Voltage"

<u>Line Current</u>: The current flowing in the lines is called as "Line Current".

<u>Phase Current</u>: The current flowing through the phase are called as "Phase Current".

19. What are the advantages of 3-ϕ system over 1-ϕ system?

Ans:

- Greater output
- More efficient
- Self starting
- More reliable
- Better voltage regulation

20. Define transformer.

Ans: Transformer is a static device, which transfer the electrical energy from one circuit to other circuit without changing the frequency.

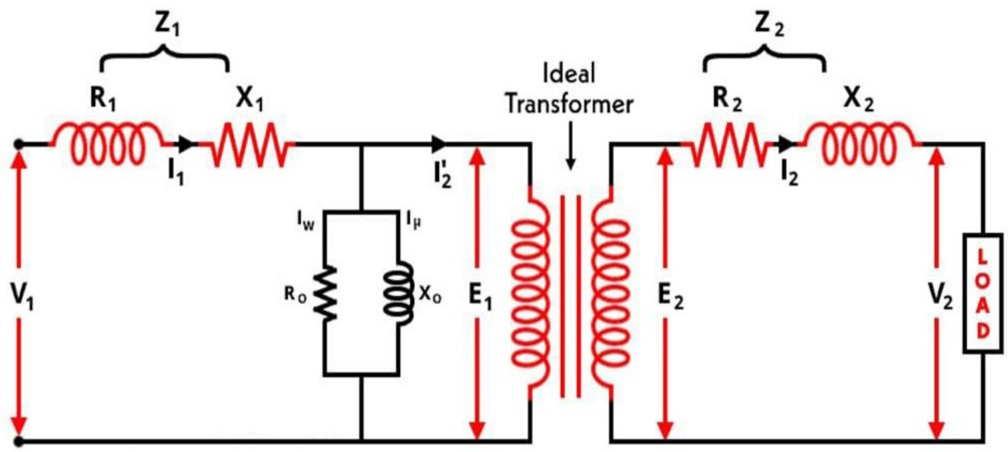
21. Distinguish between shell type and core type transformer.

Ans:

S.No.	Core Type Transformer	Shell Type Transformer
01	Construction is difficult	Easy construction
02	Rarely used	Widely used
03	Single magnetic circuit	Double magnetic circuit
04	Cylindrical concentric coils are used	Sandwiched disc type coils are used

22. Draw the approximate equivalent circuit of a transformer.

Ans:



23. Define all-day efficiency.

Ans: It is defined as the ratio between energy outputs in 24Hours to the energy inputs in 24Hours.

$$\text{All-day efficiency, } \eta_{All-d} = \frac{Energy\ output\ in\ KWH\ for\ 24\ Hours}{Energy\ input\ in\ KWH\ for\ 24\ Hours}$$

24. List the various losses in a 1-ϕ transformer.

Ans: Total Losses
$$\begin{cases} 1.\ Iron\ Losses \begin{cases} 1.\ Hysteresis\ Losses \\ 2.\ Eddy\ Current\ Losse \end{cases} \\ 2.\ Copper\ Losses \begin{cases} 1.\ Primary\ copper\ Losses \\ 2.\ Secondary\ copper\ Losses \end{cases} \\ 3.\ Stray\ Losses \\ 4.\ Dielectric\ Losses \end{cases}$$

25. State the reason for specifying the transformer ratings in KVA?

Ans: We know that iron loss in a transformer depends on voltage and copper losses depends on current. Therefore, the total losses in the transformer depends on Volt-Ampere and it is independent of load power factor. for this reason, the rating of a transformer is in KVA.

26. State the advantages of 3-ϕtransformers over 1-ϕ transformers.

Ans:

- It occupies less space
- Less weight
- Less cost
- More efficient.

27. State the conditions for parallel operation of 3-ϕ transformer.

Ans:

- Polarities of the two transformers must be same.
- The voltage ratings of the two transformers must be same.
- The percentage impedance must be same.
- Phase sequence must be the same.

28. State the advantages of Auto transformer.

Ans:

- Small size
- Less weight
- Low cost
- Less voltage drop
- Variable output

29. State the applications of auto transformer.

Ans:

- Voltage stabilizer
- Testing
- Speed control of fans
- Starter for motors.

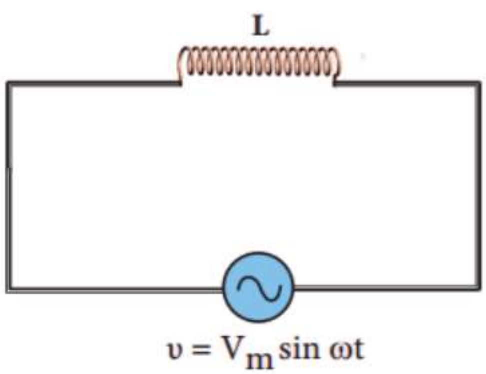
30. State the necessity of cooling of power transformer.

