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Assignment -3

1) 230V, 50Hz ac is supplied to a coil of 0.06H inductor, 2.5Ω resistance & 6.8μf capacitor in series. Calculate the current & phase angle of the circuit. Also calculate the voltage across each of the circuit components.

=> Soln.

$V = 230V$

$f = 50Hz$

$L = 0.06H$

$R = 2.5\,\Omega$

$C = 6.8\,\mu F = 6.8\times10^{-6} F$

we know,

$$X_C = \frac{1}{2\pi f c} = \frac{1}{2\pi \times 50 \times 6.8\times10^{-6}}$$

$$= 468.10\,\Omega$$

$$X_L = 2\pi f L = 2\pi \times 50 \times 0.06 = 18.85\,\Omega$$

now,

$$Z = R\angle 0^\circ + X_L \angle 90^\circ + X_C \angle -90^\circ$$

$$= 2.5\,\Omega + j18.85 - j468.10\,\Omega$$

$$= 2.5 - 449.25j\,\Omega$$

$$= 449.5 \angle -89.68^\circ$$

i) The current $I = \frac{V}{Z} = \frac{230\angle 0^\circ}{449.5\angle -89.68^\circ}$

$$= 0.5119 \angle 89.68^\circ$$

ii) $V_R = IZ_R = (0.5119 \angle 89.68) \times (2.5\,\Omega \angle 0)$

$$= 1.278V \angle 89.68^\circ$$

iii) $V_L = IX_L = (0.5119\angle 89.68)(18.85 \angle 90)$

$$= 9.649 \angle 179.68^\circ$$

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iv) $V_c = IZ_c = (0.5119 \angle 89.68)(468.10 \angle -90)$

$= 239.2\ V \angle -0.32°$

2) The following loads are connected to common supply.

⇒ Sol^n

Load A } $S = 150$ KVA at 0.707 lag

Load B } $P_1 = 100$ kW at unity

Load C } $P_2 = 75$ kW at 0.8 lag

Load D } $P_3 = 50$ kW at 0.6 lag

we know,

$$Pf_0 = \frac{P_0}{S_0}$$

$$\Rightarrow P_0 = Pf \times S_0$$

$$= 0.707 \times 150$$

$$= 106.05$$

Total active Power $(P) = P_0 + P_1 + P_2 + P_3$

$= 106.05 + 100 + 75 + 50$

$= 331.05$ kW.

Apparent Power $= S_0 + S_1 + S_2 + S_3$

$$= S_0 + \frac{P_1}{Pf_1} + \frac{P_2}{Pf_2} + \frac{P_3}{Pf_3}$$

$$= 150 + \frac{100}{1} + \frac{75}{0.8} + \frac{50}{0.6}$$

$= 427.08$ KVA

Overall power factor (PF) = $\frac{\text{overall active power (P)}}{\text{overall apparent power(S)}}$

$= \frac{331.05}{427.08}$

$= 0.775$

Now,

$PF = \cos\phi$

$\phi = \cos^{-1}(0.775)$

$= 39.19°$

$\frac{\text{Reactive power}}{\text{active power}} = \frac{VI\sin\phi}{VI\cos\phi} = \tan\phi$

$R = \tan(39.19) \times 331.05$

$= 269.82$ KVAR

3)

=> Sol$^n$,

$V = 240$ V

$Z = 10\Omega \angle 60°$

$Q_1 = 1250$ VAR

i) We know,

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

$= \frac{240\angle 0°}{10\angle 60°}$

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$= 24 \angle -60°$

$\phi = 60°$

$pf = \cos\phi = \cos 60°$

$= \frac{1}{2} = 0.5$

$P = VI\cos\phi$

$= 240 \times 24 \times \cos(-60)$

$= 2880 W.$

$Q = VI\sin\phi$

$= 240 \times 24 \times \sin(-60)$

$= 4980.3$ VAR

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

$R = Z\cos\phi$

$= 10\cos(-60)$

$= 5\,\Omega$

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

$Z^2 - R^2 = X^2$

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

$= \sqrt{10^2 - 5^2}$

$= 8.66\,\Omega$

ii) Now, when capacitor is connected

Reactive power $(Q) = Q - Q_1$

$= (4980.3 - 1250)$ VAR

$= 3738.3$ VAR

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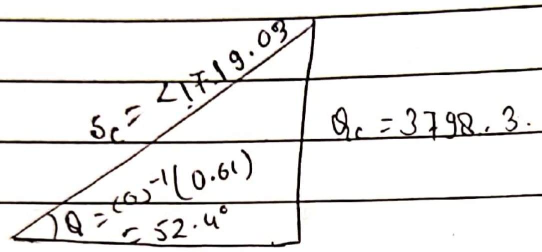
Active power remain same:

$P_t = 2880 W.$

Resultant power factor (Pf) $= \frac{P_c}{S_c} = \frac{P_t}{\sqrt{P_t^2 + Q_c^2}}$

$= \frac{2880}{\sqrt{2880^2 + (3798.3)^2}}$

$= 0.61$




$P_L = 2880$

power triangle.

4) A voltage soure $E_{an} = 120 < 30$ & the curent through it is $I_{an} = 10 < 60°$ A. find the value of P & Q & state whether the source is delivering or reseving

-> sol$^n$

$E_{an} = 120 < -30°$ V

$I_{an} = 10 < 60°$ A

$P = E_{an} I_{an}$

$= 1200 < -30°$

$P = VI\cos\phi$

$= 1200 \cos(30°)$

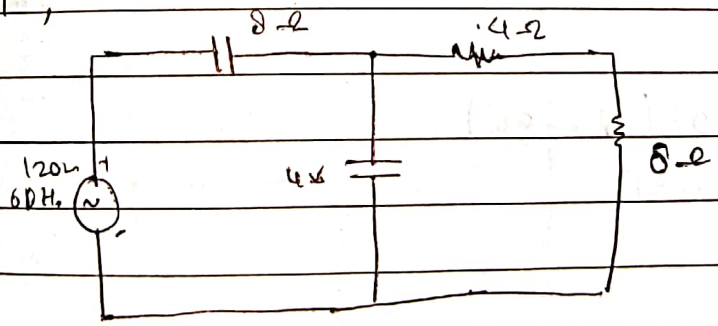
$= 1039.23$ W.

