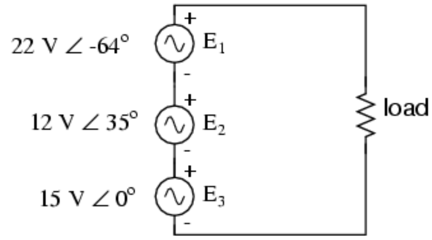
15EEE111 Fundamentals of Electrical & Electronics Engineering

Assignment #3 **Due Date: 21st February 2019**

SOLUTION

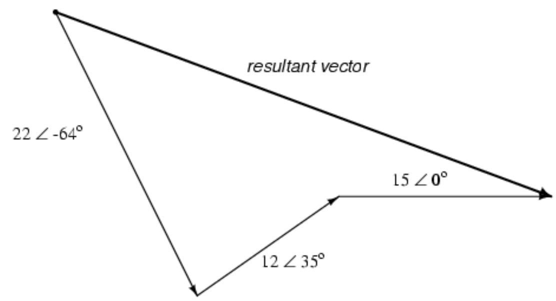
Q1. Find the total voltage across the load resistor. Also draw the phasor diagram.



Solution:

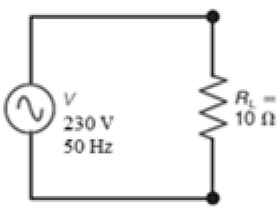
Total voltage = 34.47 – j12.89 V

= $36.8\angle -20.5^{0}$



Q2.An ac circuit consisting of a pure resistance of 10Ω is connected to an ac supply of 230 V, 50 Hz. Calculate the (i) current (ii) power consumed and (iii) equations for voltage and current.

Solution:



$$(i) I = \frac{V}{R} = \frac{230}{10} = 23A$$

$$(ii) P = VI = 230 \times 23 = 5260W$$

$$(iii) V_m = \sqrt{2}V = 325.27V$$

$$I_m = \sqrt{2}I = 32.52A$$

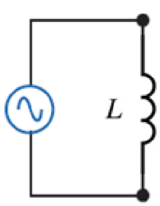
$$\omega = 2\pi f = 314 rad/\sec$$

$$v = 325.25 \sin 314t$$

$$i = 32.52 \sin 314t$$

Q3. A pure inductive coil allows a current of 10A to flow from a 230V, 50 Hz supply. Find (i) inductance of the coil (ii) power absorbed, and (iii) equations for voltage and current. Also draw the phasor diagram.

Solution:



$$(i) X_L = \frac{V}{I} = \frac{230}{10} = 23\Omega$$

$$X_L = 2\pi f L$$

$$L = \frac{X_L}{2\pi f} = 0.073H$$

$$(ii) P = 0$$

$$(iii) V_m = \sqrt{2}V = 325.27V$$

$$I_m = \sqrt{2}I = 14.14A$$

$$\omega = 2\pi f = 314 rad/\sec$$

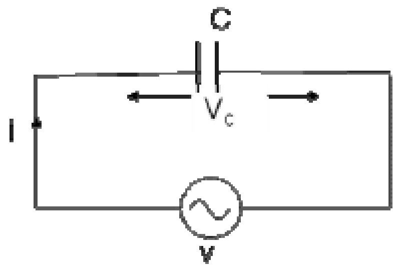
$$v = 325.25 \sin 314t$$

$$i = 14.14 \sin(314t - \pi/2)$$

SOLUTION

Q4. A 318μF capacitor is connected across a 230V, 50 Hz system. Find (i) the capacitive reactance (ii) rms value of current and (iii) equations for voltage and current.

Solution:



$$(i) X_C = \frac{1}{2\pi f C} = 10\Omega$$

$$(ii) I = \frac{V}{X_C} = 23A$$

$$(iii) V_m = \sqrt{2}V = 325.27V$$

$$I_m = \sqrt{2}I = 32.53A$$

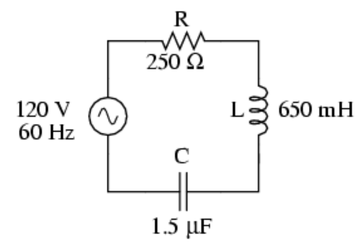
$$\omega = 2\pi f = 314 rad/\sec$$

$$v = 325.25 \sin 314t$$

$$i = 32.53 \sin(314t + \pi/2)$$

Q5. Calculate the total impedance of the circuit shown below.

