* ~~A 220V,~~

* A balanced 3 phase load consists of 3 coils having resistance of 5 Ω and inductance of 0.01 H. It is connected to a 415 V, 50 Hz 3 phase ac supply. Determine Phase voltage, phase current, power factor, active power when loads are connected in (i) star (ii) Delta

→ (i) Star

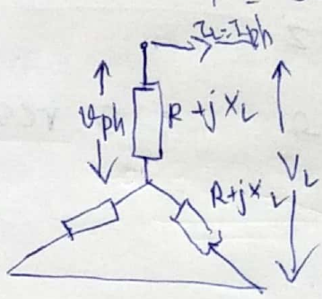
$R = 5\,\Omega$

$L = 0.01$ H

$f = 50$ Hz

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

$I_L = I_{ph}$



$V_L = 415$ V

$V_{ph} = 239.60$ V

Impedance, $|Z| = \sqrt{R^2 + X_L^2}$

$= \sqrt{R^2 + 4\pi^2 f^2 L^2}$

$= \sqrt{25 + 9.869} = \underline{5.904}$

$Z = R + jX_L$

$Z = 5 + j3.14$

$Z = \dfrac{V_{ph}}{I_{ph}}$

$5 + j3.14$

$\cancel{5.904} = \dfrac{239.60}{I_{ph}}$

$\therefore I_{ph} = \underline{40.58 \angle -32.12^\circ \text{ A}}$

$\cos\phi = \dfrac{R}{Z} = \dfrac{5}{5.904} = 0.846$

$\phi = \cos^{-1}(0.846) = \underline{32.22}$

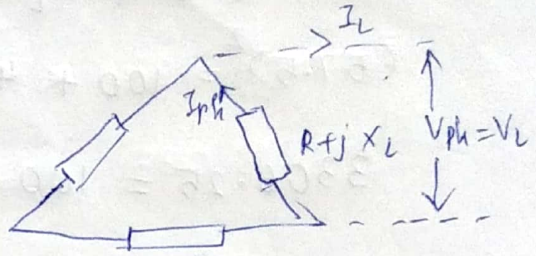
~~Active power = $VI\cos\phi$~~

~~$= \underline{8.225 \text{ kW}}$~~

Active power = $\sqrt{3} V_L I_L \cos\phi$

$= \sqrt{3} \times 415 \times 40.58 \times 0.846$

$= 24.67$ KW



(ii) $V_{ph} = V_L = 415$ V

$I_{ph} = \frac{I_L}{\sqrt{3}}$

R = 5 Ω

$Z = R + jX_L$

$Z = 5 + j3.14$

$Z = \frac{V_{ph}}{I_{ph}}$ $\therefore I_{ph} = \cancel{40.58}\ 83 \angle -32.12^\circ$ A

$I_L = \cancel{70.28}\ 143.76 \angle -32.12^\circ$ A

$\cos\phi = \frac{R}{Z}$ $\therefore \cos\phi = 0.846$

Active power $= \sqrt{3} V_L I_L \cos\phi$ $= \cancel{24.67 \text{ KW}}$ $= 87.42$ KW $\cancel{142.737 \text{ KW}}$

* A 10 Ω resistor and 300mH inductor are connected in series across 230 V sinusoidal voltage. Circuit current is 4 A. Calculate supply frequency and phase angle b/w current and voltage

→ R = 10 Ω

L = 30 mH

I = 4 A

V = 230 V

$Z = \frac{V}{I} = \frac{230}{4} = 57.5$

$Z = \sqrt{R^2 + X_L^2}$

$(57.5)^2 = 100 + 4\pi^2 f^2 \times 9 \times 10^{-6} \times 10^2 \times 10^2$

$3306.25 = 100 + 355.30 \times 10^{-2} f^2$

$f^2 = \frac{3206.25}{355.30} \times 10^{2}$

$f^2 = 9.02 \times 10^4$

$f = \sqrt{9.02 \times 10^{2}} = \cancel{300\ Hz} = 30\ Hz$

$\cos\phi = \frac{R}{Z} = \frac{10}{57.5} = \cancel{79.9}$

$\therefore \phi = 79.98^\circ$

$30\times(2)^2$

900×10^{-6}

$X_L = 56.6$

$X_L = 2\pi f L$

* A series circuit containing capacitance 2µF and a resistor of 500 Ω. An ac source is connected which draws a current of 50 ∠0 mA. The angular frequency of A.C. source is 400π

