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BCT-A
019

classmate
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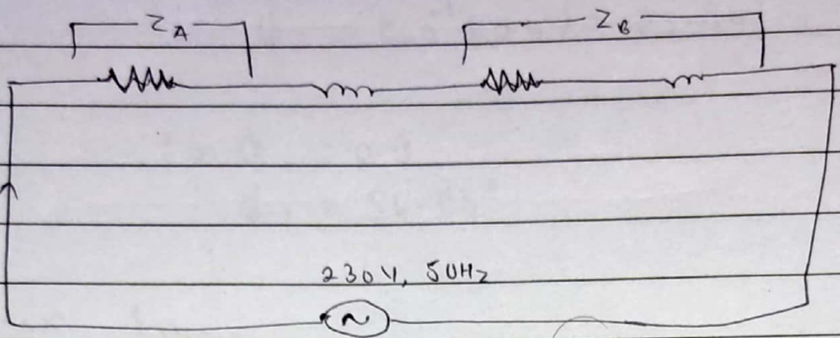
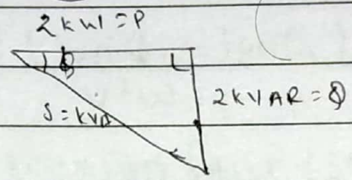
Page

Assignment - 4

Q

→ Sol^n,





$$KVA = \sqrt{2^2+2^2}$$
$$= 2.82$$
$$= 2820\ VA$$

The,

Current through circuit $(I) = \frac{2820}{230} = 12.26A$

Also,

$$P = I^2 R_{eqv.}$$
$$2000 = (12.26)^2 (R_A + R_B)$$
$$\frac{2000}{(12.26)^2} = 5 + R_B$$
$$R_B = 8.30\ \Omega$$

Then,

Impendence of whole circuit $(Z_T) = \frac{230}{12.26}$

$$= 18.76$$

$$X_A + X_B = \sqrt{Z^2 - (R_A + R_B)^2}$$
$$= \sqrt{(18.76)^2 - (5+8.30)^2}$$
$$= \sqrt{(18.76)^2 - (13.3)^2}$$
$$= 13.23\ \Omega$$

Scanned with CamScanner

Now,

$X_B = 2\pi f L_B$

$= 2\pi \times 50 \times 0.018$

$= 5.65\,\Omega$

$X_A = 13.22\,\Omega - 5.65\,\Omega$

$= 7.58\,\Omega$

$2\pi f L_A = 7.58$

$L_A = \frac{7.58}{2\pi f} = \frac{7.58}{2\pi \times 50}$

$= 0.024\,H.$

Then,

$Z_A = \sqrt{R_A^2 + X_A^2}$

$= \sqrt{5^2 + 7.58^2}$

$= 9.080\,\Omega$

Then,

Pd across coil A $= I.Z_A$

$= 12.26 \times 9.80$

$= 120.148\,V.$

$Z_B = \sqrt{R_B^2 + X_B^2} = \sqrt{8.30^2 + 5.65^2}$

$= 10.04\,\Omega$

Then,

Pd. across coil B $= I.Z_B$

$= 12.26 \times 10.04$

$= 123.09\,V$

Inductance of coil A $(L_A) = 0.024\,H$

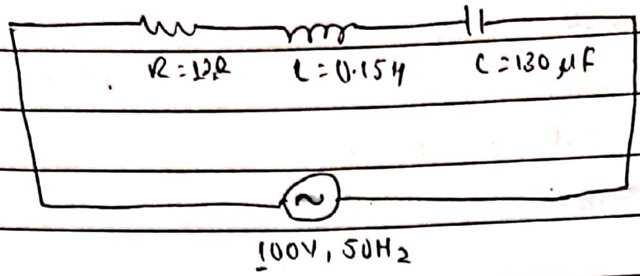
Resistance of coil B $(R_B) : 8.30\,\Omega$

Voltage across each coil. $(V_A) = 120.148\,V$

$(V_B) = 123.09\,V$

Q.4.b

⇒ Soln.



