Q44) $W_1 = 2500W$

$W_2 = 500W$

i) When both readings are positive

$$\tan\phi = \sqrt{3}\left(\frac{W_1 - W_2}{W_1 + W_2}\right) = \sqrt{3}\left(\frac{2500 - 500}{2500 + 500}\right)$$

$\therefore \phi = 49.1°$

$pf = \cos\phi = 0.66$

ii) $W_1 = 2500W$

$W_2 = -500W$

When one wattmeter is reversed

$$\tan\phi = \sqrt{3}\left(\frac{W_1 - W_2}{W_1 + W_2}\right) = \sqrt{3}\left(\frac{2500 + 500}{2500 - 500}\right)$$

$\therefore \phi = 68.95°$

$pf = \cos\phi = 0.36$

Q45) $i = 141.4 \sin 314t$

Comparing with $i = I_m \sin \omega t$

i) Peak value $= I_m = 141.4A$

ii) $\omega = 314$

$\because \omega = 2\pi f$

$\therefore 314 = 2\pi f$

$\therefore f = 49.98Hz$

iii) $T = \frac{1}{f} = 0.02 sec$

iv) $t = 3\times10^{-3} sec$

$i = 141.4 \sin 314(3\times10^{-3})$

$= 141.4 \times 0.016$

$= 2.32A$

846) Time period is $0<t<T$

$v = V_m \quad , 0<t<T/2$

$\;\; = 0 \quad , T/2<t<T$

$$v_{avg} = \frac{1}{T}\int_0^T v\,dt = \frac{1}{T}\int_0^{T/2} V_m\,dt = \frac{V_m}{T}\int_0^{T/2} dt = \frac{V_m}{T}\left[t\right]_0^{T/2}$$

$$\therefore v_{avg} = \frac{V_m}{T}\left[\frac{T}{2}\right] = \frac{V_m}{2}$$

$$v_{rms} = \sqrt{\frac{1}{T}\int_0^T (v)^2 dt} = \sqrt{\frac{1}{T}\int_0^{T/2} (V_m)^2 dt} = \sqrt{\frac{V_m^2}{T}\left[t\right]_0^{T/2}}$$

$$= \sqrt{\frac{V_m^2}{T}\left[\frac{T}{2}\right]} = \frac{V_m}{\sqrt{2}}$$

847) $f = 50Hz$

$X_{L_1} = 2\pi f L_1 = 2\pi \times 50 \times 0.0191 = 6\Omega$

$X_{C_2} = \frac{1}{2\pi f C_2} = \frac{1}{2\pi \times 50 \times 398 \times 10^{-6}} = 8\Omega$

$X_{L_3} = 2\pi f L_3 = 2\pi \times 50 \times 0.0138 = 4.34\Omega$

Let $Z_1 = R_1 + jX_{L_1} = 2 + j6$

$Z_2 = R_2 - jX_{C_2} = 7 - j8$

$Z_3 = R_3 + jX_{L_3} = 8 + j4.34$

$I_2 = 10A$

$V_2 = I_2 \times Z_2 = 10(7 - j8) = 70 - j80$

$V_2 = V_1 = 70 - j80$

$I_1 = \frac{V_1}{Z_1} = \frac{70 - j80}{2 + j6} = -8.5 - j14.5$

$I = I_1 + I_2$ (only in rectangular or cartesian form)

$\therefore I = -8.5 - j14.5 + 10 = 1.5 - j14.5$

$\frac{1}{Z_p} = \frac{1}{Z_1} + \frac{1}{Z_2} \quad \therefore Z_p = 5.95 + j4.21$

Total $Z = Z_p + Z_3 = 13.95 + j8.55$

$V_{AB} = IZ$

$= (1.5 - j14.5)(13.95 + j8.55)$

$= 144.9 - j189.45 = 238.51 \angle -52.59°$

Q48) Let $Z_1 = R = 30\Omega$

$V = 110V$

$f = 50Hz$

$I = 5A$

Let $Z_2 = -jX_C$

$$\frac{1}{Z} = \frac{1}{Z_1} + \frac{1}{Z_2} = \frac{1}{30} - \frac{1}{jX_C} = \frac{1}{30} + \frac{j}{X_C} = \frac{X_C + j30}{30X_C}$$

$$\therefore Z = \frac{30X_C}{X_C + j30} \times \left(\frac{X_C - j30}{X_C - j30}\right) = \frac{30X_C^2}{X_C^2 + 900} - j\frac{900X_C}{X_C^2+900}$$

$$\therefore |Z| = \sqrt{\left(\frac{30X_C^2}{X_C^2+900}\right)^2 + \left(\frac{900X_C}{X_C^2+900}\right)^2}$$

$\because |V| = |I||Z|$

$$\therefore 110 = 5 \times \sqrt{\frac{900X_C^4 + 810000X_C^2}{(X_C^2+900)^2}}$$

$\therefore 484(X_C^2+900)^2 = 900X_C^4 + 810000X_C^2$

$484X_C^4 + 871200X_C^2 + 392040000 = 900X_C^4 + 810000X_C^2$

$\therefore 416X_C^4 - 61200X_C^2 - 392040000 = 0$

$X_C^2 = 1047.12\Omega$

$\therefore X_C = 32.36\Omega$

$X_C = \frac{1}{2\pi fC} \quad \therefore 32.36 = \frac{1}{2\pi \times 50 \times C} \quad \therefore C = 9.84 \times 10^{-5} F$