$Q_1 = VI\sin\phi$
$= 1200 \sin(30)$
$= 600$ VAR.

Her, current lead the voltage, so the load is supplying reactive power & the soure is receiving reactive power.

5. For the circuit shown
a) Find the effective value of the current delivered by the soure. Write down the expression for the instantaneous values of the current.
b) Draw a carefully labelled phasor diagram showing the source voltage, soure current, voltage $V_{AB}$ & $V_{BC}$
c) Compute the power supplied by the source & the line pf.

=> Sol$^n$,




=> Sol$^n$,

We have,

$V = 120\ V\angle 0^\circ$

$f = 60\ Hz$

a) $Z_1 = -j8 = 8\angle -90^\circ\ \Omega$

$Z_2 = -j4 = 4\angle -90^\circ\ \Omega$

$Z_3 = 12\Omega \angle 0^\circ$

So,

$$Z = Z_1 + (Z_2 \parallel Z_3)$$

$$= Z_1 + \frac{Z_2 \times Z_3}{Z_2 + Z_3}$$

$$= (8 \angle -90) + \frac{(4 \angle -90^\circ) \times (12 \angle 0^\circ)}{(4 \angle -90^\circ) + (12 \angle 0^\circ)}$$

$$= 11.68 \angle -84.09^\circ$$

Now,

$$I_{rms} = \frac{V}{Z} = \frac{120 \angle 0^\circ}{11.66 \angle -84.09}$$

$$= 10.29 \angle 84.09^\circ$$

$$I_m = I_{rms} \times \sqrt{2}$$

$$= 10.29 \times \sqrt{2}$$

$$= 14.55$$

$$i = i_m \sin(\omega t + \phi)$$

$$= 14.55 \sin(\omega t + 84.09^\circ)$$

$$V_1 = I_{rms} Z_1$$

$$= (10.29 \angle 84.09)(8 \angle -90^\circ)$$

$$= 89.32 \angle -5.91^\circ$$

$$V_2 = I_{rms} Z_2$$

$$= (10.29 \angle 84.09)(4 \angle -90)$$

$$= 41.16 \angle -5.91^\circ$$

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b)

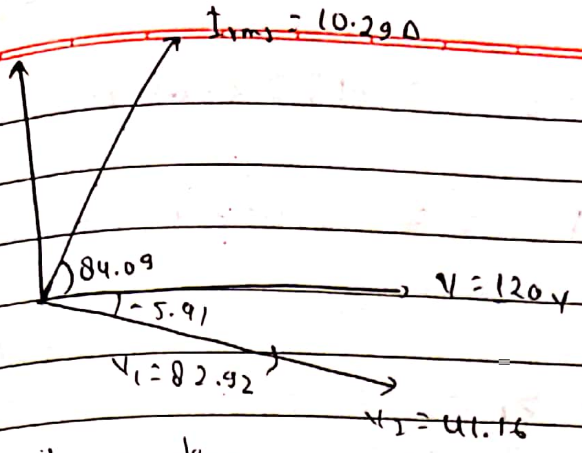
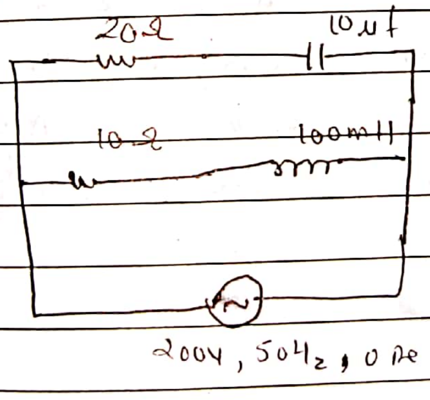



fig: phasor diagram

(a) $P = VI\cos\phi$
$= 120 \times 10.29 \times \cos(84.09)$
$= 127.15\,W$

$pf = \cos\phi = \cos(84.09)$
$= 0.1029$ (lead)

6) calculate the magnitude & phase of the current from the source in the following AC parallel circuit.




200V, 50Hz, 0°

=> Sol$^n$,

We have,

$V = 200\angle 0°\,V$

$f = 50Hz$

$X_C = \frac{1}{2\pi fC} = \frac{1}{2\pi \times 50 \times 10^{-5}} = 318.3$

$X_L = 2\pi fL = 2\pi \times 50 \times 100 \times 10^{-3} = 31.4$

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$Z_1 = 20 - j318.30 \quad = 318.9 \angle -86.45$

$Z_2 = 10 + j31.41 \quad = 32.96 \angle 72.34$

$Z = Z_1 \parallel Z_2 = \dfrac{Z_1 \cdot Z_2}{Z_1 + Z_2}$

$= \dfrac{(318.9 \angle -86.40)(32.96 \angle 72.34)}{(318.9 \angle -86.40) + (32.96 \angle 72.34)}$

$= 36.44 \angle 69.96.$

$I = \dfrac{V}{Z} = \dfrac{200 \angle 0^\circ}{36.44 \angle 69.96}$

$= 5.48 \angle -69.96^\circ$ //

7) Two coil A & B are connected in series across a 240V, 50 Hz supply. The resistance of A is 5 Ω & the inductance of B is 0.015 H. If the input from the supply 3kW & 2KVAR. Find the inductance of A & the resistance of B. Calculate the voltage across each othe.

