Subject Name & Code:

BASIC ELECTRICAL ENGINEERING- BE01R00051

Assignment – 2

Q-1: Define following terms (i) Cycle, (ii) Time period, (iii) Frequency, (iv) RMS Value, (v) Average value, (vi) Peak factor, (vii) Form factor, (viii) Line Voltage/Current, (ix) Active power. (x) Power factor.

Answer:

(i) Cycle
A *cycle* in an alternating quantity (e.g., voltage or current) refers to one complete set of positive and negative values, repeating identically over time.

(ii) Time Period (T)
The *time period* is the duration in seconds required to complete one full cycle of the waveform. It is denoted by T and measured in seconds (s).

(iii) Frequency (f)
Frequency is the number of cycles completed per second. It is the reciprocal of the time period:

$$f = \frac{1}{T}$$

The unit is Hertz (Hz).

(iv) RMS Value
The *Root Mean Square (RMS) value* of an alternating quantity is the equivalent steady (DC) value that produces the same heating effect in a resistive load. For a sinusoidal waveform:

$$V_{\text{rms}} = \frac{V_{\text{max}}}{\sqrt{2}}$$

(v) Average Value
The *average value* of an alternating quantity over one complete cycle is zero for a symmetrical waveform. For a half-cycle of a sine wave:

$$V_{\text{avg}} = \frac{2V_{\text{max}}}{\pi}$$

(vi) Peak Factor (Crest Factor)
Peak factor is the ratio of the peak (maximum) value to the RMS value:

$$\text{Peak Factor} = \frac{V_{\max}}{V_{\text{rms}}}$$

For a sine wave, this equals $\sqrt{2} \approx 1.414$.

(vii) Form Factor
Form factor is the ratio of the RMS value to the average value (over a half-cycle):

$$\text{Form Factor} = \frac{V_{\text{rms}}}{V_{\text{avg}}}$$

For a sine wave, this equals $\frac{\pi}{2\sqrt{2}} \approx 1.11$.

(viii) Line Voltage/Current
In polyphase systems, *line voltage* is the voltage between any two line conductors, and *line current* is the current flowing in each line conductor.

(ix) Active Power (P)
Active power is the real power consumed in a circuit, measured in watts (W). It is given by:

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

where $\cos\phi$ is the power factor.

(x) Power Factor
Power factor is the ratio of active power to apparent power:

$$\text{PF} = \frac{P}{S} = \cos\,\phi$$

It indicates the phase relationship between voltage and current.

Q-2: Explain AC circuit containing pure inductance with phasor diagram.

Answer:

In a purely inductive AC circuit, only inductance L is present (resistance and capacitance are negligible). The voltage across the inductor leads the current by $90°$.

Relationship:

$$v_L = L\frac{di}{dt}$$

For sinusoidal current $i = I_m \sin(\omega t)$:

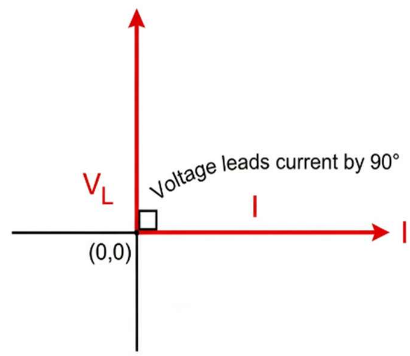
$$v_L = \omega L I_m \sin\left(\omega t + \frac{\pi}{2}\right)$$

Thus, $V_L = I \cdot X_L$, where $X_L = \omega L$ is the inductive reactance.

Phasor Diagram Description:

- Draw a horizontal reference axis representing the current phasor I.
- Draw the voltage phasor V_L perpendicular upward from the origin (leading by 90°).
- Label magnitudes $V_L = IX_L$ and show the 90° angle.

Diagram: (**Diagram is AI generated and only for reference)**



Q-3: Analyze series RL circuit with phasor diagram and equation.

Answer:

A series RL circuit consists of resistance R and inductance L connected in series across an AC supply V.

Impedance:

$$Z = R + jX_L = \sqrt{R^2 + X_L^2} \angle \tan^{-1}\left(\frac{X_L}{R}\right)$$

Current:

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

Phasor Diagram:

- Voltage across R, $V_R = IR$, is in phase with current I.

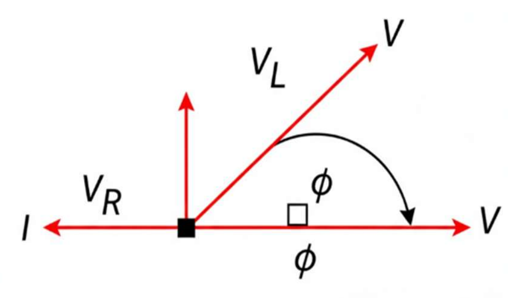
- Voltage across L, $V_L = IX_L$, leads I by 90°.
- Supply voltage V is the phasor sum of V_R and V_L, lagging I by angle ϕ.