When $I = 4A$

$\because |V| = |I| \cdot |Z|$

$$\therefore 110 = 4 \times \sqrt{\frac{900X_C^4 + 810000X_C^2}{(X_C^2+900)^2}}$$

$756.25(X_C^2+900)^2 = 900X_C^4 + 810000X_C^2$

$756.25X_C^4 + 1361250X_C^2 + 612562500 = 900X_C^4 + 810000X_C^2$

$143.75X_C^4 - 551250X_C^2 - 612562500 = 0$

$\therefore X_C^2 = 4734.78\Omega$

$\therefore X_C = 68.81\,\Omega$

$X_C = \dfrac{1}{2\pi f_1 C}$

$\therefore 68.81 = \dfrac{1}{2\pi f_1 \times 9.84\times10^{-5}}$

$\therefore f_1 = 23.51\,Hz$

Q49) For coil A:-

$I_1 = 2A$

$Pf_1 = \cos\phi_1 = 0.8$ (lag)

$V_1 = 10V$

$Z_1 = \dfrac{V_1}{I_1} = \dfrac{10}{2} = 5\,\Omega$

$\cos\phi_1 = \dfrac{R_1}{Z_1}$

$\therefore 0.8 = \dfrac{R_1}{5}$ $\therefore R_1 = 4\,\Omega$

$Z_1 = \sqrt{R_1^2 + X_{L_1}^2}$

$\therefore 5 = \sqrt{(4)^2 + X_{L_1}^2}$

$\therefore X_{L_1} = 3\,\Omega$

For coil B:-

$I_2 = 2A$

$Pf_2 = \cos\phi_2 = 0.7$ (lag)

$V_2 = 5V$

$Z_2 = \dfrac{V_2}{I_2} = \dfrac{5}{2} = 2.5\,\Omega$

$\cos\phi_2 = \dfrac{R_2}{Z_2}$

$\therefore 0.7 = \dfrac{R_2}{2.5}$ $\therefore R_2 = 1.75\,\Omega$

$Z_2 = \sqrt{R_2^2 + X_{L_2}^2}$

$\therefore 2.5 = \sqrt{(1.75)^2 + X_{L_2}^2}$

$\therefore X_{L_2} = 1.79\,\Omega$

(i) When coil A and B are connected in series

$\because Z_1 = R_1 + jX_{L_1} = 4 + j3$

$Z_2 = R_2 + jX_{L_2} = 1.75 + j1.79$

Total $Z = Z_1 + Z_2 = 5.75 + j4.79$

$I = 2A$

$V = I.Z = 11.5 + j9.58 = 14.97\angle 39.8^\circ$

(ii) When coil A and B are connected in parallel

$\dfrac{1}{Z} = \dfrac{1}{Z_1} + \dfrac{1}{Z_2}$

$\therefore Z = 2.11 + j0.57$

$I = 2A$

$V = I.Z = 4.22 + j1.14 = 4.36\angle 15.17^\circ$

Q50) $V_L = 173.2V$

$W_1 = 301W$

$W_2 = 1327W$

Total power $= W_1 + W_2$

$= 301 + 1327 = 1628W$

$\tan\phi = \sqrt{3}\left(\frac{W_1 - W_2}{W_1 + W_2}\right) = \sqrt{3}\left(\frac{301 - 1327}{301 + 1327}\right)$

$\therefore \phi = -47.51°$

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

$\therefore 1628 = \sqrt{3} \times 173.2 \times I_L \cos(-47.51)$

$\therefore I_L = 8.03A$

For star connection,

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

$\therefore 173.2 = \sqrt{3} V_{ph}$

$\therefore V_{ph} = 100V$

$I_L = I_{ph} = 8.03A$

$Z_{ph} = \frac{V_{ph}}{I_{ph}} = \frac{100}{8.03} = 12.45\Omega$

Q51) $S = 5031\angle 26.57°\,VA = 4499.67 + j2250.32$

$V = 212.1\angle 0° = 212.1 + j0$

Since $\boxed{\text{Apparent Power} = \text{Active Power} + j\,\text{Reactive Power}}$

$\therefore$ Active power $= 4499.67W$

Reactive power $= 2250.32\,VAR$

Active power $= 4499.67 = VI\cos\phi$

$4499.67 = 212.1 \times I\cos\phi$

$\therefore I\cos\phi = 21.22$ —— (I)

Reactive power $= VI\sin\phi$

$2250.32 = 212.1 \times I\sin\phi$

$\therefore I\sin\phi = 10.61$ —— (II)

Dividing eqn (I) by eqn (II)

$\therefore \tan\phi = 0.5$

$\therefore \phi = 26.57°$

Subs. in eqn (I)

$\therefore I\cos(26.57) = 21.22$

$\therefore I = 23.73A$

$Z = \frac{V}{I} = \frac{212.1}{23.73} = 8.94\,\Omega$

Q52) Reactive power $= 15\,KVAR = 15,000\,VAR$

$Pf = 0.8$ (lag)

$\therefore \cos\phi = 0.8 \quad \therefore \phi = 36.87°$ (lag)