⇒ Soln,

$R = 5\,\Omega$

$L = 0.015\,H$

$P = 3\,kW$

$Q = 2\,kVAR$

$V = 240\,V$

$f = 50\,Hz$

$Z_1 = 5 + ijX_L \quad = 5 + j4.71 \quad = 6.86 \angle 43.28°$

$Z_2 = R + j.471 = 10.97 + j \quad = 11.93 \angle 23.23°$

we know,

$$\frac{Q}{P} = \frac{VI \sin\phi}{VI \cos\phi}$$

$$\frac{2}{3} = \tan\phi$$

$$\phi = 33.7°$$

$$P = VI \cos\phi$$

$$I = \frac{P}{P\cos\phi} = \frac{3 \times 1000}{240 \times \cos 33.7}$$

$$= 15.024 \angle 33.7°$$

In series, $I = I_1 = I_2$

$$Z = Z_1 + Z_2$$

$$= (5 + jX_L) + (R + j4.71)$$

$$Z = (5 + R) + j(X_L + 4.71)$$

we know,

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

$$Z = \frac{V}{I} = \frac{240}{15.024} = 15.97$$

we have

$$15.97 = (5 + R) + j(X_L + 4.71)$$

comparing, we get,

$$15.97 = 5 + R$$

$$R = 10.97.$$

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$0 = X_L + 4.71$

$X_L = 4.71$

$2\pi f L' = 4.71$

$L' = \frac{4.71}{2\pi \times 50} = 0.015\ H.$

Now,

$V_1 = I Z_1$

$= (15.024 \angle 53.7)(6.86 \angle 43.28)$

$= 103.06 \angle 76.98°$

$V_2 = I Z_2$

$= (15.024 \angle 33.7) \times (11.93 \angle 23.23°)$

$= 179.23 \angle 56.93$

8) A circuit of three branches A, B, & C, A & B are in parallel while C is series with this parallel combination of A & B. The impedance of branches are $Z_A = (4+j3)\ \Omega$, $Z_B = (10-j7)\Omega$ & $Z_C = (6+j5)\Omega$. If the voltage 230V at 50 Hz is applied to the circuit. Calculate

a) Total power of the whole circuit.

b) Draw the complete phasor diagram.

=) Sol$^n$.

According to the question,

$(A \| B) + C$ => A parallel B whole series with C.

We have

$Z_A = (4+j3)\ \Omega = 5 \angle 36.36°$

$Z_B = (10-j7)\ \Omega = 12.20 \angle -34.99°$

$Z_C = (6+j5)\ \Omega = 7.81 \angle 39.8°$

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$V = 230V$

$f = 50Hz$

we know,

$$Z = (Z_A \parallel Z_B) + Z_C$$

$$= \frac{Z_A Z_B}{Z_A + Z_B} + Z_C$$

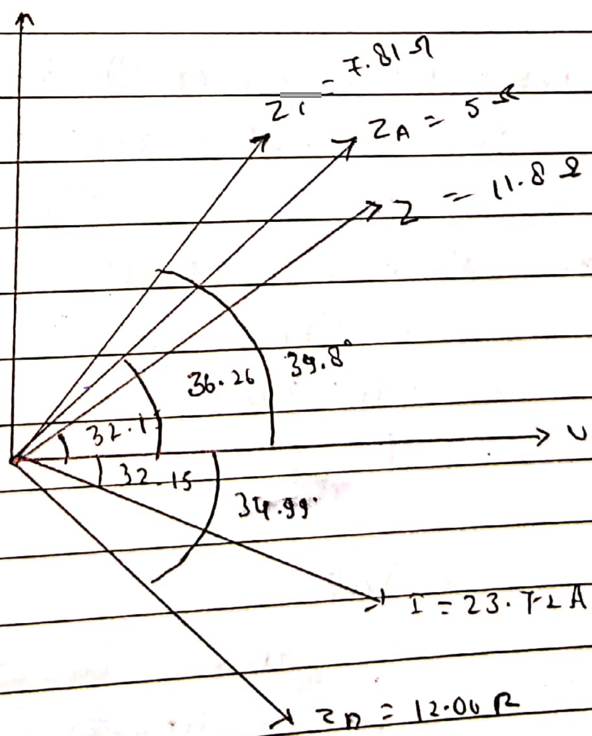
$$= \frac{(5\angle 36.86)(12.20\angle -34.99)}{(5\angle 36.86) + (12.20\angle -34.99)} + (7.81\angle 39.8)$$

$$= 9.99 + 6.28j$$

$$= 11.8 \angle 32.15^\circ.$$

Here,

Power factor $= \cos\phi = \cos(-32.15^\circ)$

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9) A circuit is composed of a resistance of 9 Ω & series connected inductive reactance of 12 Ω. When a voltage is applied to the circuit, the resulting steady current is found to be $i = 28.3 \sin 377t$. What is the value of complex impedance? Determine time expression for applied voltage. Find the value of inductance in Henry.

⇒ Sol$^n$.

$$Z = 9 + j12 = 15 \angle 53.13°$$

$$i = 28.3 \sin 377t$$

we know

$$I_{rms} = \frac{i_m}{\sqrt{2}}$$

$$I_{rms} = \frac{28.3}{\sqrt{2}} = 20 \angle 0°$$

now,

$$i \times R = (28.33 \sin 377t)(15 \angle 53.13°)$$

$$V = 424.5 (\sin 377t + 53.13°)$$

Where,

$$\sin \omega t = \sin 377t$$

$$\omega = 377$$

$$2\pi f = 377$$

$$f = \frac{377}{2\pi}$$

we have,

$$\cancel{\sin \omega t = \sin 377t}$$

$$\cancel{\omega = 377}.$$

$$X_L = 12\,\Omega$$

$$\Rightarrow 2\pi f L = 12$$

$$\Rightarrow L = \frac{12}{2\pi f} = \frac{12}{2\pi \times \frac{377}{2\pi}} = 0.0318\ H.$$

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11) A 50Hz, 220V is applied to a 0.637 induction:

(i) Write the eqⁿ for the applied voltage & current through the inductor

(ii) Plot the voltage & current wave forms.

(iii).