Solution:



$$X_L = 2\pi fL = (2)(\pi)(60\text{ Hz})(650\text{ mH})$$
$$= 245.04\ \Omega$$

$$X_C = \frac{1}{2\pi fC} = \frac{1}{(2)(\pi)(60\text{ Hz})(1.5\ \mu\text{F})}$$

$$X_C = 1.7684\text{ k}\Omega$$

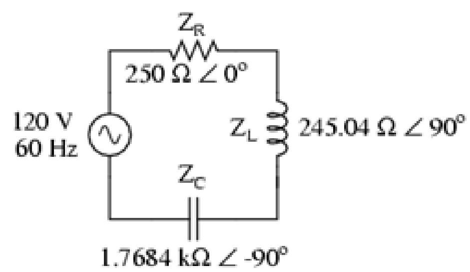
$$Z_R = 250 + j0\ \Omega \quad or \quad 250\ \Omega \angle 0^\circ$$

$$Z_L = 0 + j245.04\ \Omega \quad or \quad 245.04\ \Omega \angle 90^\circ$$

$$Z_C = 0 - j1.7684k\ \Omega \quad or \quad 1.7684\text{ k}\Omega \angle -90^\circ$$

$$Z_{total} = (250 + j0\ \Omega) + (0 + j245.04\ \Omega) + (0 - j1.7684k\ \Omega)$$

$$Z_{total} = 250 - j1.5233k\ \Omega \quad or \quad 1.5437\text{ k}\Omega \angle -80.680^\circ$$



Q6.A coil having a resistance of 7Ω and an inductance of 31.8mH is connected to 230V, 50Hz supply. Calculate (i) the circuit current (ii) phase angle (iii) power factor (iv) power consumed, (v) reactive power and (vi) apparent power. Also draw the phasor diagram.

Solution:

$$X_L = 2\pi fL = 2 \times 3.14 \times 50 \times 31.8 \times 10^{-3} = 10\Omega$$

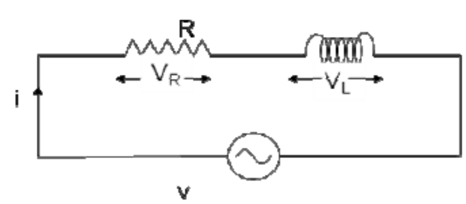
$$Z = \sqrt{R^2 + X_L^2} = \sqrt{7^2 + 10^2} = 12.2\Omega$$

$$(i) I = \frac{V}{Z} = \frac{230}{12.2} = 18.85A$$

$$(ii) \phi = \tan^{-1}\left(\frac{X_L}{R}\right) = \tan^{-1}\left(\frac{10}{7}\right) = 55^\circ lag$$

$$(iii) PF = \cos\Phi = \cos(55^\circ) = 0.573 lag$$

$$(iv) P = VI\cos\Phi = 230 \times 18.85 \times 0.573 = 2484.24W$$



v) Reactive power Q = VI sinϕ = 230 x 18.85 x 0.795 = 3.46 kVAR
vi) Apparent power = 4.25 kVA

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SOLUTION

Q7. A 200 V, 50 Hz, inductive circuit takes a current of 10A, lagging 30 degree. Find (i) the resistance (ii) reactance (iii) inductance of the coil.

Solution:

$$Z = \frac{V}{I} = \frac{200}{10} = 20\Omega$$

$$(i) R = Z\cos\phi = 20\times\cos 30^\circ = 17.32\Omega$$

$$(ii) X_L = Z\sin\phi = 20\times\sin 30^\circ = 10\Omega$$

$$(iii) L = \frac{X_L}{2\pi f} = \frac{10}{2\times 3.14\times 50} = 0.0318H$$

Q8. A Capacitor of capacitance 79.5μF is connected in series with a non-inductive resistance of 30Ω across a 100V, 50Hz supply. Find (i) impedance (ii) current (iii) phase angle (iv) equation for the instantaneous value of current. Also draw the phasor diagram.