$R = 12\,\Omega$

$L = 0.15\,H$

$C = 130\,\mu F = 130 \times 10^{-6} F$

$f = 50H$

Then,

$$X_L = 2\pi f L = 2\pi \times 50 \times 0.15$$
$$= 47.12\,\Omega$$

$$X_C = \frac{1}{2\pi f C} = \frac{1}{2\pi \times 50 \times 130 \times 10^{-6}}$$
$$= 24.48\,\Omega$$

Then,

i) Impedence $(Z) = R + jX_L - jX_C$
$$= 12 + j47.12 - j24.48$$
$$= 25.62 \angle 62.07^\circ$$

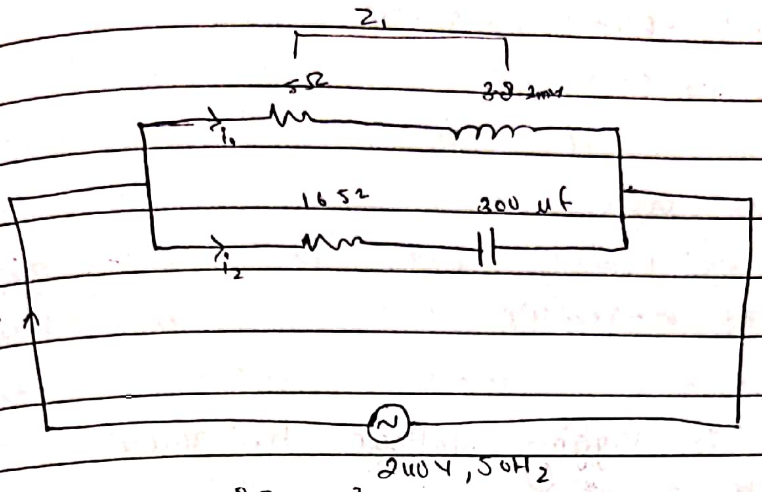
ii) Current through circuit $(I) = \dfrac{100\angle 0^\circ}{25.67\angle 62.07}$
$$= 3.90 \angle -62.07^\circ$$

iii) Phase angle $(\phi) = 62.07^\circ$

iv) Power factor $= \cos\phi$
$$= \cos(62.07)$$
$$= 0.468 \text{ (lagg)}$$

Q4(

$\Rightarrow$ Sol^n:



$L = 38.2\ mH = 38.2 \times 10^{-3} H$

$C = 300\ \mu f = 300 \times 10^{-6} f$

Then,

$X_L = 2\pi f L = 2\pi \times 50 \times 38.2 \times 10^{-3}$

$= 12\ \Omega$

$X_C = \dfrac{1}{2\pi f C} = \dfrac{1}{2\pi 50 \times 300 \times 10^{-6}}$

$= 10.61\ \Omega$

Then

$Z_1 = R_1 + jX_L = 5 + j12$

$= 13 \angle 67.38\ \Omega$

$Z_2 = R_2 - jX_C = 16 - j10.61$

$= 19.198 \angle -33.54\ \Omega$

Now,

(i) Current in each branch

$i_1 = \dfrac{V}{Z_1} = \dfrac{240 \angle 0^\circ}{13 \angle 67.38} = 18.46 \angle -67.38^\circ A$

$i_2 = \dfrac{V}{Z_2} = \dfrac{240 \angle 0^\circ}{19.198 \angle -33.54} = 12.5 \angle 33.54^\circ A$

ii) Total current

$i = i_1 + i_2$

$= 18.46 \angle -67.38 + 12.5 \angle 33.54$

$= 20.23 \angle -30.04° A$

iii) Circuit phase angle

$V = 240 \angle 0° V$

$I = 20.23 \angle -30.04° A$

Hence

current is lagging voltage by 30.04°

$\phi = 30.04°$

iv) circuit impedence

$$Z_T = \frac{Z_1 \times Z_2}{Z_1 + Z_2}$$

$$= \frac{(13 \angle 67.38)(13.198 \angle -33.54)}{(13 \angle 67.38) + (13.198 \angle -33.54)}$$