⇒ Solⁿ,

$f = 50Hz$

$V = 220V$

$L = 0.637$

we know

(i) $V = V_m \sin(\omega t + \phi)$

$= V_m \sin \omega t$

$= (V_{rms} \times \sqrt{2}) \sin \left(\frac{X_L}{L}\right) t$

$= 311 \sin \left(\frac{2\pi \times 50 \times L}{L}\right) t$

$V(t) = 311 \sin(314t)$

&

$V = V \sin(\omega t + \phi)$

$V = \frac{V_m}{X_C} \sin(\omega t + \phi)$

$i = \frac{220}{2\pi \times 50 \times L} \sin\left(314t - \frac{\pi}{2}\right) \quad \left[\phi = \frac{\pi}{2}\right]$

$i(t) = 1.55 \sin 314t$

(ii)

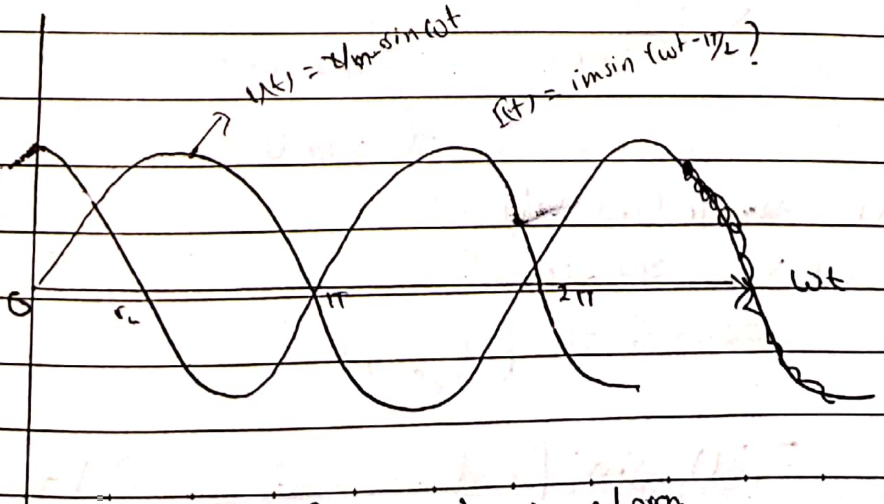


fig: voltage & current waveform

(iii) Draw the phasor diagram for voltage & current

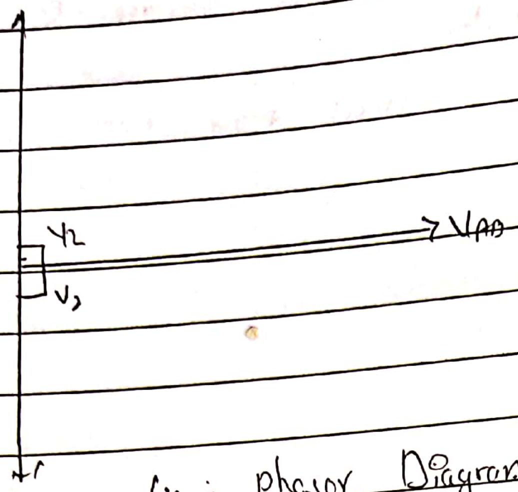


fig: phasor Diagram

12. A 50Hz, 220V voltage is applied to a capacitor of value 0.636 μF.

i) Write eqⁿ for instantaneous voltage & current as function of time t. Assume voltage at time t=0.

ii) to be zero & going positive

iii) Plot V & I against angle ωt.

iv) Draw the phasor diagram for voltage & current

=> Solⁿ,

$f = 50Hz$

$V_{rm} = 220V$

$C = 0.636\,\mu F = 0.636 \times 10^{-6} F$

$X_C = \frac{1}{2\pi f C} = \frac{1}{2\pi \times 50 \times 0.636}$

$= 5004.87$

i) $V(t) = V_m \sin(\omega t + \phi)$

$= V_{rms} \times \sqrt{2} \sin \omega t$

$= 220 \times \sqrt{2} \sin\left(\frac{1}{X_C C}\right)t$

$= 311 \sin\left(\frac{1}{5004.87 \times 0.636 \times 10^{-6}}\right)t.$

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$= 311 \sin 314t$

$$\frac{v(t)}{R} = \frac{V_m}{X_c} \sin(\omega t + \phi)$$

$$i(t) = \frac{V_{rms} \times \sqrt{2}}{X_c} \times \sin\left(\omega t + \frac{\pi}{2}\right)$$

$$= \frac{220 \times \sqrt{2}}{5004.87} \sin\left(\omega t + \frac{\pi}{2}\right)$$

