Series R-L Circuits

1. A series RL circuit has R = 30 Ω and L = 0.1 H. It is connected to a 230 V, 50 Hz supply. Find the current and power factor.

Solution:

$X_L = 2\pi fL = 2\pi \times 50 \times 0.1 = 31.42\ \Omega$

$Z = \sqrt{(R^2 + X_L^2)} = \sqrt{(30^2 + 31.42^2)} = 43.42\ \Omega$

$I = V/Z = 230/43.42 = 5.30\ A$

$PF = \cos\theta = R/Z = 30/43.42 = 0.691$ lagging.

2. A series RL circuit draws 5 A from a 200 V, 50 Hz supply. The power consumed is 600 W. Find R and L.

Solution:

$P = I^2R \Rightarrow R = P/I^2 = 600/25 = 24\ \Omega$

$Z = V/I = 200/5 = 40\ \Omega$

$X_L = \sqrt{(Z^2 - R^2)} = \sqrt{(1600 - 576)} = 32\ \Omega$

$L = X_L/(2\pi f) = 32/(314.16) = 0.102$ H.

3. In a series RL circuit, R = 40 Ω, L = 0.2 H, V = 230 V, f = 50 Hz. Find voltage across resistor and inductor.

Solution:

$X_L = 62.83\ \Omega$, $Z = 74.47\ \Omega$

$I = 230/74.47 = 3.09\ A$

$V_R = IR = 123.6$ V, $V_L = IX_L = 194.1$ V.

4. A coil of resistance 20 Ω and inductance 0.15 H is connected to 100 V, 50 Hz supply. Calculate active power, reactive power and apparent power.

Solution:

$X_L = 47.12\ \Omega$, $Z = 51.20\ \Omega$, $I = 1.953$ A

$P = I^2R = 76.3$ W

$Q = I^2X_L = 179.7$ VAR

$S = VI = 195.3$ VA.

5. A series RL circuit has impedance 50 Ω and power factor 0.8 lagging when connected to 200 V AC. Find current, active power and inductance if frequency is 50 Hz.

Solution:

$I = 200/50 = 4$ A

$P = VI\cos\theta = 200 \times 4 \times 0.8 = 640$ W

$R = Z\cos\theta = 40\ \Omega$, $X_L = Z\sin\theta = 30\ \Omega$

$L = 30/(2\pi \times 50) = 0.0955$ H.

6. Find the frequency at which the inductive reactance of a 0.25 H inductor equals the resistance of 50 Ω in a series RL circuit.

Solution:

$X_L = R \Rightarrow 2\pi fL = 50$

$f = 50/(2\pi \times 0.25) = 31.83$ Hz.

7. A series RL circuit takes 10 A at 0.6 power factor lagging from 200 V supply. Find the value of pure resistance to be connected in series to improve PF to 0.8 lagging.

Solution:

Original: $Z1 = 20\ \Omega$, $R1 = 12\ \Omega$, $X_L = 16\ \Omega$

New: $\cos\theta 2 = 0.8$, $R2 = 0.8\ Z2$, $X_L = 0.6\ Z2$

$16 = 0.6\ Z2 \Rightarrow Z2 = 26.67\ \Omega$, $R2 = 21.33\ \Omega$

Added resistance = 21.33 - 12 = 9.33 Ω.

Parallel R-L Circuits

8. A pure resistor of 40 Ω is connected in parallel with a pure inductor of 0.1 H across 230 V, 50 Hz supply. Find total current and power factor.

Solution:

$I_R = 230/40 = 5.75$ A

$X_L = 31.42\ \Omega$, $I_L = 230/31.42 = 7.32$ A

$I = \sqrt{(I_R^2 + I_L^2)} = 9.31$ A

$PF = I_R/I = 0.618$ lagging.

9. In a parallel RL circuit, the current through resistor is 8 A and through inductor is 6 A. Supply voltage is 200 V. Find total current, power and power factor.

Solution:

$I = \sqrt{(8^2 + 6^2)} = 10$ A

$P = V I_R = 200 \times 8 = 1600$ W

PF = 8/10 = 0.8 lagging.

10. A parallel combination of R = 30 Ω and L = 0.15 H is connected to 100 V, 50 Hz. Calculate branch currents and total current.

Solution:

$I_R = 100/30 = 3.333$ A

$X_L = 47.12$ Ω, $I_L = 2.122$ A

$I = \sqrt{(3.333^2 + 2.122^2)} = 3.95$ A.

11. A parallel RL circuit draws 12 A at 0.5 PF lagging from 240 V supply. Find the resistance and inductive reactance.

Solution:

$I_R = I \cos\theta = 6$ A, $I_L = I \sin\theta = 10.392$ A

$R = V/I_R = 40$ Ω, $X_L = V/I_L = 23.1$ Ω.

12. Two parallel branches: one is pure R = 20 Ω, other is pure L with $X_L = 30$ Ω. Supply 150 V. Find total power and reactive power.

Solution:

$I_R = 7.5$ A, $I_L = 5$ A

$P = V I_R = 1125$ W

$Q = V I_L = 750$ VAR.

Mixed / Additional Problems

13. A series RL circuit has R = 15 Ω, X_L = 20 Ω. Connected to 100 V AC. Find current, PF, and voltage across L.

Solution:

Z = 25 Ω, I = 4 A, PF = 0.6 lag, V_L = 80 V.

14. Series circuit: R = 8 Ω, L = 0.04 H, f = 50 Hz, V = 120 V. Calculate impedance, current and active power.

Solution:

X_L = 12.57 Ω, Z = 14.9 Ω, I = 8.05 A, P = 518 W.

15. Parallel RL: R = 50 Ω, X_L = 50 Ω, V = 200 V. Find total current and power factor.

Solution:

I_R = 4 A, I_L = 4 A, I = 5.657 A, PF = 0.707 lag.

16. A coil takes 5 A and dissipates 400 W when connected to 100 V, 50 Hz. Find its resistance and inductance.

Solution:

$R = P/I^2 = 16\ \Omega$, Z = 20 Ω, X_L = 12 Ω, L = 0.0382 H.

17. Series RL circuit has PF 0.707 lagging. R = 30 Ω. Find X_L and current if V = 150 V.

Solution:

$\theta = 45°$, $X_L = R = 30\ \Omega$, $Z = 42.43\ \Omega$, $I = 3.536$ A.

18. Parallel combination of 25 Ω resistor and 0.08 H inductor across 110 V, 60 Hz. Find total current.

Solution:

$X_L = 30.16\ \Omega$, $I_R = 4.4$ A, $I_L = 3.647$ A, $I = 5.72$ A.

19. A series RL circuit consumes 1 kW at 0.8 PF lagging from 250 V supply. Find current and reactive power.

Solution:

$P = VI\cos\theta \Rightarrow I = 1000/(250\times0.8) = 5$ A

$Q = VI\sin\theta = 750$ VAR.

20. In a series RL circuit, voltage across R is 60 V and across L is 80 V. Supply frequency 50 Hz, R = 30 Ω. Find supply voltage, current and inductance.

Solution:

$V = \sqrt{(60^2 + 80^2)} = 100$ V

$I = V_R/R = 2$ A

$X_L = V_L/I = 40\ \Omega$, $L = 0.127$ H.