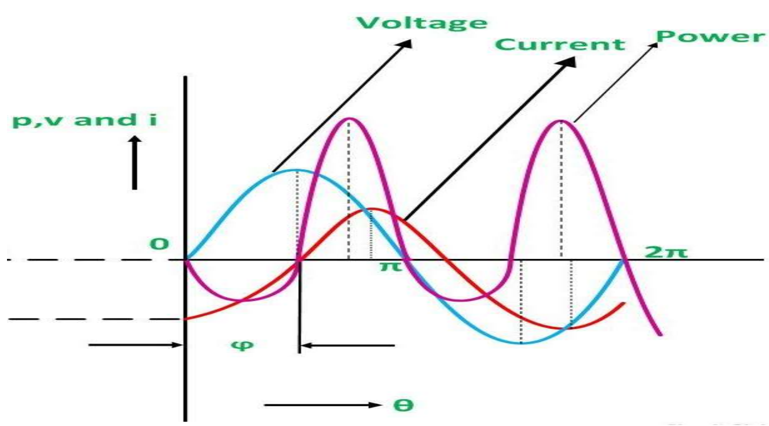
Ans: In transformers losses are takes place in core and the windings. To keep down the temperature i.e; to dissipate the heat from the core and windings cooling system is necessary.

LONG ANSWER QUESTIONS

31. Show that the power consumed by a pure inductance is zero when AC supply is applied to Inductance.

Ans: Consider a circuit containing a coil of pure inductance connected across an alternating voltage source.





Let an alternating voltage applied across the circuit, $v = V_m \sin \omega t$

An alternating current 'I' flows through a pure inductive coil causes a back emf is induced in it.

$$e = -L\frac{di}{dt}$$

$$v = -e = -\left(-L\frac{di}{dt}\right)$$

$$v = L\frac{di}{dt}$$

$$V_m \sin \omega t = L\frac{di}{dt}$$

$$di = \frac{1}{L} V_m \sin \omega t \; dt$$

Integrating above equation on both sides

$$\int di = \int \frac{1}{L} V_m \sin \omega t \; dt$$

$$i = \frac{V_m}{L}\left(\frac{-\cos\omega t}{\omega}\right)$$

$$i = \frac{-V_m}{\omega L}(\cos\omega t)$$

$$i = -I_{max}\cos\omega t \qquad \left[\because I_{max} = \frac{-V_m}{\omega L}\right]$$

The power consumed in the pure inductance at any instant is equal to the product of voltage and current at that instant.

$\therefore$ Instantaneous power, $p = vi = V_m \sin\omega t\,(-I_{max}\cos\omega t)$

$$= -V_m I_m \sin\omega t\cos\omega t$$

$$= \frac{-2V_m I_m \sin\omega t\cos\omega}{2}$$

$$= \frac{-V_m I_m}{2}\sin 2\omega t$$

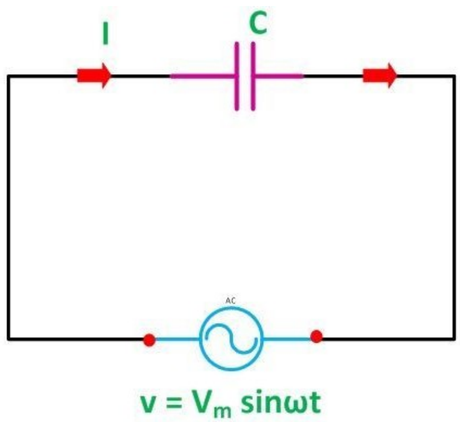
$\therefore$ The power for whole cycle, $P = \int_0^{2\pi} \frac{-V_m I_m}{2}\sin 2\omega t\; dt$

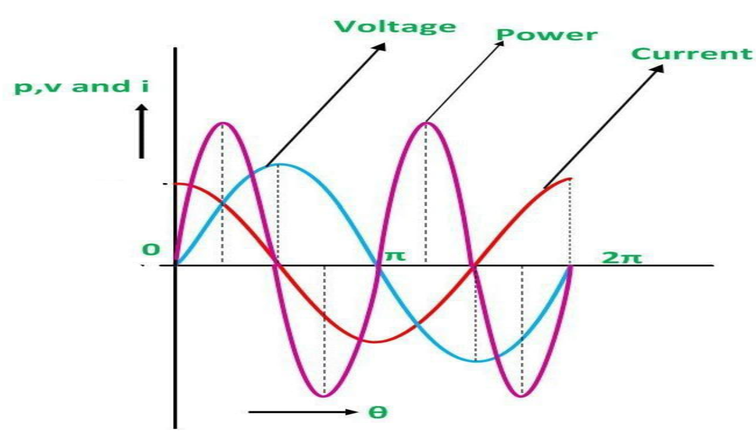
$$= \frac{-V_m I_m}{2}\int_0^{2\pi}\sin 2\omega t\; dt$$

$$\boxed{P = 0}\ \text{Watts}$$

32. Show that the power consumed by a pure capacitance is zero when AC supply is applied to Capacitance.

Ans: Let us consider a pure capacitance is connected across an AC supply.





