Subject Name & Code:

BASIC ELECTRICAL ENGINEERING- BE01R00051

Assignment – 2

Q-1: An alternating voltage is given by v=325sin(314t) Determine: (a) Peak value (b) RMS value (c) Frequency (d) Time period

---

Answer:

Given:

$$V_m = 325 \text{ V}, \omega = 314 \text{ rad/s}$$

To Find:
(a) Peak value, (b) RMS value, (c) Frequency, (d) Time period

Formulas:

$$V_{\text{rms}} = \frac{V_m}{\sqrt{2}}, f = \frac{\omega}{2\pi}, T = \frac{1}{f}$$

Solution:
(a) Peak value = 325 V
(b) $V_{\text{rms}} = \frac{325}{\sqrt{2}} = 229.8$ V
(c) $f = \frac{314}{2\pi} = 50$ Hz
(d) $T = \frac{1}{50} = 0.02$ s

Final Answer:

$$\boxed{V_m = 325 \text{ V}, V_{\text{rms}} = 229.8 \text{ V}, f = 50 \text{ Hz}, T = 0.02 \text{ s}}$$

Q-2: A sinusoidal current has peak value of 15 A. Find: (a) RMS value (b) Average value (c) Form factor (d) Peak factor

---

Answer:

Given: $I_m = 15$ A

(a) RMS value:

$$I_{rms} = \frac{I_m}{\sqrt{2}} = \frac{15}{\sqrt{2}} \approx 10.61 \text{ A}$$

(b) Average value (full cycle):

$$I_{avg} = \frac{2I_m}{\pi} = \frac{30}{\pi} \approx 9.55 \text{ A}$$

(c) Form factor:

$$FF = \frac{I_{rms}}{I_{avg}} = \frac{10.61}{9.55} \approx 1.111$$

(d) Peak factor:

$$PF = \frac{I_m}{I_{rms}} = \sqrt{2} \approx 1.414$$

Final Answer:

$$\boxed{I_{rms} = 10.61 \text{ A}, I_{avg} = 9.55 \text{ A}, FF = 1.111, PF = 1.414}$$

Q-3: Two voltages are given as: V1=100∠0°V and V2=80∠30°V. Find the resultant voltage using phasor method.

Answer:

Given:

$$V_1 = 100\angle 0^\circ = 100 + j0$$
$$V_2 = 80\angle 30^\circ = 80(\cos 30^\circ + j\sin 30^\circ) = 69.282 + j40$$

To Find: Resultant voltage $V_R = V_1 + V_2$

Formula:
Phasor addition:

$$V_R = (a_1 + a_2) + j(b_1 + b_2)$$

Magnitude: $|V_R| = \sqrt{(\text{Re})^2 + (\text{Im})^2}$
Angle: $\theta = \tan^{-1}\left(\frac{\text{Im}}{\text{Re}}\right)$

Solution:

$$\text{Re} = 100 + 69.282 = 169.282$$
$$\text{Im} = 0 + 40 = 40$$
$$|V_R| = \sqrt{(169.282)^2 + (40)^2} = \sqrt{28656.4 + 1600} = \sqrt{30256.4} = 173.98 \text{ V}$$
$$\theta = \tan^{-1}\left(\frac{40}{169.282}\right) = \tan^{-1}(0.2363) = 13.3^\circ$$

Final Answer:

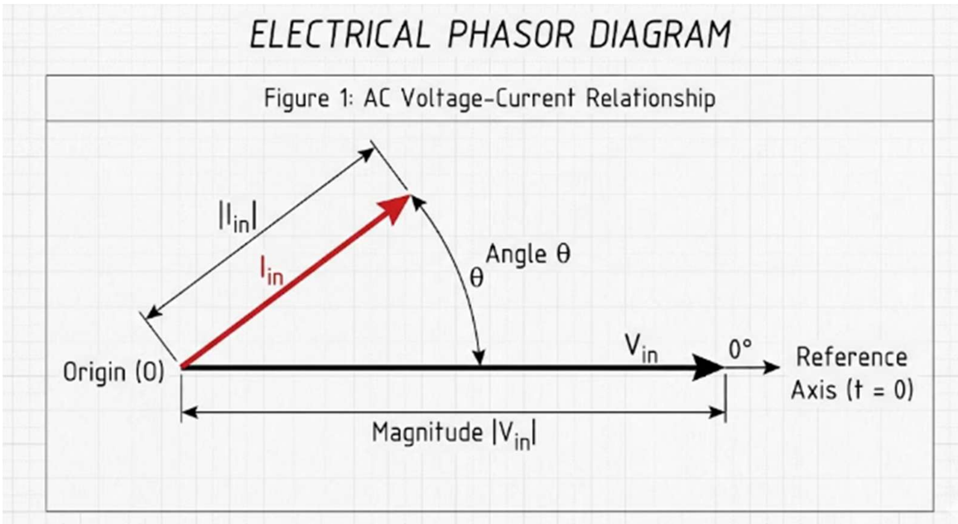
$$\boxed{V_R = 174.0\angle 13.3^\circ \text{ V}}$$

Q-4: A current of 10 A leads the voltage by 30°, Represent the voltage and current phasors.