Reactive power $= \sqrt{3}\,V_L I_L \sin\phi$

$\therefore 15,000 = (\sqrt{3}\,V_L I_L) \times \cancel{0.8}\ 0.6$

$\therefore \sqrt{3}\,V_L I_L = \cancel{18,750}\ 24,999.94$ —— (I)

Total active power $= \sqrt{3}\,V_L I_L \cos\phi$

$= (24,999.94) \times 0.8$ {Subs. from eqn (I)}

$= 19,999.95\,W$

$\therefore W_1 + W_2 = 19,999.95$ —— (I)

$\tan\phi = \sqrt{3}\left(\frac{W_1 - W_2}{W_1 + W_2}\right)$

$\therefore \tan 36.87 = \sqrt{3}\left(\frac{W_1 - W_2}{19,999.95}\right)$

$\therefore W_1 - W_2 = 8,660.27$ —— (II)

$\therefore W_1 = 14,330.11\,W$

$W_2 = 5,669.84\,W$

Q53) Time period is $0 < t < 2\pi$ $\quad \because 0.707V_m = V_m \sin t$

$\therefore t = \pi/4,\ 3\pi/4$

$v = V_m \sin t, \quad 0 < t < \pi/4$

$= 0.707V_m, \quad \pi/4 < t < 3\pi/4$

$= V_m \sin t, \quad 3\pi/4 < t < \pi$

$= 0, \quad \pi < t < 2\pi$

$$v_{avg} = \frac{1}{2\pi}\int_0^{2\pi} v\,dt = \frac{1}{2\pi}\left[\int_0^{\pi/4} V_m \sin t\,dt + \int_{\pi/4}^{3\pi/4} 0.707V_m + \int_{3\pi/4}^{\pi} V_m \sin t\,dt\right]$$

$$= \frac{1}{2\pi}\left[V_m(-\cos t)_0^{\pi/4} + 0.707V_m(t)_{\pi/4}^{3\pi/4} + V_m(-\cos t)_{3\pi/4}^{\pi}\right]$$

$$= \frac{1}{2\pi}\left[V_m\left(-\cos\frac{\pi}{4} + \cos 0\right) + 0.707V_m\left(\frac{\pi}{2}\right) + V_m\left(-\cos\pi + \cos\frac{3\pi}{4}\right)\right]$$

Q54) Let $Z_1 = 3+j2$

$Z_2 = 10+j8$

$Z_3 = 9-j6$

$V_1 = 100V$

$$I = \frac{V_1}{Z_1} = \frac{100}{3+j2} = 23.08 - j15.39 = 27.74 \angle -33.69^\circ$$

$$\frac{1}{Z_p} = \frac{1}{Z_2} + \frac{1}{Z_3}$$

$$\therefore Z_p = 7.25 - j0.13$$

$$V_2 = V_3 = I Z_p = (23.08 - j15.39)(7.25 - j0.13)$$

$$= 165.33 - j114.58 = 201.15 \angle -34.72^\circ$$

$$I_1 = \frac{V_2}{Z_2} = \frac{165.33 - j114.58}{10+j8} = 4.49 - j15.05 = 15.71 \angle -73.38^\circ$$

$$I_2 = \frac{V_3}{Z_3} = \frac{165.33 - j114.58}{9-j6} = 18.59 - j0.34 = 18.6 \angle -1.03^\circ$$

Total $Z = Z_1 + Z_p$

$$= 3+j2+7.25-j0.13$$

$$= 10.25 + j1.87$$

$$V = I \cdot Z$$

$$= (23.08 - j15.39)(10.25 + j1.87)$$

$$= 265.35 - j114.59$$

$$= 289.03 \angle -23.36^\circ$$

Q55) $R = 10\,\Omega$

$L = 0.01\,H$

$C = 100 \times 10^{-6}\,F$

$v(t) = 10 \sin 1000t$

$\because v(t) = V_m \sin \omega t$

$\therefore V_m = 10V$, $\omega = 1000\,rad/sec$, $V = \frac{V_m}{\sqrt{2}} = \frac{10}{\sqrt{2}} = 7.07V$

i) $X_L = \omega L = 1000 \times 0.01 = 10\,\Omega$

$X_C = \frac{1}{\omega C} = \frac{1}{1000 \times 100 \times 10^{-6}} = 10\,\Omega$

$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{(10)^2 + (10-10)^2} = 10\,\Omega$

ii) $I = \frac{V}{Z} = \frac{7.07}{10} = 0.707$

$Pf = \cos\phi = \frac{R}{Z} = \frac{10}{10} = 1$

$P = VI\cos\phi = 7.07 \times 0.707 \times 1 = 5W$

iii) $f_0 = \frac{1}{2\pi\sqrt{LC}} = \frac{1}{2\pi\sqrt{0.01 \times 100 \times 10^{-6}}} = 159.16\,Hz$

iv) Band width $= \frac{R}{}$

v) Quality factor =

Q56) $i = 14.14 \sin(\omega t + \pi/6)$

Comparing with $i = I_m \sin(\omega t + \theta)$

$\therefore I_m = 14.14A$

$I_{rms} = \frac{I_m}{\sqrt{2}} = \frac{14.14}{\sqrt{2}} = 10A$

Phase angle $= \theta = \frac{\pi}{6}^c$

Q57) $L_1 = 50 \times 10^{-3} H$

$R_2 = 50 \Omega$

$C_3 = 50 \times 10^{-6} F$

$V_L = 550V$

$\omega = 800$ rad/sec.