Let instantaneous value, $v = V_m \sin\omega t$

Capacitance, $C = \frac{q}{v}$

$$q = Cv = C\,V_m \sin\omega t$$

We have $i = \frac{dq}{dt}$

$$= \frac{d}{dt}(C\,V_m \sin\omega t)$$

$$= C\,V_m(\cos\omega t)\omega$$

$$= \omega C\,V_m(\cos\omega t)$$

$$= \frac{V_m}{1/\omega C}(\cos\omega t)$$

$$i = I_{max} \cos \omega t \qquad \left[\because I_{max} = \frac{V_m}{1/\omega C}\right]$$

Instantaneous power, $p = vi$

$$= V_m \sin \omega t \, I_m \cos \omega t$$
$$= \frac{V_m I_m}{2} 2 \sin \omega t \cos \omega t$$
$$= \frac{V_m I_m}{2} \sin 2\omega t$$

$\therefore$ The power for whole cycle, $P = \int_0^{2\pi} \frac{V_m I_m}{2} \sin 2\omega t \; dt$

$$= \frac{V_m I_m}{2} \int_0^{2\pi} \sin 2\omega t \; dt$$

$$\boxed{P = 0} \text{ Watts}$$

33. A resistance of 10Ω and inductance 0.1H are connected in series across a supply of 220V,50Hz. Find (a). Impedance (b). Current flowing (c). Power factor and (d). Phase angle.

Ans: **Given Data**

Resistance, R = 10 Ω
Inductance, L = 0.1H
Voltage, V = 220Volts
Frequency, F = 50Hz

Require Data

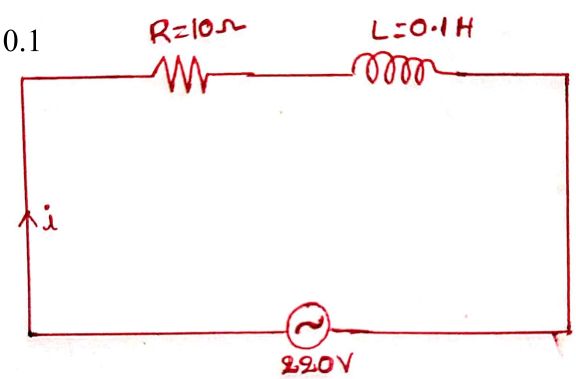
Impedance, Z = ?
Current, I = ?
Power factor = ?
Phase angle = ?

(i). Impedance, $Z = \sqrt{R^2 + X_L^2}$

$$X_L = 2\pi f L = 2\pi \times 50 \times 0.1$$
$$X_L = 31.41592\ \Omega$$

then $Z = \sqrt{(10)^2 + (31.41592)^2}$

$$\boxed{Z = 32.96290}\ \Omega$$



(ii). Current, $I = \frac{V}{Z} = \frac{220}{32.96290}$

$$\boxed{I = 6.67416} \text{ Amps}$$

(iii). Power Factor, $\cos \emptyset = \frac{R}{Z} = \frac{10}{32.96290}$

$$\boxed{\cos \emptyset = 0.30337} \text{ lag}$$

(iv). Phase angle, $\emptyset = \cos^{-1}(0.30337)$

$$\boxed{\emptyset = 72.34'}$$

34. A capacitor of 50μF is connected in series with a resistor of 100Ω. This combination is connected across a 230V, 50Hz AC supply. Calculate impedance, Current, Power factor, Active power and reactive power.

Ans: **Given Data**

Resistance, R = 100 Ω
Capacitor, C = 50μF
Voltage, V = 230Volts

Require Data

Z = ?
I = ?
$\cos \emptyset$ = ?

Frequency, F = 50Hz

P = ?

Q = ?

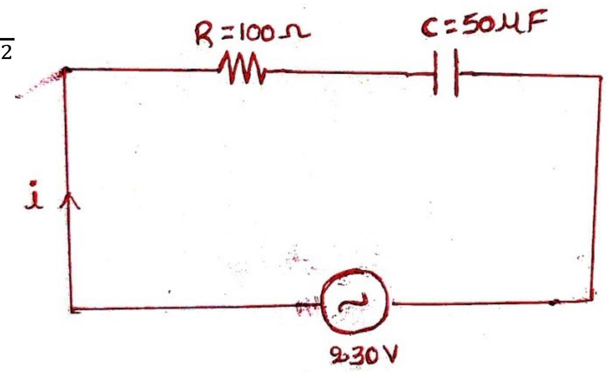
(i). Impedance, $Z = \sqrt{R^2 + X_C^2}$

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi \text{ X } 50 \text{ X } 50 \text{ X } 10^{-6}}$$

$X_C = 63.66197\ \Omega$

$Z = \sqrt{(100)^2 + (63.66197)^2}$

$\boxed{Z = 118.5447}\ \Omega$



(ii). Current, $I = \frac{V}{Z} = \frac{230}{118.5447}$

$\boxed{I = 1.94019}$ Amps

(iii). Power Factor, $\cos\phi = \frac{R}{Z} = \frac{100}{118.5447}$

$\boxed{\cos\phi = 0.84356}$ lead

$\phi = \cos^{-1}(0.84356)$

$\boxed{\phi = 32.48'}$

(iv). Active power, $P = VI\cos\phi = 230 \text{ X } 1.94019 \text{ X } 0.84356$

$\boxed{P = 376.43335}$ Watts

(v). Reactive power, $Q = VI\sin\phi = 230 \text{ X } 1.94019 \text{ X } \sin(32.48)$

$\boxed{Q = 239.63517}$ VAR

35. A resistance of 12Ω, an inductance of 0.15H and a capacitance of 100μF are connected in series across a 100V, 50Hz supply. Calculate impedance, Current, Power factor and Power consumed.