Answer:

Given: $I = 10$ A, $\phi = 30^\circ$ (I leads V).

Phasor Diagram:



Q-5: A single-phase load takes 10 A current from 230 V supply at a power factor of 0.8 lagging. Calculate: (a) Active power, (b) Reactive power, (c) Apparent power

---

Answer:

Given:
$I = 10$ A, $V = 230$ V, PF $= 0.8$

To Find: (a) Active power P, (b) Reactive power Q, (c) Apparent power S

Formulas:

$$S = VI$$
$$P = S \cdot \text{PF}$$
$$Q = S \cdot \sin\,\phi, \sin\,\phi = \sqrt{1 - \text{PF}^2}$$

Solution:

$$S = 230 \times 10 = 2300 \text{ VA}$$
$$P = 2300 \times 0.8 = 1840 \text{ W}$$

$$\sin\ \phi = \sqrt{1 - 0.8^2} = 0.6$$
$$Q = 2300 \times 0.6 = 1380\ \text{VAR}$$

Final Answer:

$$\boxed{P = 1840\ \text{W},\ Q = 1380\ \text{VAR},\ S = 2300\ \text{VA}}$$

Q-6: A load absorbs 4 kW at a power factor of 0.6 lagging. Find the apparent power and reactive power.

Answer:

Given: $P = 4\ \text{kW}, \text{pf} = 0.6\ \text{lagging}$

Apparent power:

$$S = \frac{P}{\text{pf}} = \frac{4}{0.6} \approx 6.667\ \text{kVA}$$

Reactive power:

$$Q = \sqrt{S^2 - P^2} = \sqrt{(6.667)^2 - (4)^2} \approx 5.333\ \text{kVAR}$$

Final Answer:

$$\boxed{S \approx 6.67\ \text{kVA}, Q \approx 5.33\ \text{kVAR (lagging)}}$$

Q-7: A resistor of 20 Ω is connected to 230 V, 50 Hz AC supply. Find the current and power consumed.

Answer:

Given:
$R = 20\ \Omega, V = 230\ \text{V}, f = 50\ \text{Hz}$

To Find: Current I and power consumed P

Formulas:

$$I = \frac{V}{R}, P = I^2 R = \frac{V^2}{R}$$

Solution:

$$I = \frac{230}{20} = 11.5\ \text{A}$$

$$P = \frac{230^2}{20} = \frac{52900}{20} = 2645 \text{ W}$$

Final Answer:

$$\boxed{I = 11.5 \text{ A}, \ P = 2645 \text{ W}}$$

Q-8: A pure inductance of 0.2 H and a capacitor of 50 µF is connected to 230 V, 50 Hz supply. Calculate reactance of the circuit and current.

Answer:

Given: $L = 0.2 \text{ H}, C = 50 \, \mu\text{F}, V = 230 \text{ V}, f = 50 \text{ Hz}$

Inductive reactance:

$$X_L = 2\pi f L = 2\pi(50)(0.2) = 62.83 \, \Omega$$

Capacitive reactance:

$$X_C = \frac{1}{2\pi f C} = \frac{1}{2\pi(50)(50 \times 10^{-6})} \approx 63.66 \, \Omega$$

Since L and C are in series:

$$X = X_L - X_C = 62.83 - 63.66 = -0.83 \, \Omega$$

(Net capacitive reactance)

Impedance magnitude:

$$\mid Z \mid = \sqrt{0^2 + (0.83)^2} \approx 0.83 \, \Omega$$

Current:

$$I = \frac{V}{\mid Z \mid} = \frac{230}{0.83} \approx 277.11 \text{ A}$$

Final Answer:

$$\boxed{X \approx 0.83 \, \Omega \text{ (capacitive)}, I \approx 277.1 \text{ A}}$$

Q-9: An RL series circuit has R = 10 Ω and L = 0.1 H. If supply voltage is 230 V at 50 Hz, find current and power factor.

Answer:

Given:
$R = 10\,\Omega, L = 0.1\text{ H}, V = 230\text{ V}, f = 50\text{ Hz}$

To Find: Current I and power factor PF

Formulas:

$$X_L = 2\pi f L, Z = \sqrt{R^2 + X_L^2}, I = \frac{V}{Z}, \text{PF} = \frac{R}{Z}$$

Solution:

$$X_L = 2\pi(50)(0.1) = 31.416\,\Omega$$
$$Z = \sqrt{10^2 + 31.416^2} = \sqrt{100 + 986.6} = \sqrt{1086.6} = 32.97\,\Omega$$
$$I = \frac{230}{32.97} = 6.976\text{ A}$$
$$\text{PF} = \frac{10}{32.97} = 0.303\text{ lagging}$$

Final Answer:

$$\boxed{I = 6.98\text{ A},\ \text{PF} = 0.303\text{ lagging}}$$

Q-10: In a series RC circuit, R = 20 Ω and C = 100 µF. Find impedance, current and phase angle.

Answer:

Given: $R = 20\,\Omega, C = 100 \times 10^{-6}\text{ F}$
Assume frequency $f = 50$ Hz (typical for such problems unless specified).