$= 11.85 \angle 0.045° \Omega$ #

5a)

→ Sol^n,
It is very important to understand that what fraction of total apparent power is actually the active power as active power is required to perform useful work. This factor is known as power factor i.e. the ratio of true or active power to total or apparent power.

i.e.

$$\text{Power factor} = \frac{\text{Active Power (P)}}{\text{Apparent power (S)}} = \frac{VI\cos\phi}{VI}$$

$$= \cos\phi$$

Cause of low power factor.

i) Almost 90% of industrial loads consist of induction machine which draw reactive component of current to produce magnetic field here cause low power factor.

ii) Due to improper wiring or electrical failure power imbalance occurs which is also a cause of low power factor.

Numerical Part.

soln

$V = 240V$ $\quad$ $I = 20A$

$f = 50H_2$ $\quad$ $P = VI\cos\phi = 240 \times 20 \times 0.75$

$= 3600$ watt

$\omega = 2\pi f = 2\pi \times 50$

$pf_1 = 0.75$ (lagging)

$\cos\phi = 0.75$

$\phi = \cos^{-1}(0.75)$

$= 41.40^\circ$

Illy,

$pf_2 = 0.95$ (lagging)

$\cos\phi_2 = 0.95$

$\phi_2 = \cos^{-1}(0.95) = 18.19^\circ$

Then,

If C be the capacitance of capacitor connected in series then,

$$C = \frac{P_1(\tan\phi - \tan\phi_2)}{V^2\omega}$$

$$= \frac{3600\,(\tan 41.40 - \tan 18.19)}{240^2 \times 2\pi \times 50}$$

$$= \frac{3600 \times 0.55}{240^2 \times 2\pi \times 50}$$

$$= 1.094 \times 10^{-4}$$

$$= 1.094 \times 100 \times 10^{-6}$$

$$= 109.4 \times 10^{-6}$$

$$\boxed{C = 109.4\ \mu F}$$

Q.4(c)

=> Sol^n,

Branch 1

since the first branch take a leading current its contains a capactive ~~reactance~~ X_C

Then

$V = (100 + j200)\ V$

$= 223.6 \angle 63.43° V$

Now,

$Z_1 = \frac{V}{i_1} = \frac{223.6}{16} = 13.957\ \Omega$

Then

$Z_1^2 = R_1^2 + X_C^2$

$X_C = \sqrt{(13.975)^2 - 5^2}$

$= 13.04\ \Omega$

$Z_1 = R - jX_C = 5 - j13.04$

$= 13.975 \angle -69°$

Then,

$I_1 = \frac{V}{Z_1} = \frac{223 \angle 63.43}{13.975 \angle -69}$

$= 16 \angle 132.43\ A$

$I = 16 \angle 132.43\ A$

Branch 2:

Total power consumed in both the branches

$$P = I_1^2 R_1 + I_2^2 R_2$$

$$5000 = 16^2 \times 5 + I_2^2 R_2$$

$$I_2^2 R_2 = 3720 W \quad \text{---(i)}$$

Since the power factor is lagging for branch 2, X_2 is inductive.

$$\cos\phi_2 = \frac{R_2}{Z_2}, \quad Z_2 = \frac{R_2}{\cos\phi_2} = \frac{R_2}{0.8} = 1.25 R_2$$

$$I_2 = \frac{V}{Z_2} = \frac{223.6}{1.25 R_2}$$

$$= 178.84 \quad \text{---(ii)}$$

Eq^n (i) → eq^n (ii)

$$\frac{I_2^2 R_2}{I_2 R_2} = \frac{3720}{178.88} \qquad \text{Then } R_2 = \frac{I_2 R_2}{I_2} = \frac{178.88}{20.796}$$