Ans: **Given Data**

Resistance, R = 12 Ω

Inductance, L = 0.15H

Capacitor, C = 100μF

Voltage, V = 100Volts

Frequency, F = 50Hz

Require Data

Z = ?

I = ?

$\cos\phi$ = ?

P = ?

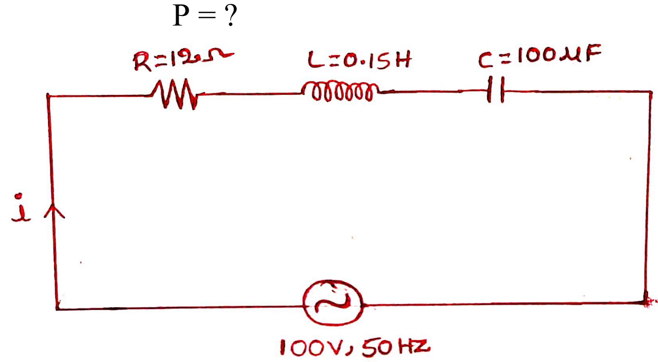
Impedance, $Z = \sqrt{R^2 + (X_L - X_C)^2}$

$X_L = 2\pi fL = 2\pi \text{ X } 50 \text{ X } 0.15$

$X_L = 47.12388\ \Omega$

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi \text{ X } 50 \text{ X } 100 \text{ X } 10^{-6}}$$

$X_C = 31.83098\ \Omega$



$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{12^2 + (47.12388 - 31.83098)^2}$

$\boxed{Z = 19.43895}\ \Omega$

Current, $I = \frac{V}{Z} = \frac{100}{19.43895}$

$\boxed{I = 5.14431}$ Amps

Power factor, $\cos\emptyset = \frac{R}{Z} = \frac{12}{19.43895}$

$\boxed{\cos\emptyset = 0.6176}$ lag

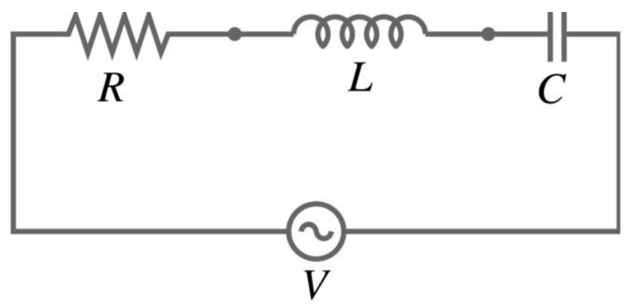
Power, $P = VI\cos\emptyset = 100 \times 5.14431 \times 0.6176$

$\boxed{P = 317.56653}$ Watts

36. Define series resonance and derive an expression for resonance frequency.

Ans: In the series RLC circuit the applied voltage and resultant current are in-phase. Then this circuit is known as "Series Resonance".

At resonance condition



$$X_L - X_C = 0$$

$$X_L = X_C$$

$$\omega_r L = \frac{1}{\omega_r C}$$

$$\omega_r^2 = \frac{1}{LC}$$

$$\omega_r = \sqrt{\frac{1}{LC}}$$

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

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

∴ Resonance frequency, $\boxed{f_r = \frac{1}{2\pi\sqrt{LC}}}$ Hz

37. Two impedances Z_1 = 6+j6 and Z_2 = 6-j6 are connected in parallel. Calculate the total (i).Conductance (ii).Susceptance (iii).Admittance (iv).Current taken from the supply and its PF. If the supply voltage is 200V, 50Hz.

Ans: **Given Data**

$Z_1 = 6+j6$

$Z_2 = 6-j6$

V = 200Volts

F= 50Hz

Require Data

G = ?

B = ?

Y = ?

I = ?