Solution:

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\times 3.14\times 50\times 79.5\times 10^{-6}} = 40\Omega$$

$$(i) Z = \sqrt{R^2 + X_C^2} = \sqrt{30^2 + 40^2} = 50\Omega$$

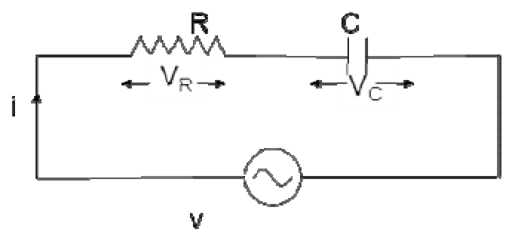
$$(ii) I = \frac{V}{Z} = \frac{100}{50} = 2A$$

$$(iii) \Phi = \tan^{-1}\left(\frac{X_C}{R}\right) = \tan^{-1}\left(\frac{40}{30}\right) = 53^\circ\ lead$$

$$(iv) I_m = \sqrt{2}I = \sqrt{2}\times 2 = 2.828A$$

$$\omega = 2\pi f = 2\times 3.14\times 50 = 314 rad/\sec$$

$$i = 2.828\sin(314t + 53^\circ)$$



Q9. A 230 V, 50 Hz ac supply is applied to a coil of 0.06 H inductance and 2.5 Ω resistance connected in series with a 6.8 μF capacitor. Calculate (i) Impedance (ii) Current (iii) Phase angle between current and voltage (iv) power factor (v) power consumed

Solution:

$$X_L = 2\pi fL = 2\times 3.14\times 50\times 0.06 = 18.84\Omega$$

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\times 3.14\times 50\times 6.8\times 10^{-6}} = 468\Omega$$

$$(i) Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{2.5^2 + (18.84 - 468)^2} = 449.2\Omega$$

$$(ii) I = \frac{V}{Z} = \frac{230}{449.2} = 0.512A$$

$$(iii) \Phi = \tan^{-1}\left(\frac{X_L - X_C}{R}\right) = \tan^{-1}\left(\frac{18.84 - 468}{30}\right) = -89.7^\circ$$

$$(iv) pf = \cos\Phi = \cos 89.7 = 0.0056\ lead$$

$$(v) P = VI\cos\Phi = 230\times 0.512\times 0.0056 = 0.66W$$

SOLUTION

Q10. A resistance R, an inductance L=0.01 H and a capacitance C are connected in series. When an alternating voltage v=400 Sin(3000t-20º) is applied to the series combination, the current flowing is 10√2 Sin(3000t-65º). Find the values of R and C.

Solution:

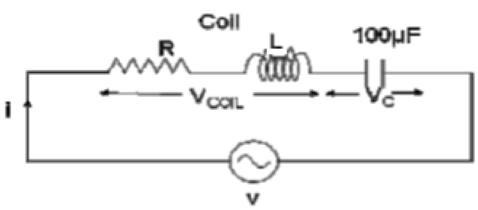
$$\Phi = 65^\circ - 20^\circ = 45^\circ lag$$
$$X_L = \omega L = 3000 \times 0.01 = 30\Omega$$
$$\tan\Phi = \tan 45^\circ = 1$$
$$\tan\Phi = \frac{X_L - X_C}{R} = 1$$
$$R = X_L - X_C$$

$$Z = \frac{V_m}{I_m} = \frac{400}{10\sqrt{2}} = 28.3\Omega Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{R^2 + R^2}$$
$$\sqrt{2}R = 28.3$$
$$R = 20\Omega$$
$$X_L - X_C = 20\Omega$$
$$X_C = 30 - 20 = 10\Omega$$
$$C = \frac{1}{\omega X_C} = \frac{1}{3000 \times 10} = 33.3\mu F$$

Q11. A coil of pf 0.6 is in series with a 100μF capacitor. When connected to a 50Hz supply, the potential difference across the coil is equal to the potential difference across the capacitor. Find the resistance and inductance of the coil.

