K. J. Somaiya College of Engineering, Mumbai-77
(Autonomous College Affiliated to University of Mumbai)
Semester: July – November 2019

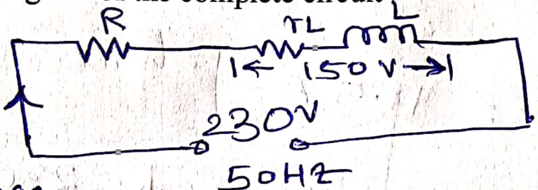
Test -2: Solution

Max. Marks: 40
Class: FY B.Tech
Branch: MECH/IT/COMP
Name of the Course: **Elements of Electrical and Electronics Engineering**

Duration: 1hr.30 min
Semester: I

Q. No.		Mark Distri.
Q. 1	When a resistor and a choke coil in series are connected across a 230V, 50Hz AC supply. The current of magnitude 4A and lagging behind supply voltage by 36° flows. If the voltage across the coil is 150V, find 1. Value of resistor 2. Draw impedance triangle of the complete circuit 3. Resistance of choke coil 4. Inductance of choke coil 5. Draw the phasor diagram of the complete circuit	10

Soln: Given



$\phi = 36^\circ$.

→ Total impedance

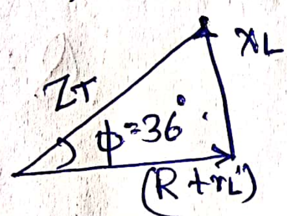
$|Z_T| = \frac{230}{4A} = 57.3\Omega$ — 1

$Z_T^2 = (R+r_L)^2 + X_L^2 \Rightarrow (57.3)^2 = (R+r_L)^2 + X_L^2$ — eqn (I) — 1

→ $Z_{coil} = \frac{150}{4} = 37.5\Omega$

$Z_{coil}^2 = r_L^2 + X_L^2 \Rightarrow (37.5)^2 = r_L^2 + X_L^2$ --- eqn (II) — 1

→ Impedance triangle



— 1

→ $(R+r_L) = Z_T \cdot \cos\phi = 57.3 \cos 36^\circ = 46.36\Omega$ --- 1

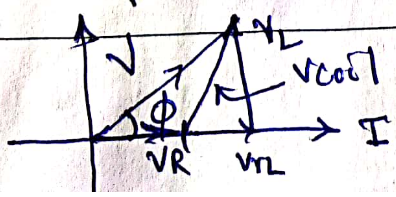
→ from equation (I) $X_L^2 = (57.3)^2 - (46.36)^2 =$

$X_L = 33.67\Omega$ $\therefore \boxed{L = \frac{33.67}{2\pi \times 50} = 0.107H}$ -- 2

→ From eqn (II) $r_L^2 = (37.5)^2 - (33.67)^2 = \cancel{16.51\Omega}$ $\boxed{r_L = 16.51}$ — 1

→ $R + r_L = 46.36$ $\therefore \boxed{R = 29.85\Omega}$ — 2.

phasor diagram



— 1

Q. 2	**Solve Any two of the following.** (a)Two impedances (12+j16) Ω and (10-j20) Ω are connected in parallel across 230 V, 50Hz supply. Find 1. Power factor 2. Active Power 3. Reactive Power 4. Apparent Power	~~10~~ 5

Soln:

$Z_1 = 12+j16$, $Y_1 = \frac{1}{Z_1} = 0.03 - j0.04$

$Z_2 = 10-j20$, $Y_2 = \frac{1}{Z_2} = 0.02 + j0.04$

$Y = Y_1 + Y_2 = 0.05 - j0$.

$Z = \frac{1}{Y} = 20\angle 0^\circ$. $\therefore \phi = 0^\circ$

→ ∴ power factor $= \cos\phi = \cos 0 = 1$ — 1

$I = \frac{230V}{20\angle 0} = 11.5A$ — 1

→ Active power $P = VI\cos\phi = 230 \times 11.5 \times 1$

$P = 2645W$. — 1

→ Reactive power $Q = VI\sin\phi = 230 \times 11.5 \times 0$

$\boxed{Q = 0 \text{ VAR}}$ — 1

→ Apparent power $S = VI = ~~2645W~~$

$= 230 \times 11.5$

$= 2645$ VA — 1

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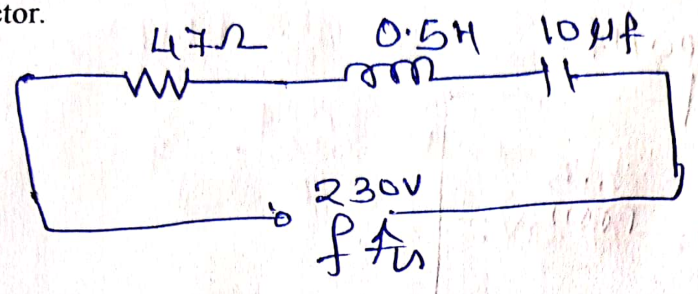
(b) A coil having resistance of 47 Ω and an inductance of 0.5H is connected in series with a 10uF capacitor to a variable frequency. An alternating voltage of 230V is applied to the circuit. At what value of the frequency will the current in the circuit be maximum? Find value of maximum current. Also find voltage across inductor and quality factor. 5