(i) Draw circuit and find source voltage

(ii) Find voltage across capacitor and resistor

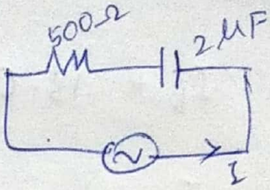
(iii) Draw voltage phasor diagram

$C = 2 \times 10^{-6}\ F$

$R = 500\ \Omega$

$I = 50\ \angle 0\ mA$

$\omega = 400\pi$



$Z = R - jX_C$

$X_C = \frac{1}{C\omega} = \frac{1}{2\times10^{-6}\times400\pi} = 397.88$

$Z = 500 - j397.88$

$|Z| = 638.99$

$Z = 638.99 \angle -38.5$

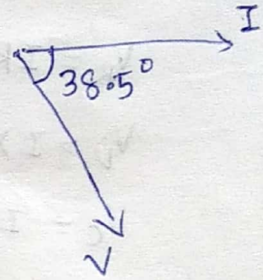
$Z = \frac{V}{I}$

$V = ZI$

$= \underline{31.94 \angle -38.51\, V}$

voltage across resistor, $V_R = I \times R$
$= 25\ V$

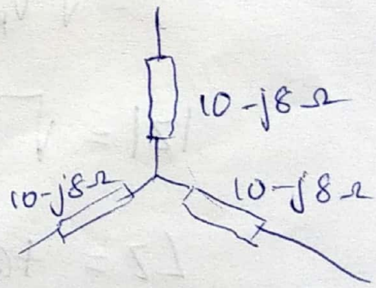
voltage across capacitor, $V_C = I \times X_C$
$= \underline{19.894\, V}$



UDSF GECT

* A 3 phase core wire, 400 V system feeds 3 loads 10-j8 Ω, connected in star. calculate I_L in each phase.

→ star:



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

$V_L = 400\ V$

$V_{ph} = 230.94\ V$

100+64

$Z = 10 - j8\ \Omega$

$Z_{ph} = 10 - j8$

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

$I_{ph} = \frac{230.94}{12.806 \angle -38.6}$

$I_{ph} = 18.033 \angle 38.6$

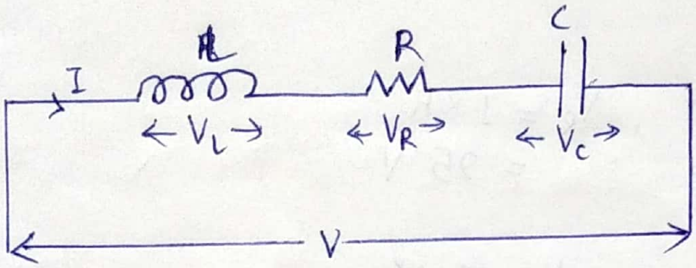
$I_L = 18.033 \angle 38.6$

$I_R = 18.033 \angle 38.6$

$I_Y = 18.033 \angle \cancel{-81.4}\ 158.6$

$I_B = 18.033 \angle \cancel{-38.6}\ 278.6$

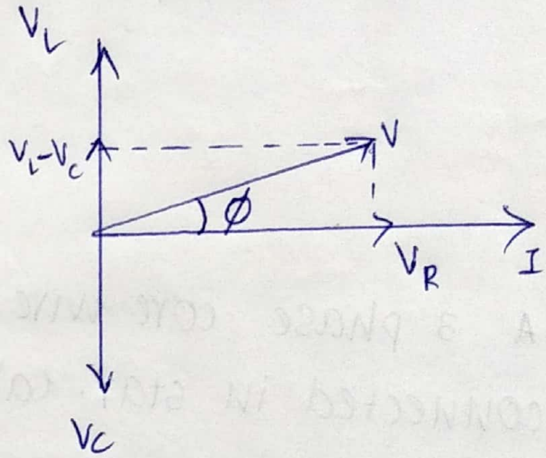
LCR circuit



$V_R = IR$

$V_L = IX_L$

$V_C = IX_C$



$$V = \vec{V_R} + \vec{V_L} + \vec{V_C}$$

$$= \sqrt{V_R^2 + (V_L - V_C)^2}$$

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

$$\angle Z = \tan^{-1}\left(\frac{X_L - X_C}{R}\right)$$

$$Z = R + j(X_L - X_C)$$

$$\cos\phi = \frac{R}{Z}$$

$P = VI\cos\phi$

$Q = VI\sin\phi$ $\qquad$ $S = VI$

3 100 Ω non-inductive resistors are connected in (a) star and (b) delta across a 400 V, 50 Hz 3 phase supply. Calculate power taken from supply in each case. If one of resistor is open circuited, what will be the value of total power taken from mains in each of 2 cases

