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BTE 2132: Electrical Fundamentals and Circuit Analysis II Laboratory

Chapter 3: Series Resonance

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Course Information

1) Aims

- To construct Alternating Current (AC) circuits
- To validate related theorems
- To assemble electric circuit from the given schematics circuits
- To work independently and in a team
- To write technical report based on the given guideline

2) Expected Outcomes

- Students will know the Alternating Current (AC) elements
- Students will be able to construct AC circuit according to the given schematic
- Student will be able to work independently or in team

3) References

- A. Robbins and W. Miller, Lab Manual to Accompany Circuit Analysis-Theory and Practice, 5th ed., DELMAR CENGAGE Learning, Fifth Edition, 2013.
- A. Robbins and W. Miller, Circuit Analysis-Theory and Practice, 5th ed., DELMAR CENGAGE Learning, Fifth Edition, 2013.
- William H. Hayt, Steven M. Durbin and Jack E. Kemmerly, Engineering Circuit Analysis, Tata McGraw-Hill Education, 8th Edition, 2013.

Chapter Content

Student should be able to calculate the resonant frequency of a series/parallel resonant circuit.

Series Resonant

- The frequencies for the resonance of AC circuit is determined by the value of inductance, capacitance and resistance.
- Basically series resonant circuit is consists of:
  - AC source
  - Resistor
  - Inductor
  - Capacitor

Series Resonance

Resonant frequency occurs when the $X_L = X_C$.

$$Z_T = R + jX_L - jX_C$$
$$= R + j(X_L - X_C)$$

$$X_L = \omega L = 2\pi f L$$

$$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$$

$$X_L - X_C = 0$$

$$\omega_C = \frac{1}{\omega C}$$

$$\omega^2 = \frac{1}{LC}$$

$$\omega_S = \frac{1}{\sqrt{LC}}$$

Series Resonance

- Converting from angular frequency to Hz

$$f_S = \frac{1}{2\pi\sqrt{LC}}$$

- Total current in the circuit at resonance

$$I = \frac{E}{Z_T} = \frac{E\angle 0°}{R\angle 0°} = \frac{E}{R}\angle 0°$$

- Voltage across each circuit element

$$V_R = IR\angle 0°$$

$$V_L = IX_L\angle 90°$$

$$V_L = IX_C\angle -90°$$

Series Resonance

- Average power dissipated by resistor

$$P_R = I^2 R \ (W)$$

- Reactive power of the inductor

$$Q_L = I^2 X_L \ (\text{VAR})$$

- Reactive power of the capacitor

$$Q_C = I^2 X_C \ (\text{VAR})$$

Quality Factor, Q

- For any resonant circuit,

  - quality factor, Q, as “Ratio of reactive power to average power”

At ω = ωs

$$Q_S = \frac{I^2 X_L A}{I^2 R}$$

$$Q_S = \frac{X_L}{R} = \frac{\omega L}{R}$$

Quality Factor

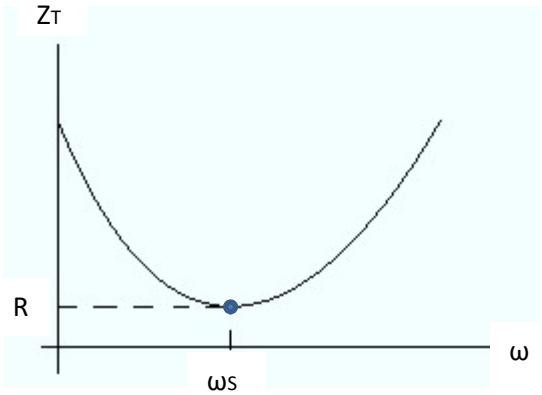
- Using Q to determine other quantities of the circuit

$$Q_S = \frac{IX_L}{IR} = \frac{V_L}{E}$$

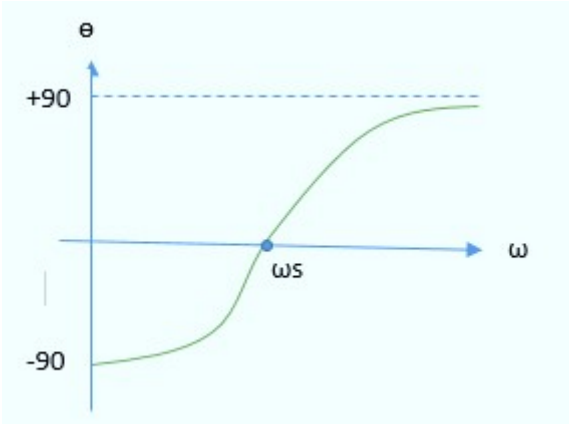
$V_C = V_{L=}\, Q_S E$ at resonance

Series resonant circuit

Series resonant circuit impedance varies with frequency



(a)



(b)

Note: (a) Impedance and (b) phase angle

References

Recommended References:

i. A. Robbins and W. Miller, Lab Manual to Accompany Circuit Analysis-Theory and Practice, 5th ed., DELMAR CENGAGE Learning, Fifth Edition, 2013.

ii. A. Robbins and W. Miller, Circuit Analysis-Theory and Practice, 5th ed., DELMAR CENGAGE Learning, Fifth Edition, 2013.

iii. William H. Hayt, Steven M. Durbin and Jack E. Kemmerly, Engineering Circuit Analysis, Tata McGraw-Hill Education, 8th Edition, 2013.

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