Capacitive reactance:

$$X_C = \frac{1}{2\pi(50)(100 \times 10^{-6})} \approx 31.83\,\Omega$$

Impedance:

$$Z = R - jX_C = 20 - j31.83$$

Magnitude:

$$|Z| = \sqrt{20^2 + 31.83^2} \approx 37.59\,\Omega$$

Phase angle:

$$\phi = -\tan^{-1}\left(\frac{31.83}{20}\right) \approx -57.87^\circ$$

Assuming voltage V given, if not, current in terms of V is:

$$I = \frac{V}{|Z|}, \text{leads voltage by } 57.87^\circ.$$

Final Answer:

$$\boxed{|Z| \approx 37.59\ \Omega, \phi \approx -57.87^\circ}$$

Q-11: In a parallel RC circuit, R = 40 Ω and C = 100 μF. Find line current and phase angle.

Answer:

Given:
$R = 40\ \Omega$, $C = 100 \times 10^{-6}$ F, $V = 230$ V, $f = 50$ Hz

To Find: Line current I_L and phase angle ϕ

Formulas:

$$X_C = \frac{1}{2\pi f C}, I_R = \frac{V}{R}, I_C = \frac{V}{X_C}$$
$$I_L = \sqrt{I_R^2 + I_C^2}, \phi = \tan^{-1}\left(\frac{I_C}{I_R}\right)$$

Solution:

$$X_C = \frac{1}{2\pi(50)(100 \times 10^{-6})} = \frac{1}{0.031416} = 31.83\ \Omega$$
$$I_R = \frac{230}{40} = 5.75\text{ A}$$
$$I_C = \frac{230}{31.83} = 7.226\text{ A}$$
$$I_L = \sqrt{(5.75)^2 + (7.226)^2} = \sqrt{33.06 + 52.22} = \sqrt{85.28} = 9.235\text{ A}$$
$$\phi = \tan^{-1}\left(\frac{7.226}{5.75}\right) = \tan^{-1}(1.257) = 51.5^\circ\ \text{(leading)}$$

Final Answer:

$$\boxed{I_L = 9.24\text{ A}, \phi = 51.5^\circ\text{ leading}}$$

Q-12: A resistor of 40 Ω and an inductor of 0.2 H and capacitor of 120 µF are connected in parallel across 230 V, 50 Hz supply. Find (1) the current of each branch (2) the resultant current (3) Power factor of the circuit

---

Answer:

Given: $R = 40\ \Omega, L = 0.2\ \text{H}, C = 120\ \mu\text{F}, V = 230\ \text{V}, f = 50\ \text{Hz}$

Branch currents:

$$I_R = \frac{V}{R} = \frac{230}{40} = 5.75\ \text{A (in phase)}$$
$$X_L = 2\pi(50)(0.2) = 62.83\ \Omega, I_L = \frac{230}{62.83} \approx 3.66\ \text{A (lags 90°)}$$
$$X_C = \frac{1}{2\pi(50)(120 \times 10^{-6})} \approx 26.53\ \Omega, I_C = \frac{230}{26.53} \approx 8.67\ \text{A (leads 90°)}$$

Net reactive current:

$$I_X = I_C - I_L = 8.67 - 3.66 = 5.01\ \text{A (leading)}$$

Resultant current:

$$I = \sqrt{I_R^2 + I_X^2} = \sqrt{(5.75)^2 + (5.01)^2} \approx 7.63\ \text{A}$$

Power factor:

$$pf = \frac{I_R}{I} = \frac{5.75}{7.63} \approx 0.754\ \text{leading}$$

Final Answer:

$$\boxed{I_R = 5.75\ \text{A},\ I_L = 3.66\ \text{A},\ I_C = 8.67\ \text{A},\ I = 7.63\ \text{A},\ \text{pf} \approx 0.754\ \text{leading}}$$

Q-13: A R-C series circuit having Resistance R = 5.77 Ω and reactance XC = 3.33 Ω is connected across 230 V, 50 Hz ac supply. Find (a) current (b) Power factor (c) Average power.

Answer:

Given:
$R = 5.77\ \Omega,\ X_C = 3.33\ \Omega,\ V = 230\ \text{V},\ f = 50\ \text{Hz}$

To Find: (a) Current I, (b) Power factor PF, (c) Average power P

Formulas:

$$Z = \sqrt{R^2 + X_C^2}, I = \frac{V}{Z}, \text{PF} = \frac{R}{Z}, P = I^2 R$$

Solution:

$$Z = \sqrt{(5.77)^2 + (3.33)^2} = \sqrt{33.29 + 11.09} = \sqrt{44.38} = 6.662\,\Omega$$
$$I = \frac{230}{6.662} = 34.52\text{ A}$$
$$\text{PF} = \frac{5.77}{6.662} = 0.866\text{ leading}$$
$$P = (34.52)^2 \times 5.77 = 1191.5 \times 5.77 = 6872\text{ W}$$

Final Answer:

$$\boxed{I = 34.5\text{ A, PF} = 0.866\text{ leading, } P = 6872\text{ W}}$$

Q-14: A circuit consumes a power of 1000 W at 0.6 leading power factor, when connected to 200 V, 50 Hz ac supply. Calculate (a) Current (b) Apparent power (c) Reactive power.