$$= 62.2 \times 10^{-3} \sin\left(314 + \frac{\pi}{2}\right).$$

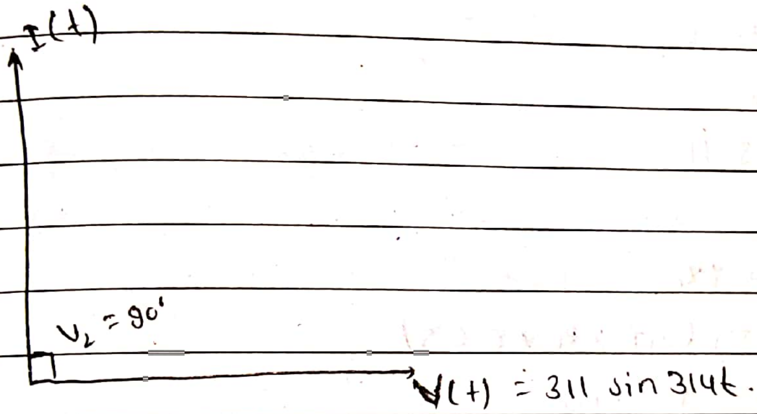


fig: phasor diagram

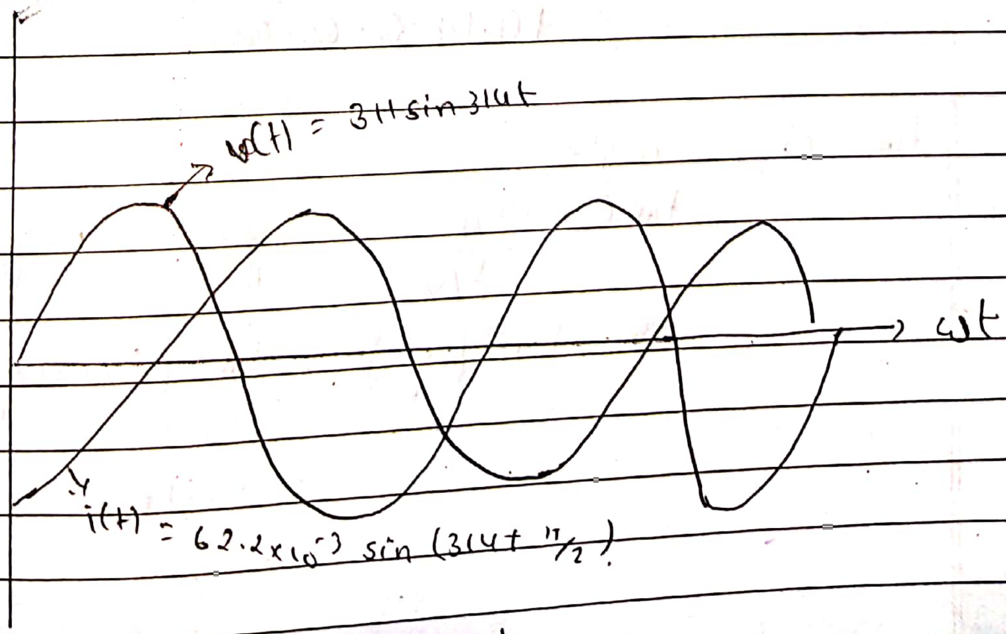


fig: v & i vs. ωt.

13. A sinusoida voltage $v = 230\angle 15°$ of frequency 50Hz is applied to a series R-L circuit consisting of $R = 4\Omega$ & $L = 0.05H$. Calculate

(i) The rms current & its phase angle

(ii) power factor.

(iii) Average power drawn by the circuit

(iv) Reactive power & apparent power

(v) Q-factor of the coil.

=> Soln.

$V = 230\angle 15$

$f = 50Hz$

$R = 4\Omega$

$L = 0.05H$

we know

$Z = R + jX_L$

$= 4 + j(2\pi \times 50 \times 0.05)$

$= 4 + j15.70$

$= 16.20\angle 75.75°$

Now

$I = \frac{V}{Z} = \frac{230\angle 15°}{16.20\angle 75.70}$

$= 14.19\angle -60.70°$

for phase angle,

$\tan\theta = \frac{I/R}{I/X_L} = \frac{I \times X_L}{R\, I} = \frac{X_L}{R}$

$\theta = \tan^{-1}\left(\frac{X_L}{R}\right) = \tan^{-1}\left(\frac{2\pi \times 50 \times 0.05}{4}\right)$

$= 75.70°$

ii) Power factor $= \cos\theta$

$= \cos(75.71)$

$= 0.246$

iii) Average Power (P) $= VI\cos\theta$

$= 230 \times 14.19 \times \cos(75.71)$

$= 805\ W.$

iv) Reactive Power (Q) $= VI\sin\theta$

$= 230 \times 14.19 \times \sin(75.71)$

$= 3162.71 \approx 3163\ VAR$

Apparent power (S) $= VI$

$= 230 \times 14.19$

$= 3263.7$

$\approx 3264\ VA$

Q) A 200V, 50Hz supply is applied to a coil of resistance $R = 10\Omega$ & inductance 0.2H. Calculate
i) the reactance & impedence of the coil.
ii) current & it phase angle relative to applied voltage
Draw the phasor diagram.

=> soln,

$V = 200V\angle 0°$

$f = 50Hz$

$R = 10\Omega$

$L = 0.2H.$

we know

i) $Z = R + jX_L$

$= 10 + j(2\pi f L)$

$= 10 + j(62.83)$

$= 63.62 \angle 80.95° \ \Omega$

$X_L = 2\pi f L$

$= 2\pi\ 50 \times 0.2$

$= 62.83\ \Omega \angle 90°$

we know,

(iii) $I = \frac{V}{Z} = \frac{200\ V \angle 0°}{63.62 \angle 80.95}$

$= 3.14 \angle -80.95°$

for phase angle

$\tan\phi = \frac{I/R}{I/X_L} = \frac{I}{R} \times \frac{X_L}{I} = \frac{X_L}{R}$

$\phi = \tan^{-1}\left(\frac{X_L}{R}\right) = \tan^{-1}\left(\frac{62.83}{10}\right)$

$= 80.95°$

now

$V_R = I Z_R$

$= (3.14 \angle -80.95)(10 \angle 0)$

$= 31.4 \angle -80.95$

$V_L = I Z_L$

$= (3.14 \angle -80.95)(62.83 \angle 0°)$

$= 197.28 \angle 9.05°$

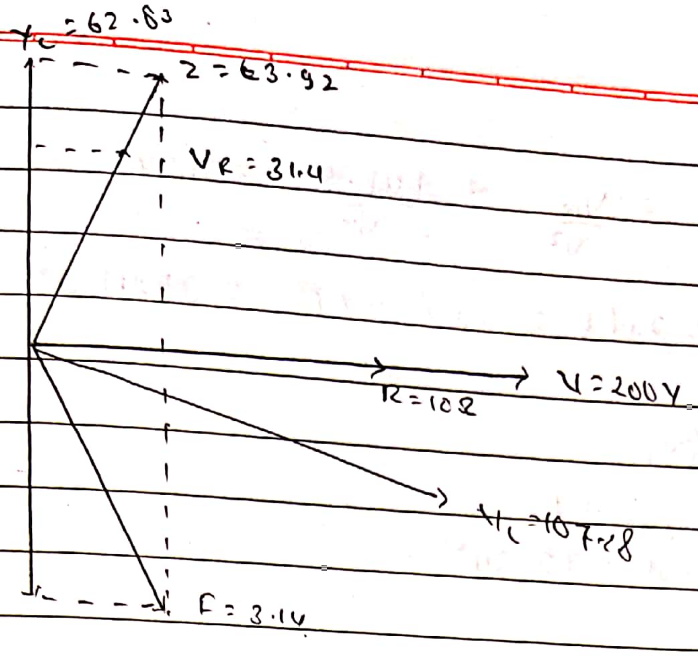


fig :- phasor Diagram

15. A voltay $V = 141.4 \sin 314t$ is applied to a coil having inductive of 0.1H & resistance 10 Ω find
i) expression for instantane current
ii) rms vale of the voltage & current
iii) Power factor
v) Power consumed in the coil.

