Lecture 16: Mutual Inductance

Chapter 6
Inductance, Capacitance, and Mutual Inductance
Sections 6.4, 6.5
Transformers and Their Applications

Transmission Line Transformer
(7200 V to 240 V or 120 V)

Center Tapped Transformer
(power distribution, microphone, automobiles, AC-to-DC rectifiers)

Ignition Coil (12 V to 40000 V)
Transformer: Basics

Voltage Ratio =

Current Ratio =
Mutual inductance is the ability of one coil to induce a voltage across a neighboring coil [unit=H].
Mutually Coupled Coils: Dot Convention

- When the current enters the dotted terminal in one coil, the polarity of induced voltage in other coil is positive at its dotted terminal.

- When the current leaves the dotted terminal in one coil, the polarity of induced voltage in other coil is negative at its dotted terminal.
Mutual Inductance

Mutual inductance is the ability of one coil to induce a voltage across a neighboring coil [unit=H].

\[ M = M_{21} = M_{12} = \mu N_2 N_1 = k \sqrt{L_1 L_2}; 0 \leq k \leq 1 \]

\[ L_1 = \mu N_1^2 \text{ (eq.6.54)}; L_2 = \mu N_2^2 \text{ (eq.6.55)} \]

Where, \( \mu \)=magnetic constant=magnetic permeability [N/A²]

\( N_1 \)=number of turns in left coil

\( N_2 \)=number of turns in right coil

\( \phi_{11} \)=magnetic flux produced by current 1 through \( N_1 \) turns

\( \phi_{21} \)=magnetic flux produced by current 1 through \( N_1 \) and \( N_2 \) turns

\( \phi_{22} \)=magnetic flux produced by current 2 through \( N_2 \) turns

\( \phi_{12} \)=magnetic flux produced by current 2 through \( N_1 \) and \( N_2 \) turns

\( M=M_{21}=M_{12} \)=mutual inductance [H], \( k \)=coefficient of coupling
Suppose that you designing a step-up transformer in a car to go from $v_1 = 12\text{ V}$ to $v_2 = 12000\text{ V}$.

Assume that the self-inductance of primary coil $L_1 = 100\text{ mH}$ and the coupling coefficient, $k=0.75$.

(a) What is the value of $L_2$?

(b) What is the value of mutual inductance, $M$?
Analysis using Mesh Current Method

\[
-v_g + i_1 R_1 + L_1 \frac{di_1}{dt} - M \frac{di_2}{dt} = 0
\]

\[
i_2 R_2 + L_2 \frac{di_2}{dt} - M \frac{di_1}{dt} = 0
\]