$$I_2 = 20.796 A \qquad = 8.60 \Omega$$

$$Z_2 = 1.25 R_2 = 1.25 \times 8.60$$

$$= 10.75 \Omega$$

Again,

$$Z_2^2 = R_2^2 + X_2^2$$

$$X_2 = \sqrt{Z_2^2 - R_2^2}$$

$$= \sqrt{(10.75)^2 - (8.6)^2}$$

$$= 6.45 \Omega$$

$$Z_2 = R + jX_2$$

$$= 8.6 + j6.45$$

$$= 10.75 \angle 36.87^\circ \Omega$$

$$I_2 = \frac{V}{Z_2} = \frac{223.6 \angle 63.43}{10.75 \angle 36.87}$$

$$\boxed{I_2 = 20.8 \angle 26.56 \, A}$$

finally,

Total current (I) $= I_1 + I_2$

$= 16 \angle 132.43 + 20.8 \angle 26.56^\circ$

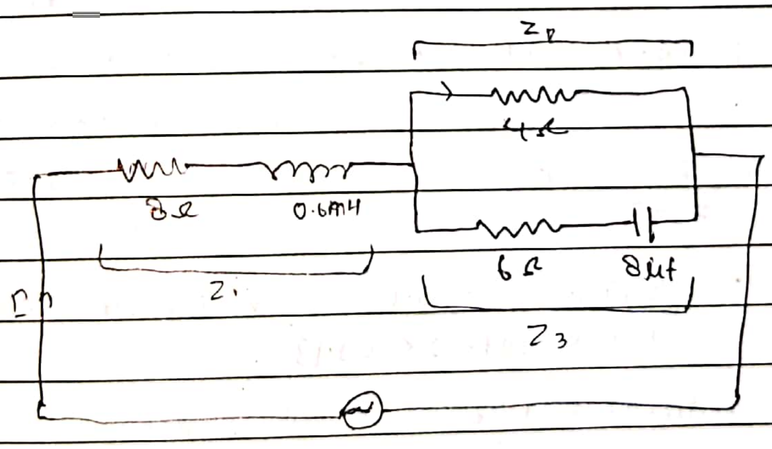
$= 7.81 + 21.1j$

$= 22.5 \angle 69.69^\circ A$

$$\boxed{I = 22.5 \angle 69.69^\circ A}$$

68.Q

=> soln,



for Z_1

$L = 0.6mH = 0.6 \times 10^{-3} H$

$X_L = 2\pi f L = 2\pi \times 50 \times 0.6 \times 10^{-3}$

$= 0.188$

Then,

$Z_1 = 8 + j0.188$

$= 8 \angle 1.34^\circ \, \Omega$

$Z_2 = 4 + j0$

$= 4 \angle 0$

$Z_3 = 6 - jX_c$

$= 6 - j\frac{1}{2\pi 50 \times 8 \times 10^{-6}}$

$= 6 - j397.88$

$= 397.29 \angle -89.13° \, \Omega$

Then

$Z_L = Z_1 + Z_2 \| Z_3$

$= Z_1 + \frac{Z_2 \times Z_1}{Z_2 + Z_2}$

$= 8 \angle 1.34 + \frac{(4\angle 0) \times (397.92 \angle -89.13)}{(4\angle 0) + (397.92 \angle -89.13)}$

$= 11.99 \angle 0.70°$

Then,

$I = \frac{V}{Z_T} = \frac{220 \angle 0°}{11.99 \angle 0.70} = 18.34 \angle -0.70° \, A$

$I = 18.34 \angle -0.70° \, A$

Again,

$I_1 = \frac{Z_3}{Z_2 + Z_3} \cdot I$

$= \frac{397.92 \angle -89.13}{4\angle 0 + 397.92 \angle -89.13} \times 18.34 \angle -0.70°$

$= 18.33 \angle -1.27°$

$I_1 = 18.33 \angle -1.27$

Finally,

$I_2 = I - I_1 = 18.34 \angle -0.70 - 18.33 \angle -1.27°$

$= 0.18 \angle 85.87° A$

$$\boxed{I_2 = 0.18 \angle 85.87° A}$$

Scanned with CamScanner

7.8.4a

⇒ Solⁿ:

$Z_1 = 40 - j318.31 = 320.81 \angle -82.83° A$

$Z_2 = 50 + j62.83 = 80.29 \angle 51.48$

Then

$$Z_T = \frac{Z_1 \times Z_2}{Z_1 + Z_2} = \frac{(320.81 \angle -82.83) \times (80.29 \angle 51.48)}{(320.81 \angle -82.83) + (80.29 \angle 51.48)}$$

$= 70.65 + 60.14j$

$= 95.08 \angle 39.23\ \Omega$

Then,

(i) Current through $(I) = \frac{V}{Z_T} = \frac{100 \angle 0°}{95.08 \angle 39.23}$

$= 1.05 \angle -39.23 A$

(ii) $S = V * I^*$

$= 100 \angle 0° * (1.05 \angle -39.23)^*$

$= 100 \angle 0 * (1.05 \angle -39.23)$

$= 105 \angle 39.23$

$= 81.33 + j66.40$

$= P + jQ$

Active power $(P) = 81.83$ W

Reactive power $(Q) = 66.40$ VAR

Apparent power. $(S) = 105$ VA

Q.54

⇒ ~~Sol~~ⁿ,

The effect of low power factor are as follows.

i) Low power factor for given voltage & given active power requirement of load cause higher current to flow in the circuit requiring higher rating protective device such as fuse, relay etc.

2) Higher flow of current in the circuit leads to the higher heat loss in terms of copper loss in the system thus reducing the overall transmission efficiency.

3) Due to high exchange of reactive power the system, larger voltage drop is observed which makes voltage regulating poor.

⇒ Sol^n,

$P_L = 7\,kW$

$Pf_1 = 0.7$

$\cos\phi_1 = 0.7$

$\phi_1 = 45.57°$

$Pf_2 = 0.9$

$\cos\phi_2 = 0.9$

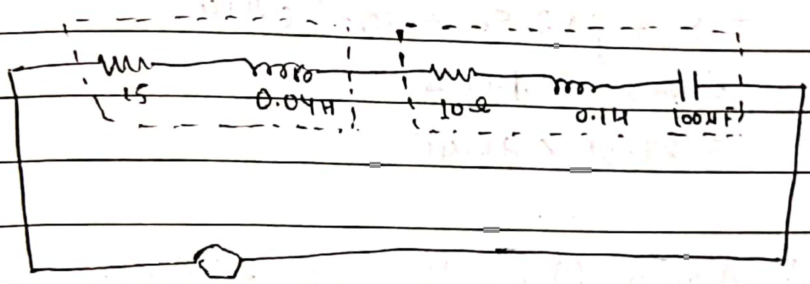
$\phi_2 = 25.84°$

Then $\Rightarrow$ P_t

$$Q_c = P_L (\tan\phi_1 - \tan\phi_2)$$
$$= 7 (\tan 45.57° - \tan 25.84°)$$
$$= 7 \times 0.535$$
$$Q_c = 3.745 \text{ KVAR}$$

9(5a)

$\Rightarrow$ Sol^n,



$\Rightarrow$ $V = 230V$

$f = 50Hz$

for Z_1

$R_1 = 15\ \Omega$

$L_1 = 0.04\ H$

$X_L = 2\pi f X_L = 2\pi \times 50 \times 0.04 = 12.56\ \Omega$

$Z_1 = R_1 + jX_L$

$= 15 + j12.56\ \Omega = 19.56 \angle 39.94\ \Omega$

for Z_2

$R_2 = 10\ \Omega$

$L_2 = 0.1H$

$X_L = 2\pi f L_2 = 2\pi \times 50 \times 0.1$

$= 31.416\ \Omega$

$C = 100\ \mu f = 100 \times 10^{-6}$

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$$X_C = \frac{1}{2\pi f C} = \frac{1}{2\pi \times 50 \times 100 \times 10^{-6}}$$

$$= 31.83\ \Omega$$

Then

$$Z_2 = R_2 + jX_L - jX_C$$
$$= 10 + j31.416 - j31.83$$
$$= 10 - j0.414$$
$$= 10.00 \angle -2.37\ \Omega$$