$V_L = 400\ V$

$f = 50\ Hz$

$R = 100\ \Omega$; 3 resistors

(a) star

$V_{ph} = \frac{V_L}{\sqrt{3}}$, $I_{ph} = I_L$

$X = 0 \quad \therefore Z = R = 100$

$V_{ph} = \frac{400}{\sqrt{3}} = 230.94\ V$

$I_{ph} = \frac{V_{ph}}{Z_{ph}} = 2.30\ A$

$I_L = I_{ph}$

$I_L = 2.30\ A$

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

$= \sqrt{3} \times 400 \times 2.30 \times 1$

$= 1593.486\ kW$

(b) Delta

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

$I_{ph} = \frac{I_L}{\sqrt{3}}$

Power consumed in star connected system

$$V_{ph} = \frac{V_L}{\sqrt{3}}$$

$$I_{ph} = I_L$$

power consumed,

$$P_{star} = 3 \times \frac{V_L}{\sqrt{3}} \times I_L \times \cos\phi$$

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

* A balanced star connected load of $8+j6\ \Omega$ is connected to a 3 phase 230 V supply. Find line currents, phase currents, active power, reactive power, total Volt ampere, pf

→ $V_L = 230\text{V}$

UDSF GECT

$Z_{ph} = 8+j6\ \Omega$

star connection

$$V_{ph} = \frac{V_L}{\sqrt{3}} = \frac{230}{\sqrt{3}} = 132.79$$

$$I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{132.79}{\sqrt{64+36}\angle 36.8} = 13.279\angle -36.8\text{ A}$$

$$= 10.632 - j7.95$$

$8+j6$

$10\angle$

$$I_L = I_{ph} = 13.279\angle -36.8\text{ A}$$

Power factor $= \cos\phi = 0.8007$

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

$P = \sqrt{3} \times 230 \times 13.279 \cancel{\angle -36.8} \times 0.8007$

$P = 4.235\ KW$

reactive power,

$Q = \sqrt{3}\, V_L I_L \sin\phi$ $V_L = 230$

$I_L = 13.279$ VA

$Q = 3.171\ KVAR$ $P =$

total VA $= \sqrt{3}\, V_L I_L$ (apparent)

$= \sqrt{3} \times 230 \times 13.279$

$= 5.289\ KVA$

I_R, I_Y, I_B

UDSF GECT

$I_R = 13.279 \angle -36.8^\circ\ A$

$I_Y = 13.279 \angle -156.8^\circ\ A$ phase diff. of 120°

$I_B = 13.279 \angle -276.8^\circ\ A$

$I_R = I_Y = I_B$ = phase currents

* A 400 V, 50 Hz 3 phase supply is applied across 3 terminals of a delta connected 3 phase load. The resistance and reactance of each phase is 6 Ω and 8 Ω. calculate I_L, I_{ph}, P, Q, apparent power