Answer:

Given: $P = 1000\text{ W}, \text{pf} = 0.6\text{ leading}, V = 200\text{ V}$

(a) Current:

$$P = VI\cos\phi \Rightarrow I = \frac{P}{V\cos\phi} = \frac{1000}{200 \times 0.6} \approx 8.333\text{ A}$$

(b) Apparent power:

$$S = VI = 200 \times 8.333 \approx 1666.67\text{ VA}$$

(c) Reactive power:

$$Q = \sqrt{S^2 - P^2} = \sqrt{1666.67^2 - 1000^2} \approx 1333.33\text{ VAR (leading)}$$

Final Answer:

$$\boxed{I = 8.33\text{ A}, S = 1666.67\text{ VA}, Q \approx 1333.33\text{ VAR (leading)}}$$

Q-15: In a series–parallel circuit, the parallel branches A and B are in series with branch C. The impedances are: ZA=(4+j3) Ω, ZB=(4−j316) Ω, ZC=(2+j8) Ω, If the

current IC=(25+j0) Amp, Determine the branch currents and voltages and the total voltage. Hence calculate the complex power for each branch and the whole circuit.

Answer:

Given:

$Z_A = (4 + j3)\ \Omega$
$Z_B = (4 - j316)\ \Omega$

$Z_C = (2 + j8)\ \Omega$
$I_C = 25\angle 0^\circ \text{ A} = 25 + j0 \text{ A}$

Step 1: Voltage across branch C

$$V_C = I_C \times Z_C = 25 \times (2 + j8) = 50 + j200 \text{ V}$$

Magnitude:

$$| V_C |= \sqrt{50^2 + 200^2} = \sqrt{2500 + 40000} = \sqrt{42500} \approx 206.16 \text{ V}$$

Step 2: Equivalent impedance of parallel branches A and B

$$Y_A = \frac{1}{Z_A} = \frac{1}{4 + j3} = \frac{4 - j3}{25} = 0.16 - j0.12 \text{ S}$$
$$Y_B = \frac{1}{Z_B} = \frac{1}{4 - j316} = \frac{4 + j316}{(4)^2 + (316)^2}$$
$$(4)^2 + (316)^2 = 16 + 99856 = 99872$$
$$Y_B = \frac{4 + j316}{99872} \approx 4.004 \times 10^{-5} + j0.003163 \text{ S}$$
$$Y_{AB} = Y_A + Y_B \approx (0.16 + 4.004 \times 10^{-5}) + j(-0.12 + 0.003163)$$
$$Y_{AB} \approx 0.16004 - j0.116837 \text{ S}$$
$$Z_{AB} = \frac{1}{Y_{AB}} \approx \frac{1}{0.16004 - j0.116837}$$

Let’s compute magnitude and phase of Y_{AB}:

$$| Y_{AB} |= \sqrt{(0.16004)^2 + (0.116837)^2} \approx \sqrt{0.025613 + 0.013651} \approx \sqrt{0.039264} \approx 0.19815 \text{ S}$$
$$\theta_Y = \tan^{-1}\left(\frac{-0.116837}{0.16004}\right) \approx \tan^{-1}(-0.730) \approx -36.1^\circ$$
$$| Z_{AB} |= \frac{1}{0.19815} \approx 5.046\ \Omega$$
$$\theta_Z = -\theta_Y = 36.1^\circ$$

So:

$$Z_{AB} \approx 5.046\angle 36.1^\circ \ \Omega$$

In rectangular:

$$Z_{AB} \approx 5.046\cos\ 36.1^\circ + j5.046\sin\ 36.1^\circ \approx 4.08 + j2.976\ \Omega$$

Step 3: Voltage across parallel branches A and B

$$V_{AB} = I_C \times Z_{AB} = 25 \times (4.08 + j2.976) = 102 + j74.4\ \text{V}$$
$$|\ V_{AB}\ | = \sqrt{102^2 + 74.4^2} \approx \sqrt{10404 + 5535} \approx \sqrt{15939} \approx 126.25\ \text{V}$$

Step 4: Branch currents A and B

$$I_A = \frac{V_{AB}}{Z_A} = \frac{102 + j74.4}{4 + j3}$$

Multiply numerator and denominator by $4 - j3$:

$$(102 + j74.4)(4 - j3) = 408 - j306 + j297.6 + 223.2$$

Wait — carefully:

$$(102 + j74.4)(4 - j3) = 102 \cdot 4 + 102 \cdot (-j3) + j74.4 \cdot 4 + j74.4 \cdot (-j3)$$
$$= 408 - j306 + j297.6 + 223.2$$
$$\text{Real: } 408 + 223.2 = 631.2$$
$$\text{Imag: } -306 + 297.6 = -8.4$$

Denominator: $4^2 + 3^2 = 25$

$$I_A = \frac{631.2 - j8.4}{25} = 25.248 - j0.336\ \text{A}$$
$$|\ I_A\ | \approx \sqrt{25.248^2 + 0.336^2} \approx 25.25\ \text{A}$$
$$I_B = \frac{V_{AB}}{Z_B} = \frac{102 + j74.4}{4 - j316}$$