Then

$$Z_T = Z_1 + Z_2$$
$$= 15 + j12.56 + 10 - j0.414$$
$$= 25 + j12.146\ \Omega$$
$$= 27.91 \angle 26.41^\circ$$

again,

(i) Current drawn $(I) = \frac{V}{Z_T} = \frac{230 \angle 0}{27.91 \angle 26.41}$

$$= 8.24 \angle -26.41$$

(ii) voltage across Z_1 $(V_1) = I.Z_1$

$$= (8.24 \angle -26.41) * (19.56 \angle 39.94)$$
$$= 161.17 \angle 13.53^\circ V.$$

iii) voltage across Z_2 $(V_2) = I.Z_2$

$$= (8.24 \angle -26.41)(10 \angle -2.37)$$
$$= 82.4 \angle -28.83 V.$$

(iv) Here

$$V = 230 V \angle 0$$
$$I = 8.24 \angle -26.41$$

current lags voltage by 26.41°

phase angle $(\phi) = 26.41$.

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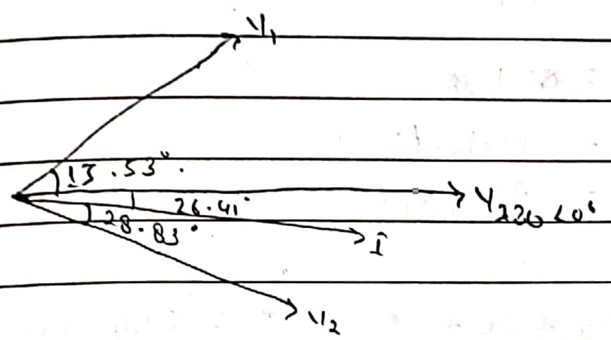
Total power factor $= \cos\phi$

$= \cos(26.41)$

$= 0.895$ (lagg).

v) Phasor diagram



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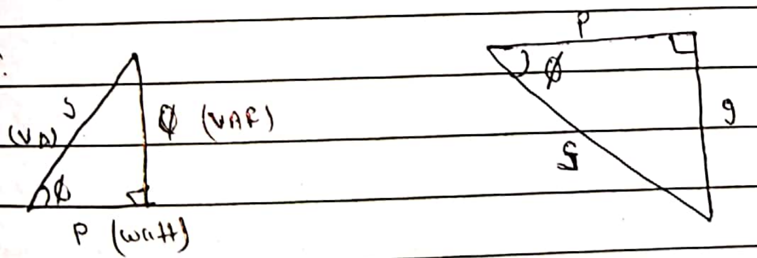
4.b

Q.

⇒ Solⁿ.



Load A

$S_1 = 250$ KVA

$\cos\phi = 0.8$

$\phi = 36.86°$

$P_1 = S \times \cos\phi$

$= 250 \times 0.8$

$= 200$ kW

Load B

$P_2 = 20$ Kw

$\cos\phi = 1$

$\phi = 0.$

$S_2 = \frac{P}{1} = 20$ kVA

$Q_2 = P\tan\phi = 20 \times \tan(0)$

$= 0.$

Load C.

$P_3 = 48$ kW

$\cos\phi = 0.6$

$\phi = \cos^{-1}(0.6)$

$= 53.13$

$S_3 = \frac{P}{0.6} = \frac{48}{0.6}$

$= 80$ kVA

$Q_3 = P \cdot \tan\phi = 48 \times \tan(53.13)$

$= 84$ kVAR

i) total kW $= 200 + 20 + 48 = 268$ kW (P)

ii) total kVAR $= 150 + 0 + 84 = 234$ kVAR (Q)

iii) total kVA $= 250 + 20 + 80 = 350$ kVA (S)

iv) Overall power factor $= \frac{P}{S} = \frac{268}{350} = 0.765$

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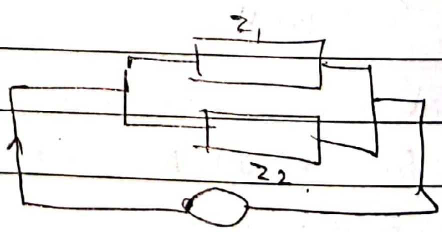
Q. 3.c

=> Sol^n.



