INDUCTANCE AND MUTUAL INDUCTANCE

Review

- Current through coil leads to magnetic flux
  - Magnetic flux has closed path – "links" the coil
- What leads to voltage in the coil?
  - Current changes with time -> leads to change in flux
  - Coil moves relative to magnetic field
- Basis for inductance – Section 3.4
  - Units: H = V-s/A

Determine the inductance and mutual inductance of coils, given their physical parameters.

Inductance L

$$L = \frac{flux\ \ linkages}{current} = \frac{\lambda}{i}$$

Flux linkages: $\lambda = N\,\phi$

$$L = \frac{N\phi}{i}$$

Inductance

- Relate to reluctance of core: $\mathcal{R} = l/(\mu A)$

$$\phi = \frac{Ni}{\mathcal{R}} \qquad L = \frac{N^2}{\mathcal{R}}$$

- What is inductance dependent on?
  - Number of turns
  - Core dimensions and material.

Induced Voltages

- Faraday's Law – voltage is induced when flux linkages change with respect to time

$$e = \frac{d\lambda}{dt} = \frac{d(Li)}{dt} = L\frac{di}{dt}$$

Mutual Inductance

- Two coils on same core
  - Flux of one coil links other coil
- Notation
  - Flux linkages of coil 2 due to current in coil 1 – λ_{21}
  - Flux linkages of coil 1 due to its own current – λ_{11}

Self Inductances

$$L_1 = \frac{\lambda_{11}}{i_1}$$

$$L_2 = \frac{\lambda_{22}}{i_2}$$

Mutual Inductance

$$M = \frac{\lambda_{21}}{i_1} = \frac{\lambda_{12}}{i_2}$$

Mutual Inductance

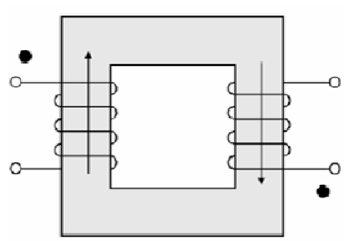
$$M = \frac{\lambda_{21}}{i_1} = \frac{\lambda_{12}}{i_2}$$

- Total Fluxes linking coils

$$\lambda_1 = \lambda_{11} \pm \lambda_{12} \qquad \lambda_2 = \lambda_{22} \pm \lambda_{21}$$

Sign depends on whether or not the fluxes are aiding or opposing

Dot Convention



- Currents entering dotted terminals produce aiding fluxes
  - RHR
- If one current enters dotted and other leaves dotted, then mutual flux linkages oppose self flux linkages.

Circuit Equations for Mutual Inductance

- Assuming coils and core are stationary or constant inductance

$$\lambda_1 = L_1 i_1 \pm M i_2 \qquad \lambda_2 = L_2 i_2 \pm M i_1$$

$$e_1 = \frac{d\lambda_1}{dt} = L_1 \frac{di_1}{dt} \pm M \frac{di_2}{dt} \qquad e_2 = \frac{d\lambda_2}{dt} = L_2 \frac{di_2}{dt} \pm M \frac{di_1}{dt}$$

Summary

- Inductance depends on the physical parameters of the core and the number of turns of the coil.
- Two coils on the same core lead to mutual inductance