Multiply numerator and denominator by $4 + j316$:

Numerator:

$(102 + j74.4)(4 + j316) = 408 + j102 \cdot 316 + j74.4 \cdot 4 + j^2 \cdot 74.4 \cdot 316$
$= 408 + j32232 + j297.6 - 23510.4$
Real: $408 - 23510.4 = -23102.4$
Imag: $32232 + 297.6 = 32529.6$

So numerator: $-23102.4 + j32529.6$

Denominator: $4^2 + 316^2 = 16 + 99856 = 99872$

$$I_B = \frac{-23102.4 + j32529.6}{99872}$$
$$\approx -0.2313 + j0.3256 \text{ A}$$
$$| I_B | \approx \sqrt{0.05348 + 0.10601} \approx \sqrt{0.15949} \approx 0.3994 \text{ A}$$

Step 5: Total voltage V_T

$$V_T = V_{AB} + V_C = (102 + j74.4) + (50 + j200) = 152 + j274.4 \text{ V}$$
$$| V_T | = \sqrt{152^2 + 274.4^2} \approx \sqrt{23104 + 75295} \approx \sqrt{98399} \approx 313.7 \text{ V}$$

Step 6: Complex power for each branch

Branch C:

$$S_C = V_C \times I_C^*$$

$$I_C^* = 25 - j0$$

$$S_C = (50 + j200) \times 25 = 1250 + j5000 \text{ VA}$$

Branch A:

$$S_A = V_{AB} \times I_A^*$$

$$I_A^* = 25.248 + j0.336$$

$$V_{AB} = 102 + j74.4$$
$$S_A = (102 + j74.4)(25.248 + j0.336)$$

Multiply:
Real: $102 \times 25.248 + 74.4 \times 0.336 = 2575.3 + 24.998 \approx 2600.3$
Imag: $102 \times 0.336 + 74.4 \times 25.248 = 34.272 + 1878.45 \approx 1912.7$

$$S_A \approx 2600.3 + j1912.7 \text{ VA}$$

Branch B:

$$S_B = V_{AB} \times I_B^*$$

$$I_B^* = -0.2313 - j0.3256$$

$$S_B = (102 + j74.4)(-0.2313 - j0.3256)$$

Multiply:
Real: $102 \times (-0.2313) + 74.4 \times (-0.3256) = -23.59 - 24.21 \approx -47.80$
Imag: $102 \times (-0.3256) + 74.4 \times (-0.2313) = -33.21 - 17.21 \approx -50.42$

$$S_B \approx -47.80 - j50.42 \text{ VA}$$

Whole circuit:

$$S_{\text{total}} = S_A + S_B + S_C$$

Real: $2600.3 - 47.80 + 1250 = 3802.5$
Imag: $1912.7 - 50.42 + 5000 = 6862.28$

$$S_{\text{total}} \approx 3802.5 + j6862.3 \text{ VA}$$

Final Answers:

$$\boxed{I_A \approx 25.25 \text{ A}, I_B \approx 0.399 \text{ A}}$$
$$\boxed{V_A = V_B = V_{AB} \approx 126.3 \text{ V}, V_C \approx 206.2 \text{ V}, V_T \approx 313.7 \text{ V}}$$
$$\boxed{S_A \approx 2600 + j1913 \text{ VA}, S_B \approx -47.8 - j50.4 \text{ VA}, S_C = 1250 + j5000 \text{ VA}, S_{\text{total}} \approx 3803 + j6862 \text{ VA}}$$

Q-16: Two impedances are connected in parallel across a 100 volt, 50 Hz a.c. supply. Impedance no. 1 has resistance of 8 Ω and capacitive reactance of 7 Ω. While impedance no. 2 has resistance of 5 Ω and inductive reactance of 6 Ω. Calculate: (i) Current through each circuit & p.f. of each circuit. (ii) Total current and p.f. of combined circuit. (iii) Power taken by the whole circuit.

Answer:

Given:

$$Z_1 = 8 - j7\ \Omega, Z_2 = 5 + j6\ \Omega, V = 100 \text{ V}$$

(i) Current through each circuit & pf:

$$I_1 = \frac{V}{\mid Z_1 \mid} = \frac{100}{\sqrt{8^2 + 7^2}} = \frac{100}{\sqrt{113}} \approx 9.41 \text{ A}$$

pf $_1 = \cos\ \phi_1 = \frac{8}{\sqrt{113}} \approx 0.754$ leading (since capacitive).

$$I_2 = \frac{V}{\mid Z_2 \mid} = \frac{100}{\sqrt{5^2 + 6^2}} = \frac{100}{\sqrt{61}} \approx 12.81 \text{ A}$$

pf $_2 = \frac{5}{\sqrt{61}} \approx 0.64$ lagging (inductive).