Solution:

$$X_C = \frac{1}{2\pi fC} = \frac{1}{2\times 3.14\times 50\times 100\times 10^{-6}} = 31.83\Omega$$
$$V_{coil} = V_c$$
$$IZ_{coil} = IX_C$$
$$Z_{coil} = X_C = 31.83\Omega$$
$$R = Z_{coil}\cos\Phi_{coil} = 31.83\times 0.6 = 19.09\Omega$$
$$X_L = \sqrt{Z_{coil}^2 - R^2} = \sqrt{31.83^2 - 19.09^2} = 25.46\Omega$$
$$L = \frac{1}{2\pi fL} = \frac{1}{2\times 3.14\times 50\times 25.46} = 0.081H$$



Q12. A current of (120-j50)A flows through a circuit when the applied voltage is (8+j12)V. Determine (i) impedance (ii) power factor (iii) power consumed and reactive power.

Solution:

$$\overline{V} = 8 + j12$$
$$\overline{I} = 120 - j50$$
$$(i)\overline{Z} = \frac{\overline{V}}{\overline{I}} = \frac{8 + j12}{120 - j50} = 0.02 + j0.11 = 0.11\angle 79.7^\circ$$
$$Z = 0.11\Omega$$
$$\Phi = 79.7^\circ$$

$$(ii)\, pf = \cos\Phi = \cos 79.7^\circ = 0.179 lag$$
$$(iii) S = VI^* = (8 + j12)\times(120 + j50) = 360 + j1840$$
$$S = P + jQ$$
$$P = 360W$$
$$Q = 1840VAR$$

Q13. The complex Volt Amperes in a series circuit are (4330-j2500) and the current is (25+j43.3)A. Find the applied voltage.

Solution:

$$\overline{S} = 4330 + j2500$$
$$\overline{I} = 25 + j43.3$$
$$\overline{V} = \frac{\overline{S}}{\overline{I^*}} = \frac{4330 + j2500}{25 - j43.3} = 86.6 + j50$$

SOLUTION

Q14. Calculate the total impedance of the circuit.

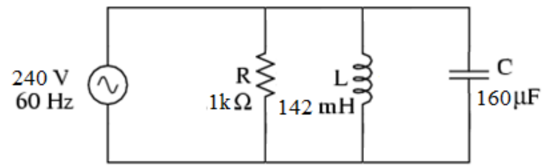
Solution:

$$X_L = \omega L = 2\pi f L = 2\pi.60.142\times10^{-3} = 53.54\Omega$$

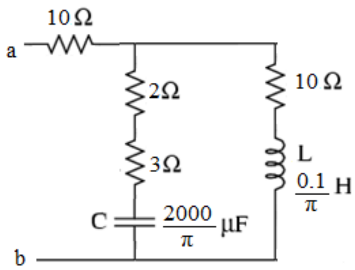
$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C} = \frac{1}{2\pi.60.160\times10^{-6}} = 16.58\Omega$$

$$Z = \frac{1}{\sqrt{\left(\frac{1}{R}\right)^2 + \left(\frac{1}{X_L} - \frac{1}{X_C}\right)^2}} = \frac{1}{\sqrt{\left(\frac{1}{1000}\right)^2 + \left(\frac{1}{53.54} - \frac{1}{16.58}\right)^2}}$$

$$Z = \frac{1}{\sqrt{1.0\times10^{-6} + 1.734\times10^{-3}}} = \frac{1}{0.0417} = 24.0\Omega$$



Q15. Find the impedance across the terminals a-b. Consider the supply frequency as 50Hz.



Solution:

$$Z_{ab} = 16 - j1.99\ \Omega$$

Q16. A parallel circuit comprises of a resistor of 20Ω in series with an inductive reactance 15Ω in one branch and a resistor of 30Ω in series with a capacitive reactance of 20Ω in the other branch. Determine the current and power dissipated in each branch if the total current drawn by the parallel circuit is 10∠-30^0 A.