⇒



Series Resonant circuit : frequency (f_r)

$$f_r = \frac{1}{2\pi\sqrt{0.5 \times 10 \times 10^{-6}}}$$ ---- 1

→ Current will be maximum at freq^n. ---- 1

$\underline{f_r = 71.17\ Hz}$ ---

$$\rightarrow I_{max} = \frac{230}{47} = 4.89A$$ ---- 1

$\rightarrow V_L = I_{max} \times X_L = I_{max}(2\pi f_r L)$

$= 4.89 \times (2\pi \times 71.17 \times 0.5)$ ---- 1

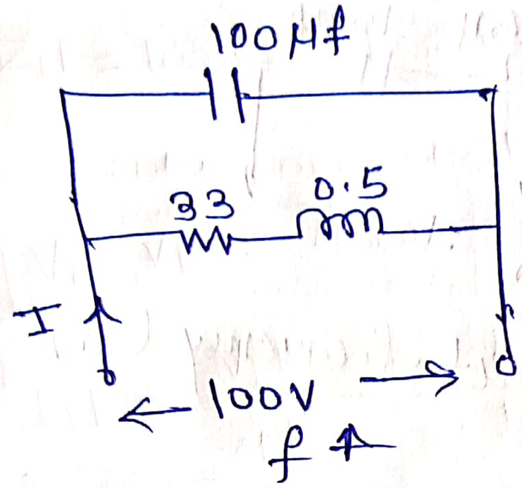
$\boxed{V_L = 1093.34}$ ---

$$\rightarrow Q = \frac{\omega_r L}{R} = \frac{2\pi \times 71.17 \times 0.5}{47}$$ ---

$\boxed{Q = 4.75}$ ---- 1

(c) An inductive coil of resistance 33Ω and inductance of 0.5H is connected in parallel with 100uF capacitor to a variable frequency, 100V supply. Find the frequency at which total current drawn by the circuit is in phase with supply voltage. Also find the value of this current. Find the current flowing through coil and capacitor. 5

⇒



⇒ At resonant freq^n I will be in phase with applied voltage

$$f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}}$$

$$f_r = \frac{1}{2\pi}\sqrt{\frac{1}{0.5 \times 100 \times 10^{-6}} - \frac{(33)^2}{(0.5)^2}}$$

$$f_r = \frac{1}{2\pi}\sqrt{20000 - 4356} =$$

$\boxed{f_r = 19.9\,Hz}$ 1

⇒ $I = \frac{100}{Z_D}$ $\because Z_D = \frac{L}{CR} = \frac{0.5}{100 \times 10^{-6} \times 33} = 151.5$

$I = \frac{100}{151.51} = 0.66\,A$ 2

⇒ $I_C = \frac{V}{X_C} = \frac{100}{X_C}$ $\therefore I_C = 1.25\,A$ 1

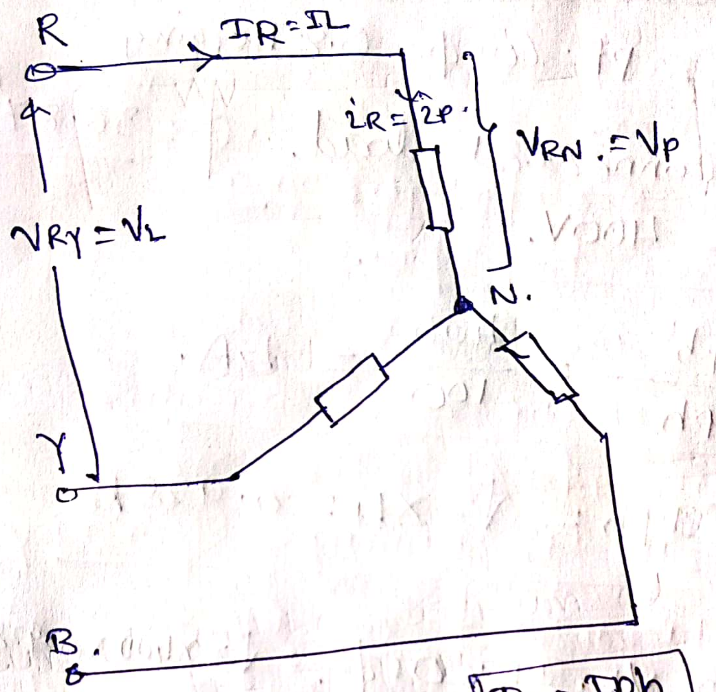
$X_C = \frac{1}{2\pi f_r C} = \frac{1}{2\pi \times 19.9 \times 100 \times 10^{-6}} = 79.97\,\Omega$