→ $f = 50\ Hz$

$V_L = 400\ V$ $I_L = \sqrt{3}\, I_{ph}$

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

$R = 6\ \Omega$ $X = 8\ \Omega$

$\cancel{I_L = \frac{V_L}{R} = \frac{400}{6} = 66.66\ A}$

$\cancel{I_L = \sqrt{3}\ I_{ph}}$

$\cancel{I_{ph} = 38.48\ A}$

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

$$Z_{ph} = 6 + j8$$

$$I_{ph} = \frac{400}{10\angle 53.13} = 40 \angle -53.13$$

$$I_L = \sqrt{3}\ I_{ph}$$

$$I_L = 69.28 \angle -53.13$$

$$P = \sqrt{3}\ V_L I_L \cos\phi$$

$$= \sqrt{3} \times 400 \times 69.28 \times \cos(53.13)$$

$$= 28.79\ KW$$

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

$$= \sqrt{3} \times 400 \times 69.28 \times \sin(53.13)$$

$$= 38.398\ KVAR$$

apparent power, $S = \sqrt{3}\ V_L I_L$

$$= \sqrt{3} \times 400 \times 69.28$$

$$= 47.998\ KVA$$

power factor $= 0.6$

* 3 impedances $Z_1 = 8 + j6\ \Omega$, $Z_2 = 4 + j3\ \Omega$ and $Z_3 = 18 - j9\ \Omega$ are connected in series across ac supply. If voltage drop across Z_1 is $40 + j30$ V, calculate
(i) current in circuit (ii) voltage drop across Z_2, Z_3
(iii) Total supply voltage (iv) Total power consumed
(v) Power factor (vi) Draw phasor diagram.

(i)

$Z_1 = 8 + j6\ \Omega$

$Z_2 = 4 + j3\ \Omega$

$Z_3 = 18 - j9\ \Omega$

Voltage drop across $Z_1 = 40 + j30$ V

$$I_1 = \frac{|V|}{|Z|} = \frac{\sqrt{40^2 + 30^2}}{\sqrt{8^2 + 6^2}} = \frac{50}{10} = 5A$$

Since series connection, current will be same

$\therefore$ Total current in circuit $= 5$ A

(ii)

$$V_{z1} = I \times Z_1$$
$$= 5(8 + j6)\ V = 40 + 30j$$

$$V_{z2} = I \times Z_2$$
$$= 5(4 + j3)\ V = 20 + j15\ V$$

$$V_{z3} = I \times Z_3$$
$$= 5(18 - j9)\ V = 90 - j45\ V$$

(iii)

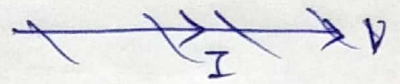
$$\text{Total voltage} = V_{z1} + V_{z2} + V_{z3}$$
$$= 5(8 + 4 + 18) + j5(3 + 6 - 9)$$
$$= 5 \times (30 + 0j) = 150 + 0j\ V$$

(iv) Power, $P = VI\cos\phi = 150 \times 5 \times \cos 0 = \cancel{450\text{ W}} \Rightarrow 750\text{W}$

(v) Power Factor, $\cos\phi = \frac{R}{Z} = \frac{30}{30} = 1$

$\phi = \cos^{-1}(1) = 0$

(vi) Phasor



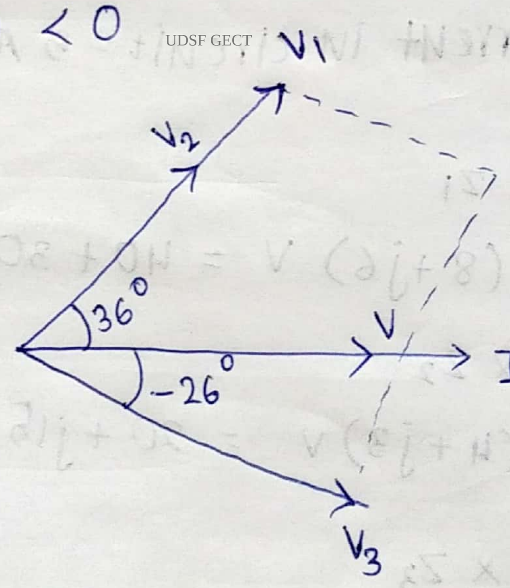
polar form

$V_1 = 40 + j30 = 50 \angle 36.8698$

$V_2 = 20 + j15 = 25 \angle 36.8698$

$V_3 = 90 - j45 = 100.62 \angle -26.565$

$V = 150 \angle 0$



$\frac{1600}{900}$
2500

$\theta = \tan^{-1}\left(\frac{3}{4}\right)$

$\tan^{-1}\left(\frac{3}{4}\right)$

$\frac{150 \times 5}{750}$

* A circuit consists of resistor of value 50 Ω and an inductor of 1 mH. Under steady state condition, what is the value of energy stored in inductor if applied voltage is 150 V dc ?