$X_{L_1} = 2\pi f L_1 = \omega L_1 = 800 \times 50 \times 10^{-3} = 40\Omega$

$X_{C_3} = \frac{1}{2\pi f C_3} = \frac{1}{\omega C_3} = \frac{1}{800 \times 50 \times 10^{-6}} = 25\Omega$

let $Z_1 = jX_{L_1} = j40\ \Omega$

$Z_2 = R_2 = 50\ \Omega$

$Z_3 = -jX_{C_3} = -j25\ \Omega$

$\frac{1}{Z_p} = \frac{1}{Z_2} + \frac{1}{Z_3}$ $\therefore Z_p = 10 - j20$

$Z_{ph} = Z_1 + Z_p = j40 + 10 - j20 = 10 + j20 = 22.36 \angle 63.44^\circ$

Comparing with $Z_{ph} = |Z_{ph}| \angle \phi$

$\therefore \phi = 63.44$ (lag)

i) For Delta connection:-

$V_L = V_{ph} = 550V$

$I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{550}{22.36} = 24.6A$

ii) $I_L = \sqrt{3} I_{ph} = 42.6A$

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

$= \sqrt{3} \times 550 \times 24.6 \times \cos(63.44) = 10,478.45 W$

iv) $Pf = \cos\phi = \cos 63.44 = 0.4471$ (lag)

v) Reactive power $= \sqrt{3} V_L I_L \sin\phi$

$= \sqrt{3} \times 550 \times 24.6 \times \sin(63.44) = 20,961.51 VAR$

Q58) $X_L = 20\Omega$

$f = 50Hz$

$R = 15\Omega$

$V = 200V$

$Z = \sqrt{R^2 + X_L^2} = \sqrt{(15)^2+(20)^2} = 25\Omega$

i) $Pf = \cos\phi = \frac{R}{Z} = \frac{15}{25} = 0.6(\text{lag})$

ii) $I = \frac{V}{Z} = \frac{200}{25} = 8A$

iii) Since current and voltage are in phase
∴ circuit is at resonance with capacitor in parallel with coil

∴ $Z_{coil} = 25\Omega$, $X_L = 2\pi f L$ ∴ $20 = 2\pi \times 50 \times L$
∴ $L = 0.064H$

∴ $Z_{coil} = \sqrt{\frac{L}{C}}$

∴ $25 = \sqrt{\frac{0.064}{C}}$ ∴ $C = 1.02 \times 10^{-4} F$

iv) $Z_{dynamic} = \frac{L}{RC} = \frac{0.064}{15 \times 1.02 \times 10^{-4}} = 41.83\Omega$

$I = \frac{V}{Z_{dynamic}} = \frac{200}{41.83} = 4.78A$

859) $R_1 = 10\Omega$

$L_1 = 10\times10^{-3}H$

$R_2 = 10\Omega$

$C_2 = 500\times10^{-6}F$

$V = 230V$

$f = 50Hz$

$X_{L_1} = 2\pi f L_1 = 2\pi\times50\times10\times10^{-3} = 3.14\Omega$

$X_{C_2} = \dfrac{1}{2\pi f C_2} = \dfrac{1}{2\pi\times50\times500\times10^{-6}} = 6.37\Omega$

i) $Z_1 = R_1 + jX_{L_1} = 10 + j3.14$

$Z_2 = R_2 - jX_{C_2} = 10 - j6.37$

$\dfrac{1}{Z} = \dfrac{1}{Z_1} + \dfrac{1}{Z_2}$ $\therefore Z = 6.1 - j0.63 = 6.13\angle{-5.89^\circ}$

$I = \dfrac{V}{Z} = \dfrac{230}{6.1 - j0.63} = 37.31 + j3.85 = 37.51\angle{5.89^\circ}$

ii) $I_1 = \dfrac{V}{Z_1} = \dfrac{230}{10 + j3.14} = 20.94 - j6.57 = 21.94\angle{-17.43^\circ}$

$I_2 = \dfrac{V}{Z_2} = \dfrac{230}{10 - j6.37} = 16.36 + j10.42 = 19.4\angle{32.5^\circ}$

iii) $\because Z_1 = 10.48\angle{17.43^\circ}$ $\therefore \phi_1 = 17.43(\text{lag})$ $\therefore pf_1 = \cos\phi_1 = 0.954(\text{lag})$

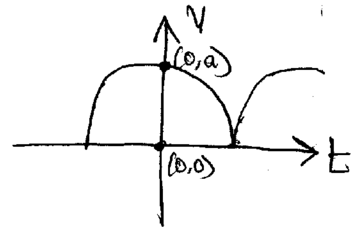
$\because Z_2 = 11.86\angle{-32.5^\circ}$ $\therefore \phi_2 = 32.5(\text{lead})$ $\therefore pf_2 = \cos\phi_2 = 0.844(\text{lead})$