V 100

5

Q. 3	**Solve any two of the following** (a) Deduce the relation between phase and line quantities (voltage, current) and power in 3 phase star connected system.	10

5



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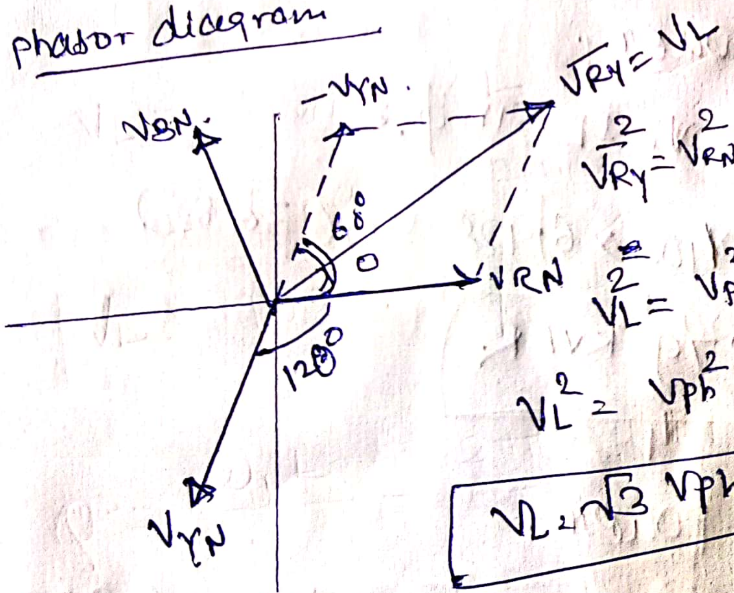
⇒ for star connection $\boxed{I_L = I_{ph}}$.

& $\overline{V_{RY}} = \overline{V_{RN}} + \overline{V_{YN}}$

phasor diagram



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

$V_L^2 = V_{ph}^2 + V_{ph}^2 + 2 V_{ph}^2 \cos 60$

$V_L^2 = V_{ph}^2 + V_{ph}^2 + 2 \cdot V_{ph}^2 \cdot \frac{1}{2}$

2

$\boxed{V_L = \sqrt{3}\, V_{ph}}$

Power = $V_L \cdot I_L \cos\phi$.

$= \sqrt{3}\, V_L I_L \cos\phi$.

1

(b) A balanced load of phase impedance 100 Ω and power factor 0.8(lag) is connected in delta to a 400 V, 3-phase supply.