(ii) Total current & pf:

Admittances:

$$Y_1 = \frac{1}{Z_1} = \frac{1}{8 - j7} = \frac{8 + j7}{113} \approx 0.0708 + j0.0619 \text{ S}$$
$$Y_2 = \frac{1}{Z_2} = \frac{1}{5 + j6} = \frac{5 - j6}{61} \approx 0.0820 - j0.0984 \text{ S}$$
$$Y_T = Y_1 + Y_2 \approx 0.1528 - j0.0365 \text{ S}$$
$$\mid Y_T \mid \approx 0.1565 \text{ S}$$
$$I_T = V \times \mid Y_T \mid = 100 \times 0.1565 \approx 15.65 \text{ A}$$
$$\phi_T = \tan^{-1}\left(\frac{-0.0365}{0.1528}\right) \approx -13.43^\circ$$

pf $_T = \cos\ \phi_T \approx 0.973$ leading.

(iii) Power taken:

$$P = VI_T \cos\ \phi_T = 100 \times 15.65 \times 0.973 \approx 1522.5 \text{ W}$$

Final Answer:

$$\boxed{I_1 \approx 9.41 \text{ A } (0.754 \text{ leading}),\ I_2 \approx 12.81 \text{ A } (0.64 \text{ lagging}),\ I_T \approx 15.65 \text{ A},\ \text{pf}_T \approx 0.973 \text{ leading},\ P \approx 1522.5}$$

Q-17: A series RLC circuit consists of a resistance of 500 Ω, inductance of 50 mH and a capacitance of 20 pF. Find: (i) The resonant frequency, (ii)The Q factor of the circuit of resonance, (iii) The half power frequency

---

Answer:

Given:

$$R = 500\ \Omega$$
$$L = 50 \times 10^{-3} \text{ H}$$
$$C = 20 \times 10^{-1} \quad \text{F}$$

To Find:
(i) Resonant frequency f_r
(ii) Quality factor Q at resonance
(iii) Half-power frequencies f_1, f_2

(i) Resonant frequency

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$
$$LC = 50 \times 10^{-3} \times 20 \times 10^{-12} = 1000 \times 10^{-1} \quad = 1 \times 10^{-12}$$
$$\sqrt{LC} = 1 \times 10^{-6}$$
$$f_r = \frac{1}{2\pi \times 10^{-6}} \approx 159154.94 \text{ Hz}$$
$$\boxed{f_r \approx 159.15 \text{ kHz}}$$

(ii) Quality factor Q

$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$
$$\frac{L}{C} = \frac{50 \times 10^{-3}}{20 \times 10^{-12}} = 2.5 \times 10^{9}$$
$$\sqrt{\frac{L}{C}} = \sqrt{2.5 \times 10^{9}} \approx 50000$$
$$Q = \frac{50000}{500} = 100$$
$$\boxed{Q = 100}$$

(iii) Half-power frequencies
For high $Q > 10$, approximate formulas:

$$f_1 \approx f_r - \frac{BW}{2}, f_2 \approx f_r + \frac{BW}{2}$$

Bandwidth:

$$BW = \frac{f_r}{Q} = \frac{159154.94}{100} \approx 1591.55 \text{ Hz}$$
$$f_1 \approx 159154.94 - 795.775 \approx 158359.17 \text{ Hz}$$
$$f_2 \approx 159154.94 + 795.775 \approx 159950.72 \text{ Hz}$$
$$\boxed{f_1 \approx 158.36 \text{ kHz}, f_2 \approx 159.95 \text{ kHz}}$$

Q-18: A resistance of 1 Ω and inductance of 0.02 H are connected in series with a capacitor across 200 V supply. Find the value of capacitance, so that current drawn by circuit will be maximum at frequency 50 Hz. Find current and voltage across capacitor.

Answer:

Given: $R = 1\,\Omega, L = 0.02\text{ H}, V = 200\text{ V}, f = 50\text{ Hz}$

For max current at resonance:

$$\omega_r L = \frac{1}{\omega_r C} \Rightarrow C = \frac{1}{\omega_r^2 L} = \frac{1}{(2\pi \times 50)^2 \times 0.02}$$
$$C = \frac{1}{(314.16)^2 \times 0.02} \approx \frac{1}{1973.9} \approx 5.066 \times 10^{-4}\text{ F} = 506.6\,\mu\text{F}$$

At resonance, $Z = R = 1\,\Omega$

$$I_{\text{max}} = \frac{V}{R} = \frac{200}{1} = 200\text{ A}$$

Voltage across capacitor:

$$V_C = I \times X_C = 200 \times \frac{1}{2\pi(50)(506.6 \times 10^{-6})}$$
$$X_C = \frac{1}{314.16 \times 5.066 \times 10^{-4}} \approx 6.28\,\Omega$$
$$V_C \approx 200 \times 6.28 = 1256\text{ V}$$

Final Answer:

$$\boxed{C \approx 506.6\,\mu\text{F}, I_{\text{max}} = 200\text{ A}, V_C \approx 1256\text{ V}}$$

Q-19: A balanced star connected load of (8 + j6) Ω per phase is connected to a 415 V, 50 Hz, 3-φ supply. Find the line current, power factor, power and total volt-amps.