Admittance for branch-1,

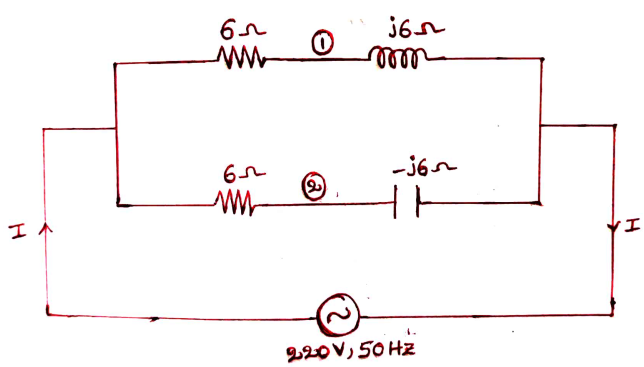
$$Y_1 = \frac{1}{Z_1} = \frac{1}{6+j6}$$

$$Y_1 = 0.08333 - j0.08333\ \mho$$

Admittance for branch-2,

$$Y_2 = \frac{1}{Z_2} = \frac{1}{6+j6}$$

$$Y_2 = 0.08333 + j0.08333\ \mho$$



Total admittance, $Y = Y_1 + Y_2 = 0.08333\text{-}j0.0833 + 0.08333 + j0.08333$

$$Y = 0.16666 \ ℧$$

Current, I = VY = 200 X 0.16666

$$I = 33.332 \text{ Amps}$$

Conductance, $G = 0.16666$ ℧

Suscepatance, $B = 0$ ℧

Phase angle, $\emptyset = \tan^{-1}\left(\frac{B}{G}\right) = \tan^{-1}\left(\frac{0}{0.16666}\right)$

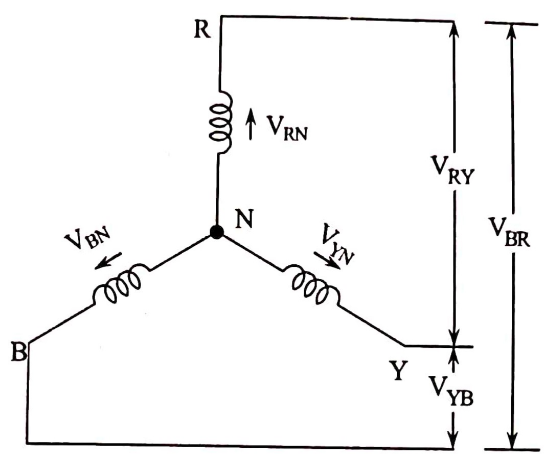
$$\emptyset = 0^0$$

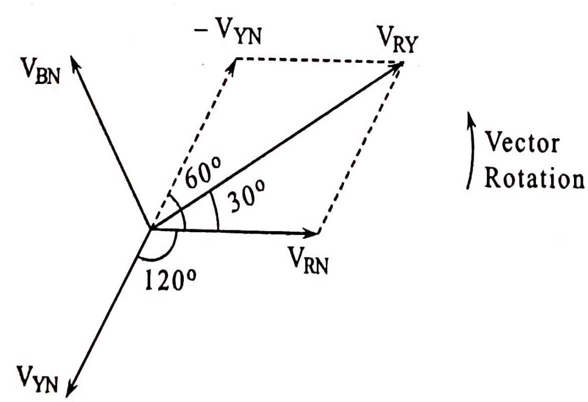
Power factor, $\cos\emptyset = \cos(0)$

$$\cos\emptyset = 1 \text{(Unity)}$$

38. Derive an expression for the line voltage and phase voltage in Star connected system.

Ans:





From the above fig.

V_{RN} , V_{YN} & V_{BN} are the phase voltages i.e; $V_{RN} = V_{YN} = V_{BN} = V_{ph}$

V_{RY} , V_{YB} & V_{BR} are the line voltages i.e; $V_{RY} = V_{YB} = V_{BR} = V_L$

The voltage between R-phase and Y-Phase is

$$V_{RY} = V_{RN} - V_{NY}$$
$$V_{RY} = V_{RN} - V_{YN}$$

Similarly $V_{YB} = V_{YN} - V_{BN}$

$$V_{BR} = V_{BN} - V_{RN}$$

From the vector diagram, the voltage between R-Phase and Y-Phase is

$$V_{RY} = \sqrt{V_{RN}^2 + V_{YN}^2 + +2V_{RN}V_{YN}\cos 60°}$$

$$V_L = \sqrt{V_{Ph}^2 + V_{Ph}^2 + +2V_{Ph}V_{Ph} \text{ X } \frac{1}{2}}$$

$$= \sqrt{3V_{Ph}^2}$$

$$\boxed{V_L = \sqrt{3}\, V_{Ph}} \text{ Volts}$$

In the 3-Ø star connected system, the line voltage is equal to $\sqrt{3}$ times to the phase voltage i.e; $V_L = \sqrt{3}\, V_{Ph}$ and the line current is equal to phase current i.e; $I_L = I_{ph}$.

39. Three coils each having a resistance of 20Ω and an inductive reactance of 15Ω are connected in star to 400V, 3-Ø, 50Hz supply. Calculate line current, power factor and power supplied.

