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Department of Electronics and Communication Engineering

EE3251 Electric Circuit Analysis

Unit IV – RESONANCE AND COUPLED CIRCUITS

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Introduction to Resonance and Coupled Circuits

Resonance:

Resonance is a phenomenon that occurs when a system oscillates at its natural frequency.

It is crucial in many electrical circuits like filters and oscillators.

Coupled Circuits:

In coupled circuits, inductive elements share energy between them through mutual inductance.

Resonance and coupling play significant roles in determining the behavior of tuned circuits, transformers, and communication systems.

Series Resonance

- **Series Resonance:**
  - In a series resonance circuit, the inductor and capacitor are connected in series, and the resonance occurs when the reactance of the inductor equals the reactance of the capacitor.
- **Resonant Frequency:**
  - The resonant frequency is given by:

$$f_0 = \frac{1}{2\pi\sqrt{LC}}$$

  where L is the inductance and C is the capacitance.
- **Impedance at Resonance:**
  - At resonance, the impedance of the circuit is minimum, and the current is maximum.

Parallel Resonance

Parallel Resonance:

In a parallel resonance circuit, the inductor and capacitor are connected in parallel.

The resonant frequency is the same as in the series case, but the impedance is maximum at resonance.

Impedance at Resonance:

At resonance, the impedance of the circuit is maximum, and the current is minimum.

Quality Factor (Q)

- **Definition of Q Factor:**
  - The quality factor is a measure of the sharpness of the resonance peak in the frequency response of the circuit.
  - It is defined as:

$$Q = \frac{f_0}{\Delta f}$$

  where f_0 is the resonant frequency and Δf is the bandwidth.

- **High Q Factor:**
  - A high Q factor indicates a narrow bandwidth and higher selectivity (sharp resonance).
  - Example: In tuned circuits used in radio receivers.

Bandwidth (BW)

- **Definition of Bandwidth:**
  - Bandwidth is the range of frequencies around the resonant frequency where the power of the circuit is greater than half of the maximum power.
  - It is given by:

$$BW = \frac{f_0}{Q}$$

- **Relationship Between Q and Bandwidth:**
  - Higher Q results in a narrower bandwidth and vice versa.
  - The bandwidth determines the circuit's ability to pass signals of a certain frequency range.

Self-Inductance and Mutual Inductance

- **Self-Inductance (L):**
  - Self-inductance is the property of a coil (or inductor) that opposes the change in current flowing through it.
  - It is defined by the relationship:

$$V = L\frac{dI}{dt}$$

- **Mutual Inductance (M):**
  - Mutual inductance is the property of two inductors where a change in current in one inductor induces a voltage in the second inductor.
  - It is defined by the relationship:

$$V_2 = M\frac{dI_1}{dt}$$

where **M** is the mutual inductance between the inductors.

Coefficient of Coupling

- Coefficient of Coupling (k):
  - The coefficient of coupling describes the extent to which two inductors are magnetically coupled.
  - It is defined as:

$$k = \frac{M}{\sqrt{L_1 L_2}}$$

where M is the mutual inductance and L_1 and L_2 are the self-inductances of the inductors.

  - k ranges from 0 (no coupling) to 1 (perfect coupling).

Dot Rule and Coupled Circuits

Dot Rule:

The dot rule is used to determine the polarity of voltage and current in coupled inductors.

If the dots are on the same side of both inductors, the voltage will be in phase. If the dots are on opposite sides, the voltage will be out of phase.

Application:

The dot rule is crucial in analyzing transformers and coupled resonant circuits.

Analysis of Coupled Circuits

- **Coupled Circuits:**
  - When two inductors are magnetically coupled, the behavior of the circuit depends on the mutual inductance and the coupling coefficient.
  - **Coupled Circuit Equations:**

$$V_1 = L_1 \frac{di_1}{dt} + M \frac{di_2}{dt}$$

$$V_2 = M \frac{di_1}{dt} + L_2 \frac{di_2}{dt}$$

  - The analysis of coupled circuits helps in designing transformers and filters.

Single Tuned Circuits

Single Tuned Circuit:

A single tuned circuit is a simple resonant circuit consisting of an inductor and a capacitor.

It is used in applications such as radio receivers for tuning to a specific frequency.

Characteristics:

A single tuned circuit can be used to filter signals, and it has a high Q factor for sharp frequency selection.

Frequency Response:

The frequency response of a single tuned circuit has a peak at the resonant frequency.

Summary of Resonance and Coupled Circuits

Key Concepts:

Resonance in series and parallel circuits defines the behavior of reactive components.

Quality Factor (Q) and **Bandwidth** are essential for analyzing resonance sharpness and frequency selectivity.

Self and Mutual Inductance are crucial in coupled circuits, influencing energy transfer.

The **Coefficient of Coupling** and **Dot Rule** are key to understanding the interaction between coupled inductors.

Single Tuned Circuits are used for frequency selection in communication systems.

References

TEXT BOOKS:

1. William H. HaytJr, Jack E. Kemmerly and Steven M. Durbin, “Engineering Circuits Analysis”,McGraw Hill publishers, 9thedition, New Delhi, 2020.

2. Charles K. Alexander, Mathew N.O. Sadiku, “Fundamentals of Electric Circuits”, SecondEdition, McGraw Hill, 2019.

3. Allan H. Robbins, Wilhelm C. Miller, “Circuit Analysis Theory and Practice”, CengageLearning India, 2013.

REFERENCES

1. Chakrabarti A, “Circuits Theory (Analysis and synthesis), DhanpatRai& Sons, New Delhi,2020.

2 Joseph A. Edminister, MahmoodNahvi, “Electric circuits”, Schaum’s series, McGraw-Hill,First Edition, 2019.

3. M E Van Valkenburg, “Network Analysis”,Prentice-Hall of India Pvt Ltd, New Delhi, 2015.

4. Richard C. Dorf and James A. Svoboda, “Introduction to Electric Circuits”, 7th Edition, JohnWiley Sons, Inc. 2018.

5. Sudhakar A and Shyam Mohan SP, “Circuits and Networks Analysis and Synthesis”,McGraHill, 2015.