=> Sol$^n$,

$V = 141.4 \sin 314t$ — (i)

$L = 0.1H$

$R = 10\ \Omega$

Comparing (i) with $V = \sin \omega t$, we get

$V_m = 141.4 \angle 0$

$\omega = 314$

or $2\pi f = 314$

or $f = \frac{314}{2\pi}$

$\therefore f = 50$

We know

$$V_{rms} = \frac{V_m}{\sqrt{2}} = \frac{141.4}{\sqrt{2}} = 100V$$

$$X_L = 2\pi f L = 2\pi \times 50 \times 0.1 = 31.41\ \Omega$$

$$Z = R + jX_L$$
$$= 10 + j\,31.41$$
$$= 32.96 \angle 72.34^\circ$$

$$\frac{V}{R} = \frac{V_m}{Z} \sin(314t)$$

$$i(t) = \frac{141.4\angle 0}{32.96 \angle 72.34} (\sin 314t)$$

$$= 4.29 \sin(314t - 72.34^\circ)$$

$$I_{rms} = \frac{I_m}{\sqrt{2}} = \frac{4.29}{\sqrt{2}} = 3.03\ A$$

$$\text{Power factor} = \cos\phi$$
$$= \cos(-72.34^\circ)$$
$$= \cos(72.34) \quad (\text{lag})$$

$$\text{Power } (P) = VI\cos\phi$$
$$= 100 \times 3.03 \times \cos(72.34^\circ)$$
$$= 91.92\ W$$

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18) When connected to 200V, 50Hz supply a certain coil draws current of 13A. If the frequency of the supply is changed to 60Hz, the current decrease to 11A. Calculate the resistance & inductance of coil.

⇒ Soln,

$V = 200V$

$f_1 = 50Hz$

$I = 13A$

$f_2 = 60Hz$

$I_2 = 11A$

We know

$$Z_1 = \frac{V}{I_1} = \frac{200}{13}$$

$$= 15.38\ \Omega$$

$$Z_1 = \sqrt{R^2 + X_1^2}$$

$$\text{or } (15.38)^2 = R^2 + 4\pi^2 \times f^2 \times L$$

$$R^2 = (15.38)^2 - 4\pi^2 \times 50^2 \times L^2 \longrightarrow i$$

again

$$Z_2 = \frac{V_1}{I_2} = \frac{200}{11}$$

$$= 18.18\ \Omega$$

again

$$Z_2 = \frac{V}{I_2} = \frac{200}{11}$$

$$= 18.18\ \Omega$$

$$Z_2 = \sqrt{R^2 + X_{L2}^2}$$

$$(18.18)^2 = R^2 + 4\pi^2 \times 60^2 \times L^2$$

$$R^2 = (18.18)^2 - 4\pi^2 \times 60^2 \times L^2 \longrightarrow ii$$

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Solving $eq^n$ (i) & (ii)

$$(15.38)^2 - 4\pi^2 \times 50^2 \times L = (18.18)^2 - 4\pi^2 \times 60^2 \times L^2$$

$$4\pi^2 (60^2 - 50^2) L^2 = (18.18)^2 - (15.38)^2$$

$$L^2 = \frac{(18.18)^2 - (15.38)^2}{4\pi^2 (60^2 - 50^2)}$$

$$L = \sqrt{2.16 \times 10^{-3}}$$

$$= 0.04655$$

from (i)

$$R^2 = (15.38)^2 - 4\pi^2 \times 50^2 \times 0.04655^2$$

$$R = \sqrt{22.67}$$

$$= 4.76\ \Omega$$

16. A 50Hz, sinusoidal voltage $(40+j30)$ Volt is applied to a series R-L circuit resulting in sinusoidal current $(4+j1)$ Amperes. Calculate:

(i) impedance of the circuit

(ii) power consumed in the circuit

(iii) power factor of the circuit.

Solution:

We have,

$$f = 50\ Hz$$

$$V = 40+j30\ V = 50\angle 36.86^\circ\ V$$

$$I = 4+j1\ A = 4.12\angle 14.03^\circ\ A$$

We know,

(i) $I = \frac{V}{Z}$

or, $Z = \frac{V}{I} = \frac{50\angle 36.86^\circ}{4.12\angle 14.023}$

$= 11.18 - 4.71j$

$= 12.135\angle -22.83^\circ$

(ii) Power (P) = $VI\cos\phi$

$= 50 \times 4.12 \times \cos(-22.83^\circ)$

$= 190W$

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(iii) Power factor $= \cos\phi$

$= \cos(-22.83^\circ)$

$= \cos(22.83^\circ)$ (lag)

An inductive coil having resistance $10\Omega$ takes a current of 2.2A when connected to 110V, 60 Hz supply. If the coil is connected to 50 Hz supply. Calculate:

(i) Current (ii) Power (iii) Power factor

Draw phase diagram when 50Hz ~~s~~supply is connected.