Answer:

Given:

$$Z_{\text{ph}} = 8 + j6\,\Omega$$
$$V_L = 415\text{ V}$$

Star connection

To Find:
Line current I_L, power factor, total power P, total VA

Step 1: Phase voltage
Star: $V_{\text{ph}} = \frac{V_L}{\sqrt{3}} = \frac{415}{\sqrt{3}} \approx 239.6 \text{ V}$

Step 2: Phase impedance magnitude

$$|Z_{\text{ph}}| = \sqrt{8^2 + 6^2} = \sqrt{64 + 36} = 10\,\Omega$$

Step 3: Phase current = Line current (star)

$$I_{\text{ph}} = I_L = \frac{V_{\text{ph}}}{|Z_{\text{ph}}|} = \frac{239.6}{10} = 23.96 \text{ A}$$

Step 4: Power factor

$$\text{PF} = \frac{R}{|Z_{\text{ph}}|} = \frac{8}{10} = 0.8 \text{ lagging}$$

Step 5: Total power
3-phase power:

$$P = \sqrt{3}V_L I_L \times \text{PF} = \sqrt{3} \times 415 \times 23.96 \times 0.8$$
$$P \approx 1.732 \times 415 \times 23.96 \times 0.8 \approx 13800 \text{ W}$$

Step 6: Total volt-amps

$$S = \sqrt{3}V_L I_L = 1.732 \times 415 \times 23.96 \approx 17250 \text{ VA}$$

Final Answer:

$$\boxed{I_L = 24.0 \text{ A, PF} = 0.8 \text{ lagging}, P \approx 13.8 \text{ kW}, S \approx 17.25 \text{ kVA}}$$

Q-20: For 3-φ star connected load consists of non-inductive resistance of 50 Ω in parallel with a capacitance of 15 µF. Calculate the line current, power absorbed, total kVA and power factor when connected to 415 V, 3 phase, 50 Hz supply.

Answer:

Given: Per phase: $R = 50\,\Omega, C = 15\,\mu\text{F}, V_L = 415 \text{ V}$

Phase voltage:

$$V_{ph} = \frac{V_L}{\sqrt{3}} = \frac{415}{\sqrt{3}} \approx 239.6 \text{ V}$$

Admittance per phase:

$$Y = \frac{1}{R} + j\omega C = \frac{1}{50} + j(2\pi \times 50 \times 15 \times 10^{-6})$$
$$Y = 0.02 + j0.004712 \approx 0.02055\angle 13.24^\circ \text{ S}$$

Phase current:

$$I_{ph} = V_{ph} \times | Y | = 239.6 \times 0.02055 \approx 4.925 \text{ A}$$

Line current = phase current for star:

$$I_L \approx 4.925 \text{ A}$$

Power absorbed per phase:

$$P_{ph} = V_{ph}^2 \times G = (239.6)^2 \times 0.02 \approx 1148.3 \text{ W}$$

Total power:

$$P_T = 3 \times P_{ph} \approx 3444.9 \text{ W}$$

Total kVA:

$$S_T = 3 \times V_{ph} I_{ph} = 3 \times 239.6 \times 4.925 \approx 3539.6 \text{ VA} = 3.54 \text{ kVA}$$

Power factor:

$$pf = \cos(13.24^\circ) \approx 0.973 \text{ leading}$$

Final Answer:

$$\boxed{I_L \approx 4.925 \text{ A}, P_T \approx 3.445 \text{ kW}, S_T \approx 3.54 \text{ kVA}, \text{pf} \approx 0.973 \text{ leading}}$$

Q-21: A 3-φ load consists of three similar inductive coils, having resistance 50 Ω and inductance 0.2 H. If Supply Voltage is 415 V, 50 Hz, calculate: (i) the line current (ii) power factor (iii) total power consumed when load is connected in star and delta.

Answer:

Given per coil:

$$R = 50\ \Omega$$
$$L = 0.2 \text{ H}$$
$$f = 50 \text{ Hz}$$
$$X_L = 2\pi f L = 2\pi \times 50 \times 0.2 = 62.832\ \Omega$$

$$Z_{\text{ph}} = 50 + j62.832\,\Omega$$
$$|\,Z_{\text{ph}}\,| = \sqrt{50^2 + 62.832^2} \approx 80.3\,\Omega$$

(i) & (ii) & (iii) for Star connection

Phase voltage:

$$V_{\text{ph}} = \frac{V_L}{\sqrt{3}} = \frac{415}{\sqrt{3}} \approx 239.6\text{ V}$$

Phase current:

$$I_{\text{ph}} = \frac{V_{\text{ph}}}{|\,Z_{\text{ph}}\,|} = \frac{239.6}{80.3} \approx 2.984\text{ A}$$

Star: $I_L = I_{\text{ph}} \approx 2.984\text{ A}$

Power factor:

$$\text{PF} = \frac{R}{|\,Z_{\text{ph}}\,|} = \frac{50}{80.3} \approx 0.622\text{ lagging}$$

Total power:

$$P = 3 \times I_{\text{ph}}^2 \times R = 3 \times (2.984)^2 \times 50$$
$$P \approx 3 \times 8.904 \times 50 \approx 1335.6\text{ W}$$

or

$$P = \sqrt{3} V_L I_L \times \text{PF} = 1.732 \times 415 \times 2.984 \times 0.622 \approx 1335\text{ W}$$