Ans: **Given Data**

$R_{ph} = 20\Omega$

$X_L = 15\Omega$

$V_L = 400$Volts

F = 50 Hz, 3-Ø star

Require Data

$I_L = ?$

$\cos \emptyset = ?$

$P = ?$

Impedance per phase, $Z_{ph} = \sqrt{(20)^2 + (15)^2}$

$Z_{ph} = 25\ \Omega$

Phase voltage, $V_{ph} = \frac{V_L}{\sqrt{3}} = \frac{400}{\sqrt{3}}$

$V_{ph} = 230.94$ Volts

Phase current, $I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{230.94}{25}$

$I_{ph} = 9.2376$ Amps

Line current, $\boxed{I_L = I_{ph} = 9.2376}$ Amps

Power factor, $\cos \emptyset = \frac{R}{Z} = \frac{20}{25}$

$\boxed{\cos \emptyset = 0.8}$ lag

Power supplied, $P = \sqrt{3}\, V_L I_L \cos \emptyset = \sqrt{3} \text{ X } 400 \text{ X } 9.2376 \text{ X } 0.8$

P = 5119.99761 Watts

$\boxed{P = 5.11999}$ KW

40. A balanced 3-Ø star connected load of 100KW taken a lagging current of 75Amps with a line voltage of 1000Volts, 50Hz. Find the circuit constant of load per phase.

Ans: **Given Data**

P = 100KW

$I_L = 75$Amps

$V_L = 1000$Volts

F = 50 Hz, 3-Ø star

Require Data

R = ?

L = ?

$X_L = ?$

Z = ?

Phase voltage, $V_{ph} = \frac{V_L}{\sqrt{3}} = \frac{1000}{\sqrt{3}}$

$V_{ph} = 577.35026$ Volts

$$I_L = I_{ph} = 75 \text{ Amps}$$

$$Z_{ph} = \frac{V_{ph}}{I_{ph}} = \frac{577.35026}{75}$$

$$\boxed{Z_{ph} = 7.698}\ \Omega$$

Power supplied, $P = \sqrt{3}\, V_L I_L \cos\emptyset$

$$\cos\emptyset = \frac{P}{\sqrt{3}\, V_L I_L} = \frac{100\ X\ 10^3}{\sqrt{3}\ X\ 1000\ X\ 75}$$

$$\cos\emptyset = 0.7698 \text{ lag}$$

Resistance, $R = Z\cos\emptyset = 7.698\ X\ 0.7698$ $\left[\because \text{ pf}, \cos\emptyset = \frac{R}{Z}\right]$

$$\boxed{R = 5.92592}\ \Omega$$

Reactance, $X_L = \sqrt{Z^2 - R^2} = \sqrt{(7.698)^2 - (5.92592)^2}$

$$\boxed{X_L = 4.91351}\ \Omega$$

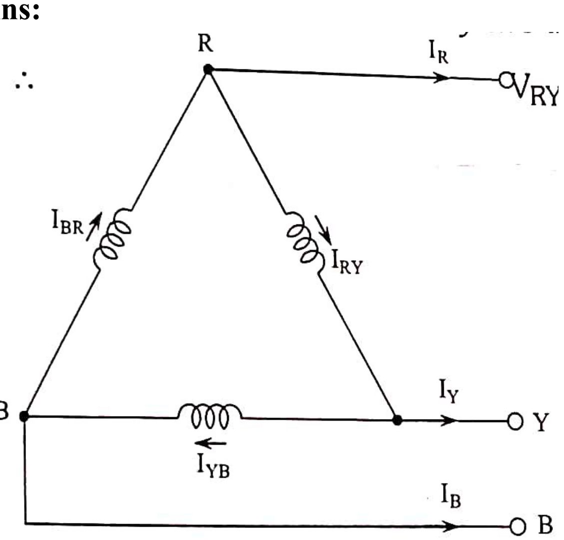
$$\text{Inductance, } L = \frac{X_L}{2\pi f} = \frac{4.91351}{2\pi\ X\ 50}$$

$$= 0.01564 \text{ H}$$

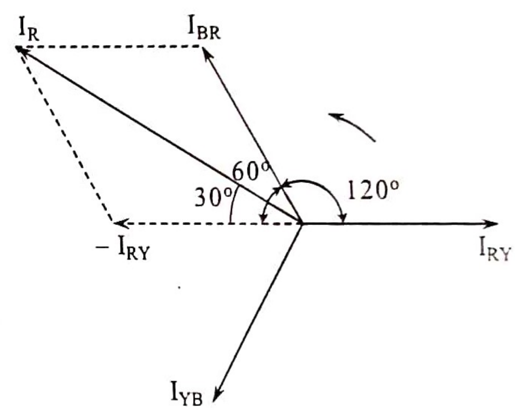
$$\boxed{L = 15.64}\ \text{mH}$$

41. Derive an expression for the line current and phase current in delta connected system.

Ans:



$V_L = V_{Ph}$



From the above fig.