Solution:

We have,

$R = 10\Omega$

$I = 2.2A$

$V = 110V$

$f = 60Hz$

$f_1 = 50Hz$

We know,

(i) $Z = R + jX_L$

$2\pi fL$

$377L$

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

or, $Z = \frac{V}{I} = \frac{110}{2.2} = ~~45.45\Omega~~ 50\Omega$

or, $(~~10~~ + j377L) = (~~10~~ ~~35.45~~ \; 40 \; 5)$

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Comparing corresponding terms we get,

$$j377L = \cancel{35.75}\ 50$$

$$\text{or } L = \frac{\cancel{35.75}\ 50}{j377}$$

$$= .132\ H$$

Now, at $f_1 = 50$ Hz

$$X_L = 2\pi f_1 L$$

$$= 2\pi \times 50 \times \cancel{0.094}\ 0.132 \angle -90^\circ$$

$$= 41.47 \angle -90^\circ$$

Then, $Z = 10 + j\cancel{29.53}\ 41.47$

$$= 42.65 \angle 76.44^\circ$$

we know,

$$I = \frac{V}{Z} = \frac{\cancel{110\angle 0^\circ}}{\cancel{31.7\angle 71.3^\circ}} \cancel{= 3.5}$$

$$= \cancel{\frac{42.65}{7}}\ \frac{110\angle 0^\circ}{42.65\angle 76.44} = 2.57\angle -76.44$$

$\therefore I = 2.57A$

Power factor $= \cos\phi$

$$= \cos(-76.44)$$

$$= 0.234 \text{ (lag)}$$

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Power (P) = $VI\cos\phi$

$= 110 \times 2.57 \times 0.234$

$= 68W$

$V_R = IR$

$= (2.57\angle 76.44)(10\angle 0^\circ)$

$= 26.1\angle 76.44^\circ$

$V_L = I \cancel{Z_L} X_L$

$= (2.57\angle 76.44)(41.47\angle -90^\circ)$

$= 106V \angle -13.56^\circ$

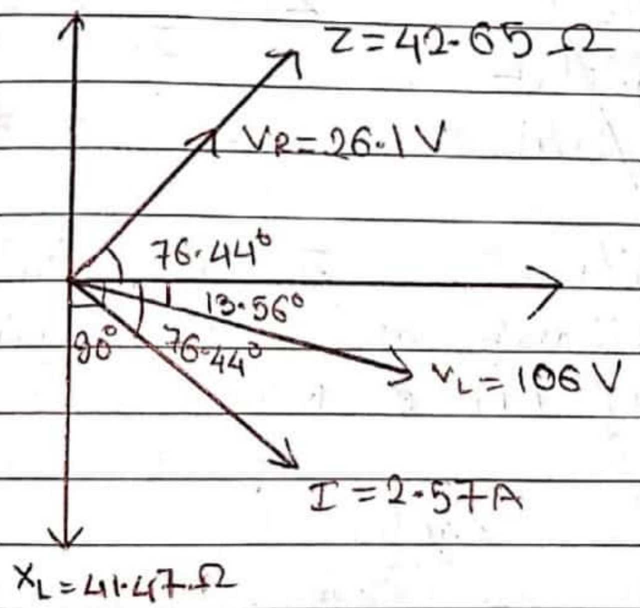


Fig: Phasor Diagram when f = 50 Hz

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Q. A coil having resistance of 10Ω and inductance of 0.2H is connected in series with coil B of resistance 30Ω and inductance of 0.1 H. The two coils in series are fed from ~~5~~200 V, 50Hz supply. Determine:

(i) The voltage across each coil

(ii) Power dissipated in each coil

(iii) Power factor of the circuit as whole.

Solution:

$R_1 = 10\Omega$

$L_1 = 0.2H$

$R_2 = 30\Omega$

$L_2 = 0.1H$

$V = 200V$

$f = 50Hz$

We know,

$Z_1 = R_1 + jX_{L_1}$

$= 10 + j2\pi f L_1$

$= 10 + j62.83 = 63.62\angle 80.95°$

$Z_2 = R_2 + jX_{L_2}$

$= 30 + j2\pi f L_2$

$= 30 + j31.41 = 43.43\angle 46.31°$

In series, $I = I_1 = I_2$ ~~So~~, and $V = V_1 + V_2$

$\cancel{I_1 = I_2}$

~~or,~~ $\cancel{\frac{V_1}{Z_1} = \frac{V_2}{Z_2}}$ or, $200\angle 0 = I_1 Z_1 + I_2 Z_2$

or, $200\angle 0 = I(Z_1 + Z_2)$

or, $\frac{200\angle 0}{(63.62\angle 80.95° + 43.43\angle 46.31°)} = I$

$\therefore I = \cancel{0.072 \angle -127.26^\circ}\ 1.95 \angle -66.99^\circ$

Now,

(i) $V_1 = IZ_1$

$= (\cancel{0.072}^{1.95} \angle \cancel{-127.26^\circ}^{-66.99^\circ})(63.62 \angle 80.95^\circ)$

$= 124.05 \angle 13.96^\circ$

$V_2 = IZ_2$

$= (1.95 \angle -66.99^\circ)(43.43 \angle 46.31^\circ)$

$= 84.68 \angle -20.68^\circ$

~~(ii) Power $(P_1) = V_1 I \cos\phi$~~

~~$= (124.05 \angle 13.96)(1.95 \angle -66.99^\circ)$~~

~~$= 124.05 \times 1.95 \times \cos(-66.99^\circ)$~~

~~$=$~~

(ii) ~~Pf~~ $\tan\phi_1 = \left(\frac{X_{L_1}}{R_1}\right) = \left(\frac{62.83}{10}\right)$

$\therefore \phi_1 = 80.95^\circ$

$\tan\phi_2 = \left(\frac{X_{L_2}}{R_2}\right) = \left(\frac{31.41}{30}\right)$

$\therefore \phi_2 = 46.31^\circ$

$P_1 = V_1 I \cos\phi_1$

$= 124.05 \times 1.95 \times \cos(80.95^\circ)$

$= 38\ W$

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$P_2 = VI\cos\phi_2$
$= 84.68 \times 1.95 \times \cos(46.31)$
$= 114W$

Overall pf $= \cos\phi$
$= \cos(-67^\circ)$
$= \cos 67^\circ$ (lag)

20. A coil draws 11A and 800 W from 220V, 50 Hz supply. Determine:
(I) The impedance of the coil
(II) The power factor
(III) Reactive and apparent power.