For Delta connection

Phase voltage = Line voltage:

$$V_{\text{ph}} = 415\text{ V}$$

Phase current:

$$I_{\text{ph}} = \frac{415}{80.3} \approx 5.168\text{ A}$$

Line current:

$$I_L = \sqrt{3} \times I_{\text{ph}} = 1.732 \times 5.168 \approx 8.952 \text{ A}$$

Power factor same: PF ≈ 0.622 lagging

Total power:

$$P = 3 \times I_{\text{ph}}^2 \times R = 3 \times (5.168)^2 \times 50$$
$$P \approx 3 \times 26.71 \times 50 \approx 4006.5 \text{ W}$$

Final Answer:
Star:

$$\boxed{I_L \approx 2.98 \text{ A, PF} \approx 0.622,\ P \approx 1.34 \text{ kW}}$$

Delta:

$$\boxed{I_L \approx 8.95 \text{ A, PF} \approx 0.622,\ P \approx 4.01 \text{ kW}}$$

Q-22: In balanced 3-φ, 415 V system, line current is 100 A. When power is measured by two wattmeters, one wattmeter indicates power and other indicates zero. What will be power factor of load & measured power? If the power factor were unity and same load current what would be the reading of each wattmeter?

Answer:

Given: $V_L = 415 \text{ V}, I_L = 100 \text{ A}, W_1 = \text{some } P, W_2 = 0$

When one wattmeter reads zero:

$$W_2 = 0 \Rightarrow \cos(\phi - 30^\circ) = 0 \Rightarrow \phi - 30^\circ = 90^\circ \Rightarrow \phi = 120^\circ$$

But pf angle ≤ 90° for loads. Actually, for $W_2 = 0$,

$$\phi = 60^\circ (\text{since } W = V_L I_L \cos(\phi \pm 30^\circ))$$

Check:

$$W_2 = V_L I_L \cos(\phi + 30^\circ) = 0 \Rightarrow \phi + 30^\circ = 90^\circ \Rightarrow \phi = 60^\circ$$

Power factor:

$$pf = \cos 60^\circ = 0.5 \text{ lagging}$$

Measured power:

$$P_T = W_1 + W_2 = W_1 + 0 = V_L I_L \cos(\phi - 30°) \times 2?$$

Better: $P_T = \sqrt{3} V_L I_L \cos\ \phi$

$$P_T = \sqrt{3} \times 415 \times 100 \times 0.5 \approx 35938.5\ \text{W} = 35.94\ \text{kW}$$

If pf were unity ($\phi = 0$):
Each wattmeter reading:

$$W = V_L I_L \cos(30°) = 415 \times 100 \times \frac{\sqrt{3}}{2} \approx 35938.5/2?$$

Actually:

$$W_1 = V_L I_L \cos(30°) \approx 35938.5\ \text{W}/\sqrt{3}?$$

Let's compute:

$$W = 415 \times 100 \times \cos(30°) \approx 415 \times 100 \times 0.866 \approx 35939\ \text{W}? That's too high.$$

Wait: For unity pf, total power $P_T = \sqrt{3} \times 415 \times 100 \times 1 \approx 71877$ W.
Each wattmeter reads:

$$W = V_L I_L \cos(30°) = 415 \times 100 \times 0.866 \approx 35938.5\ \text{W}$$

Thus $W_1 = W_2 \approx 35.94$ kW.

Final Answer:

$$\boxed{\text{pf} = 0.5\ \text{lagging}, P_T \approx 35.94\ \text{kW}, \text{At unity pf: each wattmeter reads} \approx 35.94\ \text{kW}}$$

Q-23: For 415 V, three phase system, power was measured by two wattmeters and readings were 10.5 kW and −2.5 kW. Calculate (i) power factor (ii) Line current.

Answer:

Given:

$$W_1 = 10.5\ \text{kW}$$
$$W_2 = -2.5\ \text{kW}$$

(i) Power factor
Total power:

$$P = W_1 + W_2 = 10.5 - 2.5 = 8.0\,\text{kW}$$
$$\tan\,\phi = \sqrt{3}\cdot\frac{W_1 - W_2}{W_1 + W_2} = \sqrt{3}\cdot\frac{10.5-(-2.5)}{8.0}$$
$$= \sqrt{3}\cdot\frac{13.0}{8.0} = 1.732 \times 1.625 = 2.8145$$
$$\phi = \tan^{-1}(2.8145) \approx 70.5^\circ$$
$$\text{PF} = \cos\,\phi \approx \cos\,70.5^\circ \approx 0.333$$

(ii) Line current

$$P = \sqrt{3}V_L I_L \times \text{PF}$$
$$8000 = 1.732 \times 415 \times I_L \times 0.333$$
$$I_L = \frac{8000}{1.732 \times 415 \times 0.333} \approx \frac{8000}{239.5} \approx 33.4\,\text{A}$$

Final Answer:

$$\boxed{\text{PF} \approx 0.333,\ I_L \approx 33.4\,\text{A}}$$

****