$\because Z = 6.13\angle{-5.89^\circ}$ $\therefore \phi = 5.89(\text{lead})$ $\therefore pf = \cos\phi = 0.995(\text{lead})$

iv) $P_1 = VI_1\cos\phi_1 = 230\times21.94\times0.954 = 4814.1W$

$P_2 = VI_2\cos\phi_2 = 230\times19.4\times0.844 = 3765.93W$

Q60) Equation of semi-circle is:-



$$V^2 + t^2 = a^2$$

$$\therefore V^2 = a^2 - t^2$$

$$V = \sqrt{a^2 - t^2}, \quad -a < t < a$$

$$V_{rms} = \sqrt{\frac{1}{2a}\int_{-a}^{a} V^2\,dt} = \sqrt{\frac{1}{2a}\int_{-a}^{a}(a^2 - t^2)\,dt}$$

$$= \frac{1}{\sqrt{2a}}\sqrt{\left[a^2 t - \frac{t^3}{3}\right]_{-a}^{a}} = \frac{1}{\sqrt{2a}}\sqrt{\left[a^3 - \frac{a^3}{3} + a^3 - \frac{a^3}{3}\right]}$$

$$= \frac{1}{\sqrt{2a}}\left[2a^3 - \frac{2a^3}{3}\right] = \frac{1}{\sqrt{2a}}\left(\frac{4a^3}{3}\right)$$

Q61) $V_R = 10V$

$V_L = 15V$

$V_C = 10V$

$$V = \sqrt{(V_R)^2 + (V_L - V_C)^2} = \sqrt{(10)^2 + (15-10)^2}$$

$$\therefore V = \sqrt{100 + 25} = 11.18$$

$$Pf = \cos\phi = \frac{R}{Z} = \frac{IR}{IZ} = \frac{V_R}{V} = \frac{10}{11.18} = 0.8945 (lag)$$

Q62) $V_L = 400V$, $f = 50Hz$

$Z_{delta} = 8 + j6$

$Z_{star} = 4 + j3$

Converting Delta to Star

$$\boxed{\therefore Z'_{star} = \frac{Z_{delta}}{3}} = \frac{8+j6}{3} = 2.67 + j2$$

Since Z_{star} and Z'_{star} are in parallel.

$$\frac{1}{Z_{ph}} = \frac{1}{Z_{star}} + \frac{1}{Z'_{star}} = \frac{1}{4+j3} + \frac{1}{2.67+j2}$$

$\therefore Z_{ph} = 1.6 + j1.2 = 2\angle 36.87$

For star connection

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

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

$I_{ph} = \frac{V_{ph}}{Z_{ph}} = \frac{230.94}{2} = 115.47\,A$

$I_L = I_{ph} = 115.47\,A$

Comparing with $Z_{ph} = |Z_{ph}|\angle\phi$

$\therefore \phi = 36.87$ (lag)

$\therefore pf = \cos\phi = \cos 36.87 = 0.8$ (lag)

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

$= \sqrt{3} \times 400 \times 115.47 \times 0.8$

$= 63,999.97\,W$

Reactive power $= \sqrt{3}\, V_L I_L \sin\phi$

$= \sqrt{3} \times 400 \times 115.47 \times \sin 36.87$

$= 48,000.09\,VAR$

Q63) $V = 200\angle 25° = 181.26 + j84.52$

$I_1 = 10\angle 45° = 7.07 + j7.07$

$I_2 = 20\angle -30° = 17.32 - j10$

$$z_1 = \frac{V}{I_1} = \frac{181.26 + j84.52}{7.07 + j7.07} = 18.8 - j6.84 = 20\angle -20°$$

$$z_2 = \frac{V}{I_2} = \frac{181.26 + j84.52}{17.32 - j10} = 5.74 + j8.19 = 10\angle 55°$$

For Branch Z_1:-

Comparing with $Z_1 = |Z_1| \angle \phi_1$

$\therefore \phi_1 = 20^\circ$ (lead)

Comparing with $Z_2 = |Z_2| \angle \phi_2$

$\therefore \phi_2 = 55^\circ$ (lag)

Apparent power $= VI_1$
$= 200 \times 10 = 2000\,VA = 2\,kVA$

Reactive power $= VI_1 \sin\phi_1$
$= 200 \times 10 \times \sin 20^\circ = 684.04\,VAR = 0.684\,kVAR$

Active power $= VI_1 \cos\phi_1$
$= 200 \times 10 \times \cos 20^\circ = 1879.39\,W = 1.879\,kW$

For Branch Z_2:-

Comparing with $Z_2 = |Z_2| \angle \phi_2$

$\therefore \phi_2 = 55^\circ$ (lag)

Apparent power $= VI_2$
$= 200 \times 20 = 4000\,VA = 4\,kVA$

Reactive power $= VI_2 \sin\phi_2$
$= 200 \times 20 \sin 55^\circ = 3276.61\,VAR = 3.276\,kVAR$

Active power $= VI_2 \cos\phi_2$
$= 200 \times 20 \cos 55^\circ = 2{,}294.31\,W = 2.294\,kW$

$\frac{1}{Z} = \frac{1}{Z_1} + \frac{1}{Z_2}$ $\therefore Z = 6.92 + j4.29 = 8.14 \angle 31.83^\circ$

Comparing with $Z = |Z| \angle \phi$

$\therefore \phi = 31.83^\circ$ (lag)

$pf = \cos\phi = 0.85$ (lag)