I_{RY} , I_{YB} & I_{BR} are the phase currents i.e; $I_{RY} = I_{YB} = I_{BR} = I_{ph}$

I_R , I_Y & I_B are the line currents i.e; $I_R = I_Y = I_B = I_L$

From the vector diagram, the line current,

$$I_R = I_{BR} - I_{RY}$$

$$I_Y = I_{RY} - I_{YB}$$

$$I_B = I_{YB} - I_{BR}$$

Line current, $I_R = \sqrt{I_{BR}^2 + I_{RY}^2 + 2I_{BR}I_{RY}\cos 60°}$

$$I_L = \sqrt{I_{ph}^2 + I_{ph}^2 + 2I_{ph}I_{ph} X \frac{1}{2}}$$

$$= \sqrt{3I_{Ph}^2}$$

$$I_L = \sqrt{3}\, I_{Ph} \text{ Amps}$$

In the 3-Ø delta connected system, the line current is equal to $\sqrt{3}$ times to the phase current i.e; $I_L = \sqrt{3}\, I_{Ph}$ and the line voltage is equal to phase voltage i.e; $V_L = V_{ph}$

42. Three coils each having a resistance of 10Ω and an inductance of 0.02H are connected (i) In star connection (ii).Delta connection to a 3-Ø, 50Hz. The line voltage being 500volts. Calculate the line current and power taken from the supply.

Ans:

Given Data	**Require Data**
R = 10Ω	I_L & P for star & delta
L = 0.02H	
V_L = 500Volts	
F = 50Hz	

For star connection:-

$$V_{ph} = \frac{V_L}{\sqrt{3}} = \frac{500}{\sqrt{3}} = 288.67513 \text{ Volts}$$

$$I_{Ph} = \frac{V_{ph}}{Z_{ph}}$$

$$X_L = 2\pi fL = 2\pi X 50 X 0.02$$

$$X_L = 6.28318\ \Omega$$

$$Z_{ph} = \sqrt{R_{ph}^2 + X_L^2} = \sqrt{(10)^2 + (6.28318)^2}$$

$$= 11.77828\ \Omega$$

Then $I_{Ph} = \frac{288.67513}{11.77828}$

$$I_{Ph} = 24.5091 \text{ Amps}$$

Line current, $I_L = I_{Ph} = 24.5091$ Amps

Power supplied, $P = \sqrt{3}\, V_L I_L \cos Ø$

Power factor, $\cos Ø = \frac{R}{Z} = \frac{10}{11.77828}$

$\cos Ø = 0.84902$ lag

$$P = \sqrt{3} X 500 X 24.5091 X 0.84902$$

P = 18.02088 KW

For Delta connection:-

$$V_L = V_{Ph} = 500 \text{ volts}$$

$$I_L = \sqrt{3}\, I_{Ph}$$

$$I_{Ph} = \frac{V_{Ph}}{Z_{Ph}} = \frac{500}{11.77828}$$

$$I_{Ph} = 42.45102 \text{ Amps}$$

Then Line current, $I_L = \sqrt{3} \text{ X } 42.45102$

$$I_L = 73.52732 \text{ Amps}$$

Power, $P = \sqrt{3} \text{ X } 500 \text{ X } 73.52732 \text{ X } 0.84902$

$$= 54062.64495 \text{ Watts}$$

$$P = 54.06264 \quad \text{KW}$$

43. Derive the relationship between power in start and delta connected system.

Ans: For a star connected load, $V_L = \sqrt{3}\, V_{Ph}$

$$I_{Ph} = \frac{V_{Ph}}{Z_{Ph}}$$

$$= \frac{V_L}{\sqrt{3} \text{ X } Z_{Ph}}$$

$$I_L = I_{Ph} = \frac{V_L}{\sqrt{3} \text{ X } Z_{Ph}}$$

Now power in star connected load, $P_Y = \sqrt{3}\, V_L I_L \cos\emptyset$

$$= \sqrt{3}\, V_L \frac{V_L}{\sqrt{3} \text{ X } Z_{Ph}} \cos\emptyset$$

$$P_Y = \frac{V_L^2}{Z_{ph}} \cos\emptyset \quad \text{-----}\rightarrow 1$$

For a delta connected load, $V_L = V_{Ph}$

$$I_{Ph} = \frac{V_{Ph}}{Z_{Ph}}$$

$$= \frac{V_L}{Z_{Ph}}$$

$$I_L = \sqrt{3}\, I_{Ph} = \frac{\sqrt{3}\, V_L}{Z_{Ph}}$$

Now power in star connected load, $P_\Delta = \sqrt{3}\, V_L I_L \cos\emptyset$

$$= \sqrt{3}\, V_L \frac{\sqrt{3}\, V_L}{Z_{Ph}} \cos\emptyset$$

$$= 3 \frac{V_L^2}{Z_{ph}} \cos\emptyset \quad \text{-----}\rightarrow 2$$

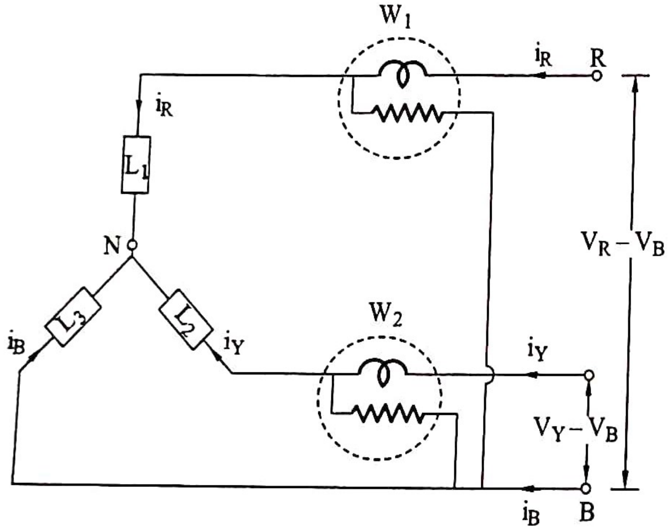
From eq'n 1&2 $\quad P_\Delta = 3\, P_Y$