$z_1 = 3 - 4j$

$z_2 = 8 + 6j$

& Current (I) = 25 A with no phase diff.

$\phi = 0^\circ$

$I = 25\angle 0^\circ$

Then

$z_T = \frac{z_1 \times z_2}{z_1 + z_2}$

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$$= \frac{(3-4j) \times (8+6j)}{(3-4j) + (8+6j)}$$

$= 4 - 2j$

$= 4.47 \angle -26.56°$

Since they are parallel to each other.

$V_1 = V_2 = i \cdot z$

$= (25 \angle 0)(4.47 \angle -26.56)$

$= 111.75 \angle -26.56.$

Then

Active power $(P) = VI \cos\phi$

$= 111.75 \times 25 \times \cos(26.56)$

$= 2500$ Watts #

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12 · 4.1 (a)

Q

=> Sol^n,

$\vec{V} = 100 \angle 0° \ V$

$\vec{V}_{z_2} = 40 \angle -30 \ V$

Since they are in series

$\vec{V} = \vec{V}_{z_1} + \vec{V}_{z_2}$

$= 100 \angle 0° - 40 \angle -30$

$= 68.35 \angle 17.01° \ V$

$\vec{V}_{z_1} = 68.35 \angle 17.01 \ V$

Now

$$I = \frac{V_{z_1}}{z_1} = \frac{68.35 \angle 17.01}{20 \angle 30}$$

$= 3.418 \angle -12.93° \ A$

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Finally

$$Z_2 = \frac{V_{Z_2}}{I} = \frac{410 \angle -30}{3.418 \angle -12.93}$$

$$= 11.187 - 3.43j$$

$$\check{Z}_2 = 11.76 \angle -17.045 \; j^\circ$$

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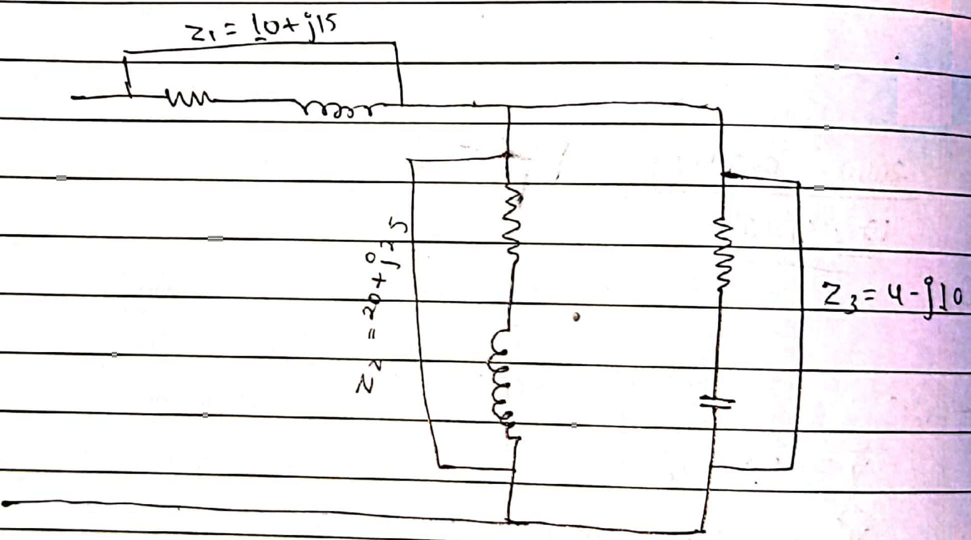
Q 4.

Q.1

=> Soln.