Calculate 1. Phase and line current 2. Phase and line voltage

3. Active Power 4. Reactive Power 5. Apparent Power

5

$\Rightarrow$ $Z_{ph} = 100\Omega$ $pf = \cos\phi = 0.8$ lagging

In Delta Connected load. $\therefore \phi = 36.87°$

$$\boxed{V_L = V_{ph} = 400V.}$$

1 — $I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{400}{100} = 4A.$

1 — $I_L = \sqrt{3} I_{ph} = \sqrt{3} \times 4 = 6.928A$

Active power

$P = \sqrt{3}.V_L.I_L.\cos\phi. = \sqrt{3} \times 400 \times 6.928 \times 0.8$

1 — $\boxed{P = 3.839 KW.}$

1 Reactive power.

$Q = \sqrt{3} V_L I_L \sin\phi. =$

$= \sqrt{3}\ 400 \times 6.928 \sin(36.87°)$

$$\boxed{Q = 2.879 KVAR.}$$

1 Apparent power.

$S = \sqrt{3}.V_L I_L = \sqrt{3} \times 400 \times 6.928$

$\boxed{S = 4.799 KVA}$

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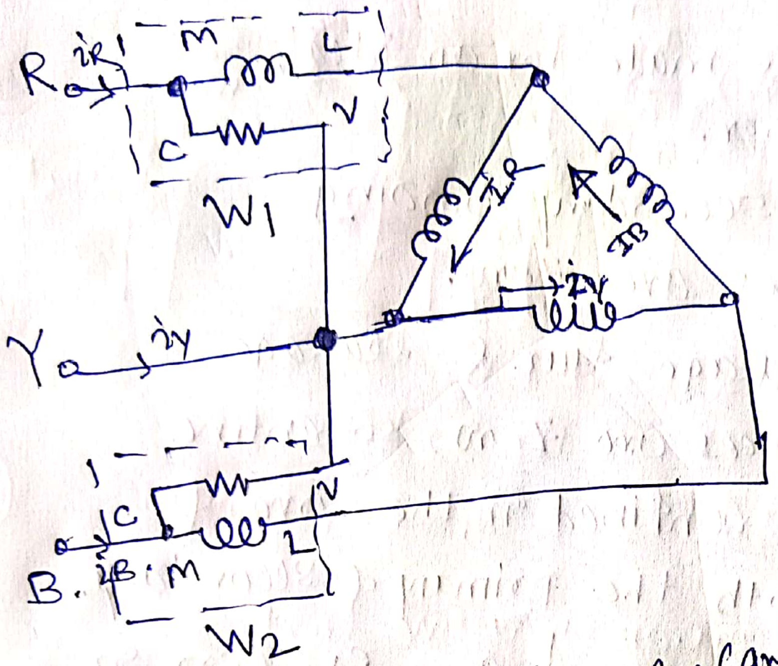
(c) Draw neat circuit diagram showing connection of two watt meter method used to measure power in three phase delta connected inductive load. With neat phasor diagram prove that two watt meters measures total power in this 3 phase load. (5)



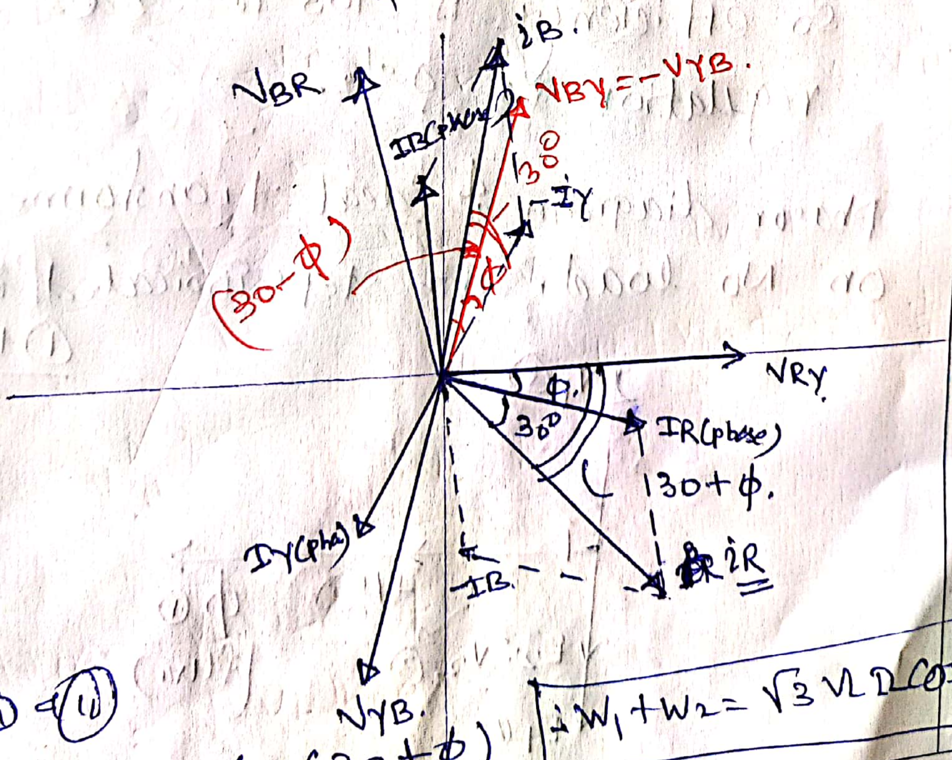
(2)

W_1 (Reading) = $i_R \times V_{RY} \times \cos$ (angle betn i_R & V_{RY}) — (i)

W_2 (Reading) = $i_B \times V_{BY} \times \cos$ (angle betn i_B & V_{BY}) — (ii)

In Delta Connected load $\bar{i}_R = \bar{I}_R - \bar{I}_B$

& $\bar{i}_B = \bar{I}_B - \bar{I}_Y$



(3)

from (i) & (ii)

$W_1 = I_L V_L \cos(30+\phi)$

$W_2 = I_L V_L \cos(30-\phi)$

$\boxed{\therefore W_1 + W_2 = \sqrt{3} V_L I_L \cos\phi.}$

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Q.4	**Solve any two of the following**	10
	(a) What are assumptions made for an ideal transformer? Draw phasor diagram of an ideal transformer with no load.	5

⇒ Assumptions made for an ideal transformer.

i) primary & secondary winding resistances are zero.

ii) The leakage flux & leakage inductances are zero, so entire flux is confined in the core & links both the primary & secondary.

iii) The reluctance of core is zero so negligible mmf is required to establish flux.

iv) The iron & core losses are zero so efficiency is 100% and regulation is 0%.