Q64) Apparent power = 10KVA = 10,000 VA

$\therefore VI = 10,000$ —— (I)

$Pf = \cos\phi = 0.342$

$\therefore \phi = 70°$

Total power $= VI\cos\phi$

$= 10,000 \times \cos 70° = 3420.2\,W$

$\therefore W_1 + W_2 = 3420.2$ —— (II)

i) p.f. is leading

$$\tan\phi = -\sqrt{3}\left(\frac{W_1 - W_2}{W_1 + W_2}\right)$$

$$\tan 70° = -\sqrt{3}\left(\frac{W_1 - W_2}{3420.2}\right)$$

$\therefore W_1 - W_2 = -5425.32$ —— (III)

Solving eqns. (II) & (III)

$\therefore W_1 = -1,002.56\,W$

$W_2 = 4,422.76\,W$

ii) p.f. is lagging

$$\tan\phi = \sqrt{3}\left(\frac{W_1 - W_2}{W_1 + W_2}\right)$$

$$\tan 70° = \sqrt{3}\left(\frac{W_1 - W_2}{3420.2}\right)$$

$\therefore W_1 - W_2 = 5425.32$ —— (IV)

Solving eqns. (II) & (IV)

$\therefore W_1 = 4422.76$

$W_2 = -1,002.56$

865) $V = 125V$

$f = 50Hz$

$I = 2.2A$

$P_R = 96.8W$

$P_R = I^2 R$

$96.8 = 2.2^2 \times R$

$\therefore R = 20\Omega$

$Z = \frac{V}{I} = \frac{125}{2.2} = 56.82$

$Z = \sqrt{R^2 + X_C^2}$ $\therefore 56.82 = \sqrt{(20)^2 + X_C^2}$

$\therefore X_C = 53.18\Omega$

$X_C = \frac{1}{2\pi f C}$ $\therefore 53.18 = \frac{1}{2\pi \times 50 \times C}$

$\therefore C = 5.99 \times 10^{-5} F$

866) $A \equiv (0, -20)$

$B \equiv (2\pi, 140)$

$m = \frac{y_2 - y_1}{x_2 - x_1} = \frac{140 + 20}{2\pi} = \frac{80}{\pi}$

Eqn. of line is $y - y_1 = m(x - x_1)$

$\therefore V = \frac{80}{\pi}(t) - 20$

$\therefore v = \frac{80t}{\pi} - 20, \quad 0 < t < 2\pi$

$v_{avg} = \frac{1}{2\pi}\int_0^{2\pi} v\,dt = \frac{1}{2\pi}\int_0^{2\pi}\left[\frac{80}{\pi}\cdot t - 20\right]dt$

$= \frac{1}{2\pi}\left[\frac{80}{\pi}\cdot\frac{t^2}{2} - 20t\right]_0^{2\pi} = \frac{1}{2\pi}\left[\frac{80}{\pi} \times \frac{4\pi^2}{2} - 40\pi\right] = 60$

$v_{rms} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi} v^2\,dt} = \sqrt{\frac{1}{2\pi}\int_0^{2\pi}\left(\frac{80t}{\pi} - 20\right)^2 dt} = \sqrt{\frac{1}{2\pi}\left[\frac{\left(\frac{80t}{\pi} - 20\right)^3}{80/\pi}\right]_0^{2\pi} \times \frac{1}{3}}$

$= \sqrt{\frac{1}{480}[140]^3} = 75.61$

Q67) $R = 5\Omega$

$C = 20\times10^{-6}F$

$V = 10V$

$\omega = 1000$ rad/sec.

$X_C = \frac{1}{\omega C} = \frac{1}{1000\times20\times10^{-6}} = 50\Omega$

Since voltage across resistor is maximum

$\therefore$ Circuit is at series resonance

$\therefore V_R = V = 10V$

$\because V_R = IR$

$\therefore 10 = 5I \quad \therefore I = 2A$

$V_C = IX_C = 2\times50 = 100V$

$V_L = V_C = 100V$

Q68)

Q71) $V(t) = 24 \sin(1000t + 20)$

$R = 15\Omega$

$L = 0.1H$

Comparing with $V(t) = V_m \sin(\omega t + \theta_1)$

$\therefore V_m = 24V,\ \omega = 1000\ rad/sec,\ \theta_1 = 20°$

Since phase angle between $V(t)$ and $i(t)$ equal to zero

$\therefore$ Circuit is at series resonance

$\therefore X_L = X_C$

$\because X_L = 2\pi f_0 L = \omega L = 1000 \times 0.1 = 100\Omega$

$\therefore X_C = 100\Omega$

$\because X_C = \frac{1}{2\pi f_0 C} = \frac{1}{\omega C}$

$\therefore 100 = \frac{1}{1000 \times C} \quad \therefore C = 10^{-5} F$

Q70) $V_L = 220V$

$f = 50Hz$

O/P power $= 11.2kW = 11,200W$

$\eta = 88\%$

$I_L = 38A$

$\eta = \frac{O/P\ power}{I/P\ power} \times 100$

$\therefore 88 = \frac{11,200}{I/P\ power} \times 100$

$\therefore$ I/P power $= 12,727.27\ W$

$\therefore W_1 + W_2 = 12.73$ —— (I)