Solution:

$$Z_1 = 20 + j15$$

$$Z_2 = 30 - j20$$

$$I = 10\angle -30^\circ = 8.66 - j5$$

$$I_1 = I\,\frac{Z_2}{Z_1 + Z_2} = (8.66 - j5)\times\frac{(30 - j20)}{(20 + j15) + (30 - j20)}$$

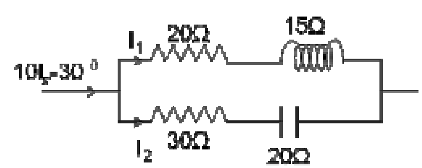
$$I_1 = 3.8 - j6.08 = 7.17\angle -60^\circ$$

$$I_2 = I - I_1 = (8.66 - j5) - (3.8 - j6.08)$$

$$I_2 = 4.86 + j1.08 = 4.98\angle -12.5^\circ$$

$$P_1 = I_1^2 R_1 = 7.17^2\times 20 = 1028.2W$$

$$P_1 = I_2^2 R_2 = 4.98^2\times 30 = 744W$$



Q17. An impedance coil in parallel with a 100µF capacitor is connected across a 200V, 50Hz supply. The coil takes a current of 4A and the power loss in the coil is 600W. Calculate (i) the resistance of the coil (ii) the inductance of the coil (iii) the power factor of the entire circuit.

Solution:

$$Z_{coil} = \frac{V}{I} = \frac{200}{4} = 50\Omega$$

$$P = I^2 R = 600W$$

$$R = \frac{600}{I^2} = \frac{600}{4^2} = 37.5\Omega$$

$$X_L = \sqrt{Z_{coil}^{\,2} - R^2} = \sqrt{50^2 - 37.5^2} = 33.07\Omega$$

$$L=\frac{X_L}{2\pi f}=\frac{33.07}{2\times3.14\times50}=0.105H$$
$$X_C=\frac{1}{2\pi fC}=\frac{1}{2\times3.14\times50\times100\times10^{-6}}=31.83\Omega$$
$$Z_1=R+jX_L=37.5+j33.07$$
$$Z_2=-jX_C=-j31.83$$

$$Z=\frac{Z_1Z_2}{Z_1+Z_2}=\frac{(37.5+j33.07)(-j31.83)}{(37.5+j33.07)+(-j31.83)}$$
$$Z=27-j32.72=42.42\angle-50.5^\circ$$
$$\Phi=-50.5^\circ$$
$$pf=\cos\Phi=\cos(-50.5^\circ)=0.6365$$

Q18. A circuit having a resistance of 20Ω and inductance of 0.07H is connected in parallel with a series combination of 50Ω resistance and 60μF capacitance. Calculate the total current, when the parallel combination is connected across 230V, 50Hz supply.

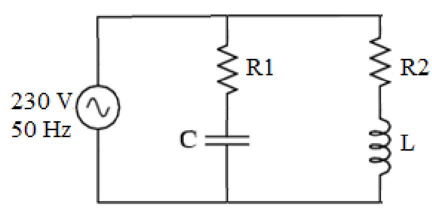
Solution:

$$X_L=2\pi fL=2\times3.14\times50\times0.07=22\Omega$$
$$X_C=\frac{1}{2\pi fC}=\frac{1}{2\times3.14\times50\times60\times10^{-6}}=53\Omega$$
$$Z_1=20+j22$$
$$Z_2=50-j53$$
$$Z=\frac{Z_1Z_2}{Z_1+Z_2}=\frac{(20+j22)(50-j53)}{(20+j22)+(50-j53)}=25.7+\mathrm{j}11.9$$
$$I=\frac{V}{Z}=\frac{230}{Z}=7.4-\mathrm{j}3.4=8.13\angle-24.9^\circ$$

Q19. Two impedances Z_1 = 12-j10 and Z_2=10+j12 are connected in parallel across a 230V, 50Hz supply. Calculate the equivalent impedance, current, power factor and power consumed.

Solution:

Z_1=12-j10 = 15.62∠-40 ohms
Z_2=10+j12=15.62∠50 ohms
Z = 11.12∠15 ohms
Current, I = 20.68∠-15 A
Pf = 0.96 lagging
Power = VI cosϕ = 4.566 kW



Q20. Three impedances Z_1, Z_2, Z_3 are connected in parallel across a 230V, 50Hz supply. The values are $Z_1=12\angle30^0$ $Z_2=8\angle-30^0$ and $Z_3=10\angle60^0$. Calculate the total impedance, total current, power factor and power consumed by the whole circuit.

Solution:

Total impedance, Z = 4.25∠14° Ω
Total current, I = 54.05∠-14° A
Power factor = 0.97 lagging
Power, P = 12.058 kW