Equation for Voltage:

$$V = \sqrt{V_R^2 + V_L^2}$$

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

Diagram: (Diagram is AI generated and only for reference)



Q-4: Explain series RLC circuit and obtain expression for impedance.

Answer:

A series RLC circuit contains resistance R, inductance L, and capacitance C in series.

Voltages:

- $V_R = IR$ (in phase with I)
- $V_L = IX_L$ (leads I by 90°)
- $V_C = IX_C$ (lags I by 90°)

Net Reactance:

$$X = X_L - X_C = \omega L - \frac{1}{\omega C}$$

Impedance:

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

Magnitude:

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

Phase angle:

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

Phasor Sum: Supply voltage $V = \sqrt{V_R^2 + (V_L - V_C)^2}$.

Q-5: What is resonance in AC circuits? Explain its significance.

Answer:

Resonance in an AC circuit occurs when the inductive reactance X_L equals the capacitive reactance X_C, causing the circuit to behave purely resistively.

Condition:

$$X_L = X_C \Rightarrow \omega L = \frac{1}{\omega C}$$
$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

where f_r is the resonant frequency.

Significance:

- Impedance is minimum ($Z = R$), current is maximum.
- Voltage across L and C can be much higher than supply voltage (voltage magnification).
- Used in tuning circuits (radio receivers), filters, and induction heating.
- Power factor becomes unity.

Q-6: Explain parallel resonance and its characteristics.

Answer:

In parallel resonance (often in a parallel LC circuit with a resistor in series with L or C), the susceptances cancel, resulting in maximum impedance.

Condition:

$$B_L = B_C \Rightarrow \frac{1}{X_L} = \frac{1}{X_C}$$

Same resonant frequency as series: $f_r = \frac{1}{2\pi\sqrt{LC}}$.

Characteristics:

- Total impedance is maximum, line current is minimum.
- Circuit acts as a rejector circuit (high impedance at f_r).
- Current through L and C can be large (circulating currents).
- Power factor is unity at resonance.
- Used in radio frequency filters and oscillator circuits.

Q-7: Derive voltage and current relation in star and delta connection.

Answer:

Star (Y) Connection:

- Line voltage $V_L = \sqrt{3} \times$ Phase voltage V_{ph}
- Line current $I_L =$ Phase current I_{ph}

Delta (Δ) Connection:

- Line voltage $V_L =$ Phase voltage V_{ph}
- Line current $I_L = \sqrt{3} \times$ Phase current I_{ph}

Derivation for Star:
Consider three phases with voltages V_{RN}, V_{YN}, V_{BN}. Voltage between lines R and Y:

$$V_{RY} = V_{RN} - V_{YN} = V_{ph}\angle 0^\circ - V_{ph}\angle - 120^\circ$$

Using phasor algebra:

$$|V_{RY}| = \sqrt{3}V_{ph}$$

Derivation for Delta:
Each phase carries current I_{ph}. At each node, line current is the difference of two phase currents:

$$I_R = I_{RY} - I_{BR}$$

Phasor subtraction yields $|I_R| = \sqrt{3}I_{ph}$.

Q-8: Explain two-wattmeter method of power measurement.

Answer:

Used to measure total power in a 3-phase, 3-wire system (balanced or unbalanced).

Connection:
Two wattmeters W_1 and W_2 are connected with their current coils in two lines (say R and Y) and voltage coils between those lines and the third line (B).

Readings:

$$W_1 = V_{RB} I_R \cos(\angle V_{RB} \& I_R)$$
$$W_2 = V_{YB} I_Y \cos(\angle V_{YB} \& I_Y)$$

Total Power:

$$P_{\text{total}} = W_1 + W_2$$

Power Factor (balanced load):

$$\tan\phi = \sqrt{3}\frac{W_1 - W_2}{W_1 + W_2}$$
$$\text{PF} = \cos\phi$$

Q-9: 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-10: 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-11: 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:

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

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-12: 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:

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

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-13: 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-14: In a parallel RC circuit, R = 40 Ω and C = 100 μF. Find line current and phase angle.

Answer:

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

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-15: 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:
$R = 5.77\ \Omega$, $X_C = 3.33\ \Omega$, $V = 230$ V, $f = 50$ 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:

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

Q-16: 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:

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

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-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:

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

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

(i) Resonant frequency

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$
$$LC = 50 \times 10^{-3} \times 20 \times 10^{-1} \quad = 1000 \times 10^{-15} = 1 \times 10^{-12}$$
$$\sqrt{LC} = 1 \times 10^{-6}$$
$$f_r = \frac{1}{2\pi \times 10^{-6}} \approx 159154.94 \text{ Hz}$$
$$\boxed{f_r \approx 159.15 \text{ kHz}}$$

(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 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:

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

Q-19: 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: $I_L = I_{\text{ph}} \approx 2.984$ 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:

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

Delta:

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

Q-20: 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:

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

****