$R = 50\,\Omega$

$L = 1\,mH$

$V = 150\,V$

$E = \frac{1}{2} L I^2$

$I = \frac{V}{R} = \frac{150}{50} = 3\,A$

$E = \frac{1}{2} L I^2$

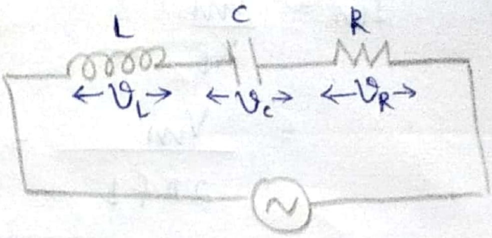
$= \frac{1}{2} \times 10^{-3} \times 9$

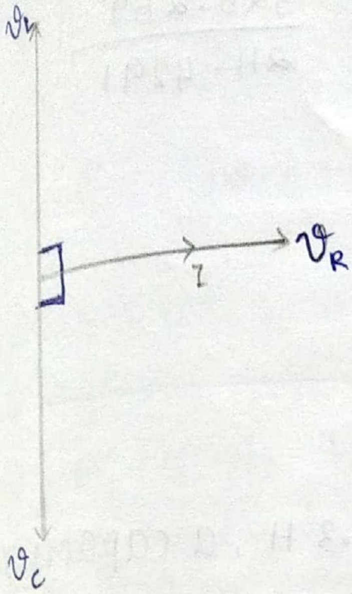
$E = \underline{\underline{4.5 \times 10^{-3}\,J}}$

under steady state condition,
→ inductor act as short circuit
→ capacitor act as open circuit
→ LR circuit act as resistive

generating system

Series LCR circuit





$$v = IR + jIX_L - jIX_C$$

$$v = I[R + j(X_L - X_C)]$$

$$Z = R + j(X_L - X_C)$$; Impedance

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

$$\phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right)$$

$\cos\phi = \dfrac{R}{Z}$; power factor

A 50 Hz, 230 V is applied to a 0.673 H inductor. Write the time equation for applied voltage and current through inductor assuming that when $t=0, v=0$ and is going +ve.

$V_{rms} = 230$ V

$f = 50$ Hz

$L = 0.673$ H

$v_m = v_{rms} \times \sqrt{2}$

$v = v_m \sin\omega t$

$v = 325.269 \sin\omega t = 325.269 \sin 314t$

$I = I_m \sin(\omega t - \pi/2)$

$$I_m = \frac{V_m}{X_L}$$

$$= \frac{V_m}{2\pi f L} = \frac{325.269}{2\pi \times 50 \times 0.673} = \frac{325.269}{211.4291}$$

$$I_m = 1.5384 \text{ A}$$

$$I = 1.538 \sin(\omega t - \pi/2) \text{ A}$$

$$I = 1.538 \sin(314t - \pi/2) \text{ A}$$

* A resistor of $10\,\Omega$, an inductor of 0.3 H, a capacitor of 'c' are connected in series across 230 V, 50 Hz main supply. ($C = 100\,\mu F$)
Calculate
(i) Impedance
(ii) current
(iii) V_R, V_L, V_C
(iv) Power in watts
(v) Power factor

→ (i) $X_L = 2\pi f L = 94.24$

$$X_C = \frac{1}{2\pi f C} = \cancel{3.18 \times 10}\ 31.847$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{100 + 3892.886} = 63.149\,\Omega$$

(ii)

$$I_{rms} = \frac{V_{rms}}{Z} = 3.64 \text{ A}$$

(iii) $V_R = IR = 3.64 \times 10 = 36.4$ V

$V_L = IX_L = 343.03$ V

$V_C = IX_C = 115.923$ V

$\cos\phi = \frac{R}{Z} = \frac{10}{63.149} = \underline{\underline{0.158}}$

$P = V_{rms} I_{rms} \cos\phi$

$P = 132.277 \text{ W}$

A circuit takes a current of 3A at a power factor of 0.6 lagging when connected to 150V, 50 Hz. Another circuit takes a current of 5A at a P.F. of 0.8 leading when connected to same supply. If these 2 circuits are connected in series to 230V, 50 Hz supply, calculate current drawn from circuit

1st circuit : RL   2nd circuit : RC

Impedance of 1st circuit :

case 1: $\cancel{Z}\cos\phi = 0.6$

$\phi = -53.13$

$I_1 = 3 \text{ A}$

$= 3 \angle -53.13 \text{ A}$

$I_2 = 5 \text{ A}$

$= 5 \angle 36.86 \text{ A}$

$Z_1 = \frac{V}{I_1} = \frac{150}{3 \angle -53.13} = 50 \angle 53$

$Z_2 = \frac{V}{I_2} = \frac{150}{5 \angle 36.86} = 30 \angle -36.86$

1st circuit :   2nd circuit :

