Inductance: Review

We know behavior of an inductor

More fundamentally

Magnetic flux

\[ \Phi = \alpha_1 i_1 \]

\[ \alpha_1 = \text{some geometric constant} \]

(from Ampere's Law)

from Faraday's law

\[ |v| = \frac{d\Phi}{dt} \]

For an N-turn coil

\[ \Phi_s = N \Phi \]

\[ |v| = |N \frac{d\Phi_s}{dt}| \]

If these are the same loop

\[ \Phi_0 = \Phi_s \]

\[ i_0 = \frac{\Phi}{\Phi_s} \]

\[ \alpha_1 \frac{di_0}{dt} \]

\[ \Phi_0 \]

\[ \Phi \]

Some Inductor Examples
Magnetic Coupling

Case 1: $i_2 = 0$

$\Phi_1 = \alpha_1 N_1 i_1$

$V_1 = N_1 \frac{d\Phi_1}{dt} = N_1 \frac{di_1}{dt}$

Looking at $L_2$:

$\Phi_{12} = \text{portion of } \Phi_1 \text{ that impinges on } L_2$‘s windings

$|V_2| = N_2 \frac{d\Phi_{12}}{dt}$, $\Phi_{12} \leq \Phi_{12} < \Phi_1$

Let’s say $\Phi_{12} = \alpha_{12} N_1 i_1$

$V_2 = \alpha_{12} N_2 N_1 \frac{di_1}{dt}$

$M = \text{“Mutual inductance”}$

when $i_2 = 0$

\[ \begin{align*}
    V_1 &= L_1 \frac{di_1}{dt} \\
    V_2 &= M \frac{di_1}{dt}
\end{align*} \]

Magnetic Coupling

Case 2: $i_1 = 0$

same circuit as previous, just mirrored & relabeled

When $i_1 = 0$

\[ \begin{align*}
    V_2 &= L_2 \frac{di_2}{dt} \\
    V_1 &= M \frac{di_2}{dt}
\end{align*} \]
Mutual Inductance

Symbols and Dot Convention

Note: Always assign positive sign convention.

Physically: If both winding currents enter the dotted terminals, the fluxes are additive.

Circuit: Current flowing into the dotted terminal of one winding will produce an open-circuit voltage that is positive at the dotted terminal of the other.