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

$12,727.27 = \sqrt{3} \times 220 \times 38 \times \cos\phi$

$\therefore \phi = 28.48°$ (lag)

$Pf = \cos\phi = 0.88$ (lag)

$\tan\phi = \sqrt{3}\left(\frac{W_1 - W_2}{W_1 + W_2}\right)$ {For lagging pf}

$\therefore \tan 28.48 = \sqrt{3}\left(\frac{W_1 - W_2}{12.73}\right)$

$\therefore W_1 - W_2 = 3.99$ — (II)

Solving eqns (I) & (II) simultaneously

$\therefore W_1 = 8.36\,kW$

$W_2 = 4.37\,kW$

869) $V = 150V$

$I = 32A$

Let $Z_1 = 5\Omega$, $Z_2 = j4\Omega$

$$\frac{1}{Z_p} = \frac{1}{Z_1} + \frac{1}{Z_2}$$

$\therefore Z_p = 1.95 + j2.44$

Total $Z = Z_p + R = (1.95+R) + j2.44$ $\therefore |Z| = \sqrt{(1.95+R)^2 + 2.44^2}$

$|V| = |I||Z|$

$\therefore 150 = 32\,|1.95 + R + j2.44|$

$\therefore 150 = 32\sqrt{(1.95+R)^2 + 2.44^2}$

$$\left(\frac{150}{32}\right)^2 = (1.95+R)^2 + 2.44^2$$

$\therefore R = 2.05\Omega$

$\therefore$ Total $Z = (1.95 + 2.05) + j2.44$

$= 4 + j2.44$

$= 4.69\angle 31.38°$

Comparing with $Z = |Z|\angle\phi$

$\therefore \phi = 31.38°$ (lag)

$\therefore pf = \cos\phi$

$= \cos 31.38°$

$= 0.8537$ (lag)

Q72) $V_s = 60\sin\omega t$ $\therefore V_m = 60V$ $\therefore V_s = \frac{V_m}{\sqrt{2}} = \frac{60}{\sqrt{2}} = 42.43V$

$Z_1 = 50\Omega$

$Z_2 = j40\Omega$

$Z_3 = -j80\Omega$

$I_1 = \frac{V_s}{Z_1} = \frac{42.43}{50} = 0.85A = 0.85\angle 0° A$

$I_2 = \frac{V_s}{Z_2} = \frac{42.43}{j40} = -j1.06A = 1.06\angle -90° A$

$I_3 = \frac{V_s}{Z_3} = \frac{42.43}{-j80} = j0.53 = 0.53\angle 90° A$

Total $I = I_1 + I_2 + I_3$ (Only in rectangular or cartesian form)

$\therefore I = 0.85 - j1.06 + j0.53$

$I = 0.85 - j0.53 = 1\angle -31.93A$

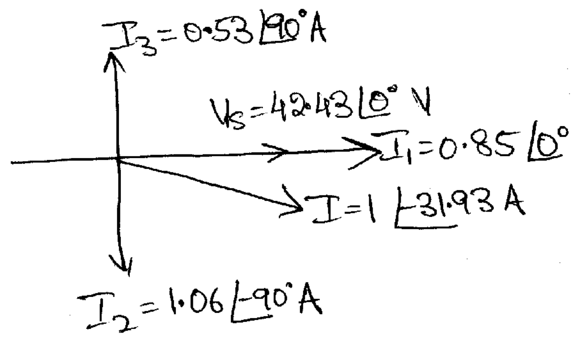
$\because Y = \frac{1}{Z} = \frac{1}{Z_1} + \frac{1}{Z_2} + \frac{1}{Z_3}$

$\therefore Y = 0.02 - j0.0125$

Total $I = V_s \times Y$

$= 42.43 \times (0.02 - j0.0125)$

$\therefore I = 0.85 - j0.53 = 1\angle -31.93A$



Q73) $I_1 = 6\sin\left(\omega t + \frac{\pi}{3}\right)$

$I_2 = 5\cos\left(\omega t + \frac{\pi}{3}\right) = 5\sin\left(\omega t + \frac{\pi}{3} + \frac{\pi}{2}\right)$

$= 5\sin\left(\omega t + \frac{5\pi}{6}\right)$

$I_3 = 3\cos\left(\omega t + \frac{\pi}{3}\right) = 3\sin\left(\omega t + \frac{\pi}{3} + \frac{\pi}{2}\right)$

$= 3\sin\left(\omega t + \frac{5\pi}{6}\right)$

Comparing with $I_1 = I_{m_1}\sin(\omega t + \theta_1)$

$\therefore I_{m_1} = 6A,\ \theta_1 = \frac{\pi}{3} = 60^\circ,\ I_{rms_1} = \frac{I_{m_1}}{\sqrt{2}} = \frac{6}{\sqrt{2}} = 4.24A$

Comparing with $I_2 = I_{m_2}\sin(\omega t + \theta_2)$

$\therefore I_{m_2} = 5A,\ \theta_2 = \frac{5\pi}{6} = 150^\circ,\ I_{rms_2} = \frac{I_{m_2}}{\sqrt{2}} = \frac{5}{\sqrt{2}} = 3.54A$