$Z_1 = 30.09 + j\,39.93$, $24.003 - 17.99j = Z_2$

$\therefore Z = Z_1 + Z_2 = 54.093 + j\,21.94$

$$\cancel{I = \frac{V}{Z} = \frac{230}{\sqrt{(54.093)^2+(21.94)^2}}}$$

$$Z = |Z| \angle \theta$$

$$Z = 58.37 \angle 22.166$$

$$I = \frac{V}{Z} = 3.94\ A$$

* A series circuit with R and L draws a current of 1A when connected across 10 V, 50 Hz supply. Assuming the resistance to be 5 Ω, Find inductance. what is the power factor? Draw phasor diagram.

→ $I = 1\ A$

$R = 5\ \Omega$

$V = 10\ V$

$f = 50\ Hz$

$$Z = \frac{V}{I} = 10$$

$$\cos\phi = \frac{R}{Z} = \frac{5}{10} = \underline{\underline{0.5}}$$

$V_R = IR$
$= 5\ V$

$$Z = \sqrt{R^2 + X_L^2}$$

$$Z^2 = R^2 + (2\pi f L)^2$$

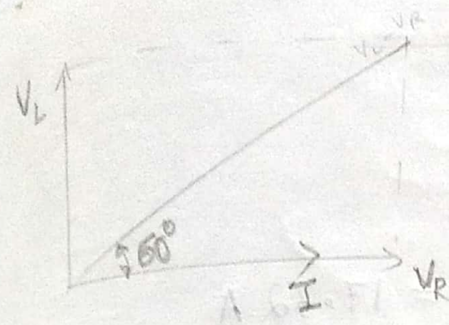
$$100 = 25 + 4\pi^2 \times 2500 \times L^2$$

$$75 = 4\pi^2 \times 2500 \times L^2$$

$$L^2 = 0.0007599$$

$$\therefore L = 0.0275$$

$$\therefore \underline{\underline{L = 2.7 \times 10^{-2}\ H}}$$



The apparent power drawn by an A.C. circuit is 10kVA and active power is 8kW. What is the reactive power? what is the power factor?

$$\text{power factor} = \frac{\text{active power}}{\text{apparent power}}$$

$S = P + jQ$ $\qquad S = 10\,kVA$

$S = \sqrt{P^2 + Q^2}$ $\qquad P = 8\,kVA$

$$10 \times 10^3 = \sqrt{(8\times10^3)^2 + Q^2}$$

$$10^8 = 64\times10^6 + Q^2$$

$$Q^2 = 10^8 - 0.64\times10^8$$

$$Q^2 = 0.36\times10^8$$

$$Q = 0.6\times10^4 = 6\,kVAR$$

$$\text{power factor} = \frac{8}{10} = 0.8$$

* Find the rms value of resultant current in a wire carrying simultaneous a dc 10 A and sinusoidal ac of peak value 20 A.

$I_{dc} = 10\,A$

$I_m = 20\,A$

→ $i = I_{dc} + I_m \sin \omega t$

$i = 10 + 20 \sin \omega t$

$$I_{rms}^2 = I_{dc}^2 + \left(\frac{I_m}{\sqrt{2}}\right)^2$$

$$= 10^2 + \left(\frac{20}{\sqrt{2}}\right)^2$$

$$I_{rms} = \sqrt{100 + 200} = \sqrt{300} = \underline{17.32 \text{ A}}$$

* The waveform of voltage and current of a circuit are given by $E = 120 \sin(314t)$ and $I = 10 \sin(314t + \pi/6)$. calculate value of resistance and capacitance which are connected in series with circuit. Also draw waveform of V, I, phasor diag. calculate power consumed by circuit

→ $E_m = 120$ V

$\omega = 314$ $\qquad \phi = \pi/6$

$I_m = 10$ A $\qquad V_{rms} = \frac{120}{\sqrt{2}}$ $\quad I_{rms} = \frac{10}{\sqrt{2}}$