Solution:

~~A~~ $I = 11A$
$P = \cancel{220A}\ 800W$
$V = 220V$
$f = 50Hz$

We know,
(1) $Z = R + jX_L$
and
$$I = \frac{V}{Z}$$
or, $$11 = \frac{220}{R + jX_L}$$
or, $R + jX_L = 20$ —— (i)

Also,

$$\tan\phi = \frac{X_L}{R} \quad \text{——— (ii)}$$

$P = VI\cos\phi$

or, $\cos\phi = \frac{P}{VI}$

or, $\phi = \cos^{-1}\left(\frac{P}{VI}\right) = \cos^{-1}\left(\frac{800}{220\times11}\right) = 70.69^\circ$

From (ii),

$\tan 70.69 = \frac{X_L}{R}$

$X_L = 2.85R \quad \text{——— (iii)}$

From (i) & (iii),

$R + j2.85R = 20$

or, $R(1+j2.85) = 20$

or, $R = \frac{20}{1+j2.85}$

$= 6.621 \angle -70.66^\circ \ \Omega$

Again,

$X_L = 2.85\times6.62$

$= 18.8\,\Omega$

$\therefore Z = (6.61 + j18.8)\,\Omega$

$I = 11\angle -70.6^\circ$

Power factor $= \cos\phi = \cos(70.6)$ (lag)

$$I_B = \frac{V}{Z_B}$$

or, $Z_B = \frac{V}{I_B} = \frac{110}{11} = 10\,\Omega$

Since, ~~$Z_T$~~ A & B are in series,

$$Z_T = Z_1 + Z_2$$
$$= 11\,\Omega + 10\,\Omega$$
$$= 21\,\Omega$$

Now,

$$I = \frac{V}{Z} = \frac{110}{21} \simeq 5.231A$$

We have,

$$P_A = 200\,W$$

or, $V_A I_A \cos\phi_A = 200$

or, $\cos\phi_A = \frac{200}{110 \times 10} = 0.181$

$$P_B = 400\,W$$

or, $V I_B \cos\phi_B = 400$

or, $\cos\phi_B = \frac{400}{110 \times 11} = 0.330$

$$\cos\phi = \frac{\cos\phi_A + \cos\phi_B}{2}$$

$$= \frac{0.181 + 0.330}{2}$$

$$= 0.2555$$

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(iii) $Q = VI\sin\phi$

$= 220 \times 11 \times \sin(70.6)$

$= 2282$ VAR

$S = VI$

$= 220 \times 11$

$= 2420$ VA

21. A coil ~~&~~ A draws current of 10A and power of 200W when driven by 110V, 60Hz supply. Another coil B draws current of 11A and power 400W when driven by the same force. What current and power will be drawn ~~by~~ from the source ~~by~~ coils A and B connected in series.

Solution:

$I_A = 10A$

$P_A = \cancel{22}\ 200W$

$V = 110V$

$f = 60 HZ$

$I_B = 11A$

$P_B = 400W$

We know,

$$I_A = \frac{V}{Z_A}$$

$$\text{or, } Z_A = \frac{V}{I_A} = \frac{110}{10} = 11\,\Omega$$

Total Power $(P_T) = VI\cos\phi$
$= 110 \times 5.23 \times 0.2555$
$= 147.2W$

Power Factor Improvement in single phase AC Circuit.

22. An inductive ~~coil~~ load of 4KW at a lagging power factor of 0.8 is connected across a 220V, 50 Hz supply. Calculate the value of the capacitance to be connected in parallel with the load to bring the resultant power factor to 0.95 lagging.

Solution:

we have,

$P_L = 4KW = 4000W$

$Pf_1 = 0.8$ (lag)

$V = 220V$

$f = 50 Hz$

we know,

$P_L = VI_L\cos\phi_1$

or, $4000 = 220 \times I_L \times 0.8$ $[\because \cos\phi = Pf]$

or, $I_L = \frac{4000}{220 \times 0.8}$

$\therefore I_L = 22.72 A$

$I_L = \frac{V}{Z_L}$

or, $22.72 = \frac{220}{Z_L}$

$$Z_L = \frac{220}{22.72} = 9.68\ \Omega$$

now

$$\cos\phi_2 = 0.95$$
$$\phi_2 = \cos^{-1}(0.95)$$
$$= 18.2^\circ$$

$$\cos\phi_1 = 0.8$$
$$\phi_1 = \cos^{-1}(0.8)$$
$$= 36.86^\circ$$

$$C = \frac{P(\tan\phi_1 - \tan\phi_2)}{V^2\omega}$$

$$= \frac{4000(\tan 36.86 - \tan 18.2)}{220^2 \times 2\pi \times 50}$$

$$= \frac{4000(0.75 - 0.32)}{1.52 \times 10^7}$$

$$= 1.10 \times 10^{-4}\ F$$

$$= 110 \times 10^{-6}\ F$$

$$= 110\ \mu F$$

23. A 100 KW load at 0.8 lagging power factor is being supplied by a 220V, 50Hz source. Calculate the reactive power drawn from the source. If a capacitor connected in parallel to the load improves its power factor to 0.9, find the capacitance of the capacitor. Also, calculate the current draw from the source before and after connecting the capacitor.

Solution:

We know,

$P = 100\ KW$

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

$V = 220V$

$f = 50Hz$

$Pf_2 (\cos\phi_2) = 0.9$

We know,

$P = VI\cos\phi_1$

or, $100 = 220 \times I \times 0.8$

or, $I = \frac{100 \times 1000}{220 \times 0.8}$

$\therefore I_{before} = \cancel{0.568\ A}\ 568.18\ A$

Now,

$Q = VI_{before} \sin\phi_1$

$= 220 \times 568.18 \times \sin(36.87^\circ)$

$= 75000\ VAR$

$= 75\ KVAR$

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when capacitor is connected

$\cos\phi_2 = 0.9$

$\phi_2 = \cos^{-1}(0.9) = 25.84°$

$\cos\phi_1 = 0.8$

$\phi_1 = 36.86°$

we know

$$C = \frac{P(\tan\phi_1 - \tan\phi_2)}{V^2\omega}$$

$$= \frac{100 \times 100\,(\tan(36.86) - \tan(25.84))}{220^2 \times 2\pi \times 50}$$

$= 1.74727 \times 10^{-3}$

$= 1747.27 \times 10^{-6}$ F

$= 1747.27\ \mu F$ #

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