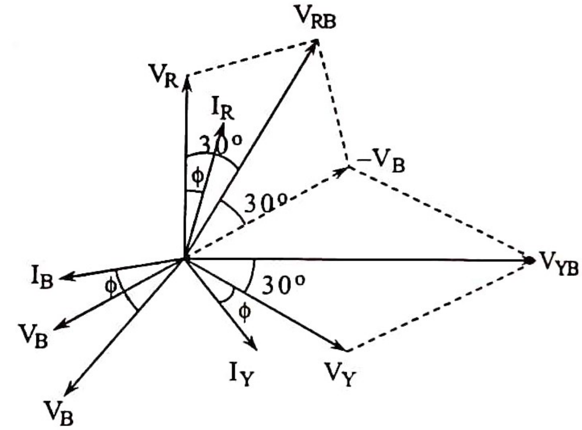
$$P_Y = \frac{1}{3} P_\Delta$$

Note: The power consumed by a balanced star connected load is one-third of that in case of a delta connected load.

44. Reduce the equation for power factor of the load using two watt-meter method.

Ans:





Watt-meter, $W_1 = V_L I_L \cos(30 - \emptyset)$ ------→1

Watt-meter, $W_2 = V_L I_L \cos(30 + \emptyset)$ ------→2

Adding eq'n 1&2

$$W_1 + W_2 = V_L I_L \cos(30 - \emptyset) + V_L I_L \cos(30 + \emptyset)$$
$$= V_L I_L\,(\cos(30 - \emptyset) + \cos(30 + \emptyset))$$
$$= V_L I_L (2\cos 30^\circ \cos\emptyset)$$
$$= V_L I_L \left(2\frac{\sqrt{3}}{2}\cos\emptyset\right)$$

$W_1 + W_2 = \sqrt{3}\, V_L I_L \cos\emptyset$ ------→3

Substarct eq'n 1&2

$$W_1 - W_2 = V_L I_L \cos(30 - \emptyset) - V_L I_L \cos(30 + \emptyset)$$
$$= V_L I_L\,(\cos(30 - \emptyset) - \cos(30 + \emptyset))$$
$$= V_L I_L (2\sin 30 \sin\emptyset)$$
$$= V_L I_L \left(2\frac{1}{2}\sin\emptyset\right)$$

$W_1 - W_2 = V_L I_L \sin\emptyset$ ------→4

Divide $\frac{Eq'n\,4}{Eq'n\,3}$

$$\frac{W_1 - W_2}{W_1 + W_2} = \frac{V_L I_L \sin\emptyset}{\sqrt{3}\, V_L I_L \cos\emptyset}$$
$$= \frac{1}{\sqrt{3}}\tan\emptyset$$
$$\tan\emptyset = \sqrt{3}\left(\frac{W_1 - W_2}{W_1 + W_2}\right)$$
$$\emptyset = \tan^{-1}\left(\sqrt{3}\left(\frac{W_1 - W_2}{W_1 + W_2}\right)\right)$$

∴ Power factor, $\boxed{\cos\emptyset = \cos\left(\tan^{-1}\left(\sqrt{3}\left(\frac{W_1 - W_2}{W_1 + W_2}\right)\right)\right)}$

45. Two watt-meters when connected to a 3-Ø, 400Volts, 50Hz motor shown a total load of 20KW. The power factor is 0.45lagging. What is the reading of each watt-meter.

Ans:

Given Data	Require Data
$V_L = 400$Volts	$W_1 = ?$
$f = 50$Hz	$W_2 = ?$
P= 20KW	
$\cos \emptyset = 0.45$	

We know that, $\cos \emptyset = 0.45$

$$\emptyset = \cos^{-1}(0.45)$$

$$\emptyset = 63.26'$$

$$V_L I_L = \frac{P}{\sqrt{3}\cos \emptyset}$$

$$= \frac{20 \text{ X } 10^3}{\sqrt{3} \text{ X } 0.45}$$

$$V_L I_L = 25660.01196 \quad \text{VA}$$

Watt-meter, $W_1 = V_L I_L \cos(30 - \emptyset)$

$$= 25660.01196 \text{ X } \cos(30 - 63.26)$$

$$W_1 = 21.45665 \text{ KW}$$

Watt-meter, $W_2 = V_L I_L \cos(30 + \emptyset)$

$$= 25660.01196 \text{ X } \cos(30 + 63.26)$$

$$W_2 = -1.45 \text{ KW}$$

* * * * *All the very best* * * * *