Here,

let Z_T be the equivalent impedance

$$z_1 = 10 + j15$$
$$z_2 = 20 + j25$$
$$z_3 = 4 - j10$$

then,

$$Z_T = Z_1 + Z_2 \| Z_3$$

$$= (10+j15) + \frac{(20+j25) \times (4-j10)}{(20+j25)+(4-j10)}$$

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$= 10 + j15 + \frac{330 - 100j}{24 + 15j}$

$= 18.014 + j5.823$

$$\boxed{Z_T = 18.014 + 5.823j}$$

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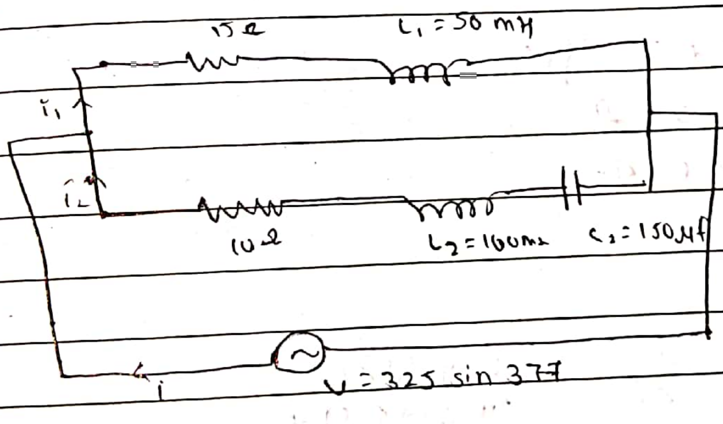
54

Q

→ soln,



voltage (v) = 325 sin 377t
comparing with $v = V_m \sin(\omega t + \phi)$

$V_m = 325$

$\omega = 377$

$\phi = 0°$

Rms voltage (V_{rms}) $= \frac{V_m}{\sqrt{2}} = \frac{325}{\sqrt{2}} = 229.81$ V

$Z_1 = R_1 + jX_{L1}$

$= 15 + j\omega_{L1}$

$\omega_{L1} = 377 \times 50 \times 10^{-3}$

$= 18.85\ \Omega$

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$Z_1 = 15 + j18.85\,\Omega$

$Z_1 = 24.089 \angle 51.48^\circ$

Then,

$Z_2 = R_2 + jX_{L_2} - jX_{C_2}$

$R_2 = 10\,\Omega$

$L_2 = 100\,mH$

$= 100 \times 10^{-3}$

$X_L = 2\pi f L$

$= \omega L$

$= 377 \times 100 \times 10^{-3}$

$= 37.7\,\Omega$

$C_2 = 150\,\mu F$

$= 150 \times 10^{-6}$

$= 1.5 \times 10^{-4}\,F$

Then,

$X_C = \dfrac{1}{\omega C}$

$= \dfrac{1}{377 \times 1.5 \times 10^{-4}}$

Then

$Z_2 = 10 + j37.7 - j17.68$

$= 10 + 20.02j\,\Omega$

$= 22.37 \angle 63.415^\circ$

i) For path 1

current (i) $= \dfrac{V}{Z_1} = \dfrac{229.81 \angle 0^\circ}{24.089 \angle 51.48}$

$= 9.54 \angle -51.48^\circ$

power factor $= \cos\phi_1 = \cos(51.49)$

$= 0.622$ (lagging)

Active power (P) $= VI \cos\phi$.

$= 229.81 \times 9.54 \times 0.622$

$= 1363.66$ watts

(ii) For path 2

current through path 2

$$i_2 = \frac{V}{Z_2} = \frac{229.81 \angle 0^\circ}{22.37 \angle 63.45}$$

$$= 10.27 \angle -63.45^\circ$$

power factor $= \cos\phi_2$

$= \cos(63.45)$

$= 0.44$ (lagging)

Reactive power (Q) $= VI_2 \sin\phi$

$= 229.8 \times 10.27 \times \sin(63.45)$

$= 1038.46$ VAR

(iii) For whole circuit.

$I = i_1 + i_2$

$= 9.54 \angle -51.48 + 10.27 \angle -63.45$

$I = 19.70 \angle -57.68^\circ$

power factor of whole circuit

$= \cos\phi$

$= \cos(57.68)$

$= 0.534$ (lag).

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