$Z = \frac{V_{rms}}{I_{rms}} = \frac{120}{10} = \underline{12}$ $\quad \angle\phi = 30^\circ$

$2\pi f = 314$

$f = 50$ Hz

$Z = |Z| \angle \phi$

$Z = 12 \angle 30^\circ$ $\qquad Z = R + jX$

$Z = 6\sqrt{3} + 6i$

$R = 6\sqrt{3} = \underline{10.39\ \Omega}$

~~$P = I^2R$~~

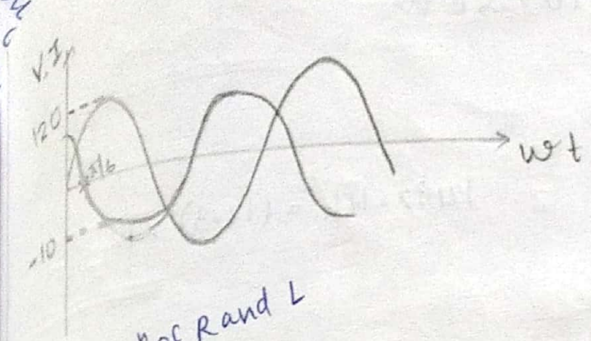
$P = V_{rms} \times I_{rms} \times \cos\phi$

$= \frac{120}{\sqrt{2}} \times \frac{10}{\sqrt{2}} \times \frac{\sqrt{3}}{2} = \underline{519.61 \text{ W}}$

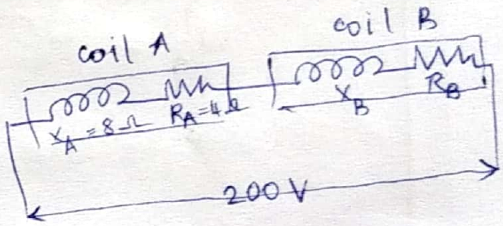
$X = 6$

$\frac{1}{2\pi f C} = 6$

$C = \frac{1}{2\pi f \times 6} = 5.3 \times 10^{-4}$ F $= 530\ \mu$F



2 (coils) combinatⁿ of R and L A and B are connected in series across 200V, 50 Hz AC supply. The power input to circuit 2.2 kW and 1.5 kVAR. If resistance of coil A is 4Ω, reactance is 8Ω, calculate resistance and reactance of coil B. Also calculate active power consumed by coil A and B, total impedance of circuit



$V = 200\ V$

$f = 50\ Hz$

$R_A = 4\ \Omega$

$X_A = 8\ \Omega$

$P = 2.2\ kW$

$Q = 1.5\ kVAR$

4.84
2.25

$S = P + jQ$

$S = \sqrt{P^2 + Q^2} = \sqrt{(2.2\times10^3)^2 + (1.5\times10^3)^2} = 2.66\ KVAR$

$S = VI$

$I = \frac{2.66\times10^3}{200} = \cancel{0.0133\ A} = 13.3\ A$

$V_A = IR_A = 13.3 \times 4 = 53.2\ V$

$V_B = 146.8$

$X_B = \frac{V_B}{I} = 11.03\ \Omega$

$P_A = I^2 R_A = (13.3)^2 \times 4 = 707.56\,W$

$P_T = P_A + P_B$

$1492.44 = (13.3)^2 \times R$

$P_B = 1492.44$

$R_B = 8.043\,\Omega$

Total impedance, $Z = \frac{V}{I}$

$Z = \sqrt{R^2 + X^2}$

$Z = \sqrt{R_A^2 + R_B^2 + X_A^2 + X_B^2}$

$\frac{V}{I} = \sqrt{R_A^2 + R_B^2 + X_A^2 + X_B^2}$

$\frac{200}{13.3} = \sqrt{16 + 71.0649 + 64 + X_B^2}$

$15.03 = \sqrt{151.0649 + X_B^2}$

UDSF GECT

$X_B = 15.03 - 12.290$

$X_B = 2.74$

$Z = \frac{V}{I} = \sqrt{(R_A + R_B)^2 + (X_A + X_B)^2}$

$15.03 = \sqrt{(12.43)^2 + (8 + X_B)^2}$

solving,

$X_B = 0.46\,\Omega$

$P_A = I^2 R_A = 707.56\,W$

$P_B = I^2 R_B = 1491.18\,W$

Total impedance = ...