Comparing with $I_3 = I_{m_3}\sin(\omega t + \theta_3)$

$\therefore I_{m_3} = 3A,\ \theta_3 = \frac{5\pi}{6} = 150^\circ,\ I_{rms_3} = \frac{I_{m_3}}{\sqrt{2}} = \frac{3}{\sqrt{2}} = 2.12A$

$I_1 = I_{rms_1}\angle\theta_1 = 4.24\angle 60^\circ = 2.12 + j3.67$

$I_2 = I_{rms_2}\angle\theta_2 = 3.54\angle 150^\circ = -3.07 + j1.77$

$I_3 = I_{rms_3}\angle\theta_3 = 2.12\angle 150^\circ = -1.84 + j1.06$

$\because I_1 + I_2 + I_3 + I_4 = 0$

$\therefore 2.12 + j3.67 - 3.07 + j1.77 - 1.84 + j1.06 + I_4 = 0$

$\therefore I_4 = 2.79 - j6.5 = 7.07\angle -66.77^\circ$

$\therefore I_{m_4} = I_{rms_4} \times \sqrt{2} = 7.07 \times \sqrt{2} = 10A$

$\therefore$ Current in wire S is:-

$I_4 = 10\sin(\omega t - 66.77^\circ)$

Q74) $L = 0.2H$

$R = 20\Omega$

$C = 200 \times 10^{-6} F$

$V = 230V$

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}} = \frac{1}{2\pi}\sqrt{\frac{1}{0.2 \times 200 \times 10^{-6}} - \frac{20^2}{0.2^2}}$$

$\therefore f_0 = 19.49 Hz$

$X_L = 2\pi f_0 L = 2\pi \times 19.49 \times 0.2 = 24.49\Omega$

$$X_C = \frac{1}{2\pi f_0 C} = \frac{1}{2\pi \times 19.49 \times 200 \times 10^{-6}} = 40.83\Omega$$

Let $Z_1 = R + jX_L = 20 + j24.49$

$Z_2 = -jX_C = -j40.83$

$$\frac{1}{Z} = \frac{1}{Z_1} + \frac{1}{Z_2} = \frac{1}{20 + j24.49} + \frac{1}{-j40.83}$$

$Z = 50\Omega$

$$I = \frac{V}{Z} = \frac{230}{50} = 4.6A$$

$\cancel{V_L = IX_L = 4.6 \times 24.49 = 112.65V}$

$\cancel{V_C = IX_C = 4.6 \times 40.83 = 187.82V}$

$V_2 = V_C = V = 230V$

$V_1 = V_{coil} = V = 230V$

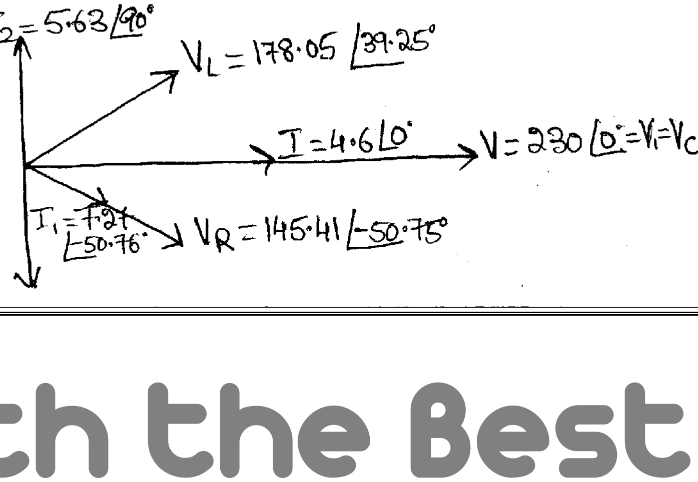
$$I_1 = \frac{V_1}{Z_1} = \frac{230}{20 + j24.49} = 4.6 - j5.63 = 7.27\angle{-50.76^\circ}$$

$V_L = I_1 X_L = (4.6 - j5.63)(j24.49) = 137.88 + j112.65 = 178.05\angle{39.25}$

$V_R = I_1 R = (4.6 - j5.63)(20) = 92 - j112.6 = 145.41\angle{-50.75^\circ}$

Phasor Diagram is:-

$$I_2 = \frac{V_2}{Z_2} = \frac{230}{-j40.83} = +j5.63 = 5.63\angle{90^\circ}$$



Q75) $p.f_{coil} = 0.6$

$C = 100\times10^{-6} F$

$f = 50Hz$

$V_{coil} = V_C$

$$X_C = \frac{1}{2\pi f C} = \frac{1}{2\pi\times50\times100\times10^{-6}} = 31.83\Omega$$

$\because V_{coil} = V_C$

$\therefore I Z_{coil} = I . X_C$

$\therefore Z_{coil} = X_C$

$\therefore Z_{coil} = 31.83\Omega$

$$\cos\phi_{coil} = \frac{R}{Z_{coil}}$$

$$\therefore 0.6 = \frac{R}{31.83}$$

$\therefore R = 19.1\Omega$

$$Z_{coil} = \sqrt{R^2 + X_L^2}$$

$$\therefore 31.83 = \sqrt{(19.1)^2 + X_L^2}$$

$\therefore X_L = 25.46\Omega$

$X_L = 2\pi f L$

$25.46 = 2\pi\times50\times L$

$\therefore L = 0.081 H$