4

phasor diagram of ideal transformer on No load. with steps indicated from ① to ⑤.

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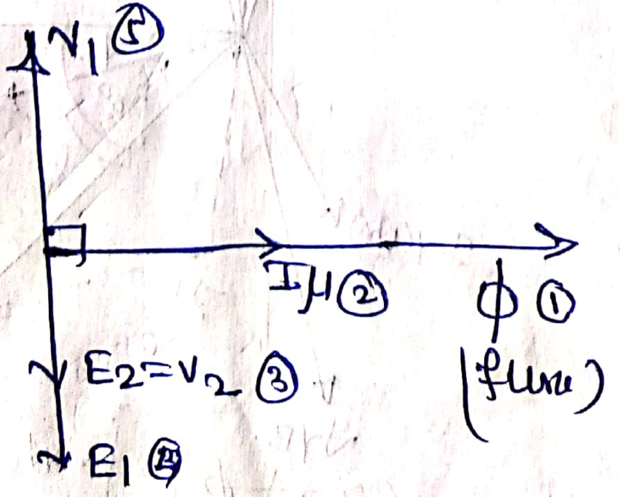

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(b) Derive the condition for maximum efficiency of a transformer.

$$\% \text{ efficiency} = \frac{\text{output power (watts)}}{\text{Input power (watts)}}$$

$$= \frac{\text{output power}}{\text{output power + losses.}}$$

$$\% \ \eta = \frac{V_2 I_2 \cos\phi_2}{V_2 I_2 \cos\phi_2 + W_1 + I_2^2 R_{02}} \quad --$$

Where W_1 & R_{02} represents iron loss & equivalent resistance reffered to the secondary side, respectively.

$$\frac{d\eta}{dI_2} = 0.$$

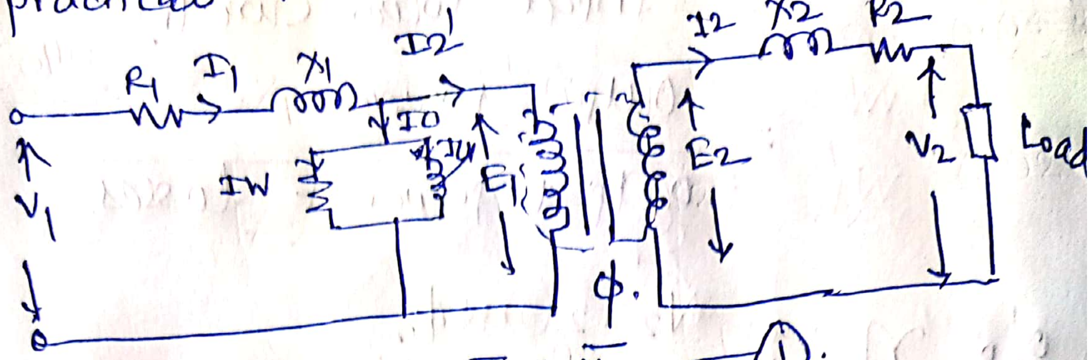
$$\frac{d}{dI_2}\left[\frac{V_2 I_2 \cos\phi_2}{V_2 I_2 \cos\phi_2 + W_1 + I_2^2 R_{02}}\right] = 0$$

Solving

$\boxed{I_2^2 R_{02} = W_1}$ So Variable Copper loss is equal to constant iron loss is the condition for maximum efficiency.

(c) Draw phasor diagram of a practical transformer on inductive load. Indicate all steps used to draw phasor diagram.

⇛ practical transformer equivalent circuit.



$\overline{E_2} = \overline{I_2R_2} + \overline{I_2X_2} + \overline{V_2}$ —— (1).

$I_2' = -KI_2$, $\overline{I_1} = \overline{I_2'} + \overline{I_0}$

$\overline{I_0} = \overline{I_W} + \overline{I_\mu}$ & $V_1 = I_1R_1 + I_1X_1 + E_1$

phasor diagram on inductive load.