Linear Circuits and Systems

Capacitors and Inductors– Part 3 of 4

Inductors

Course: Linear Circuits and Systems
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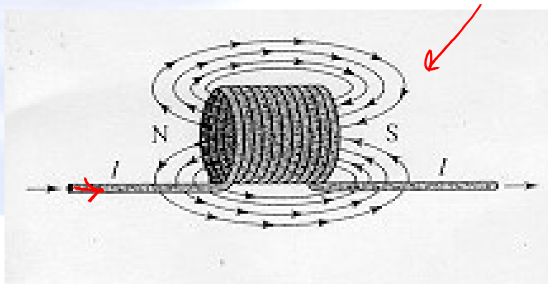
Inductance

- Electric current passing through a conductor will produce magnetic field or flux around it.
- If the wire conductor is wound around a core, magnetic filed /flux will resemble like permanent magnetic bar.



Inductance

- Inductance quantifies inductor' ability to store energy in a magnetic field when electrical current flows through it and is measured in Henry (H)
- The inductance of the coil, L, depends on permeability of core , μ, and physical construction (length l, area of cross-section A, and number of turn N)

$$\boxed{L = \frac{\mu A N}{l}}$$

Inductance

- Magnitude of flux produced depends on magnitude of current , I, and the inductance of the coil/inductor.

$$\boxed{\phi = L\,I}$$

Flux varies with time

- If the current in the inductor is varied with time (t), flux ϕ will also varied with time. Variation of flux in the windings will induce voltage.

$$\boxed{\frac{d\phi}{dt}} = L\,\frac{dI}{dt}$$

$$I = \frac{1}{L}\int v\,dt \longleftarrow v = L\,\frac{dI_L}{dt}$$

Energy stored in inductor:

Voltage $\rightarrow$ $\boxed{v = L\frac{di}{dt}}$ $\leftarrow$

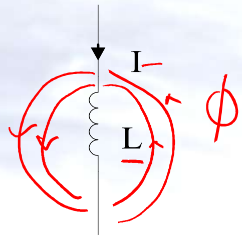
Power $\quad p = iv = iL\frac{di}{dt}$

For duration of dt sec

$$\int dw = pdt = Li\frac{di}{dt}dt \quad = \int Lidi$$

For current changes between i = 0 to i = I

$$W = L\int_0^I idi \quad = L\left[\frac{i^2}{2}\right]_0^I = \boxed{\frac{1}{2}LI^2}$$

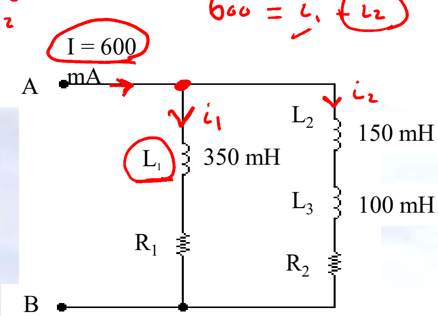


Inductor stores energy in the form of magnetic fields.

Example

$W_2 = \frac{1}{2}L_2 i_2^2$ $\quad 600 = i_1 + i_2$

By supplying a total of constant current at 600 mA, L_1 is found to store an energy of 28 mJ in its magnetic field. Calculate the total energy stored in L_2?



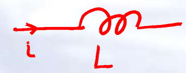
$\rightarrow$ $W_1 = ½L_1I_1^2$ $\leftarrow$

$\rightarrow$ $I_1 = \sqrt{(2W_1/L_1)} = \sqrt{[(2 \times 28 \times 10^{-3})/(350 \times 10^{-3})]} = 400$ mA

$\rightarrow$ $I_2 = I - I_1$(Kirchoff's current law) = 600 – 400 = 200 mA

$W_2 = ½L_2I_2^2 = ½ \times 150 \times 10^{-3} \times (200 \times 10^{-3})^2 = 3$ mJ

- Conclusion



$$\phi = L\, i$$

$$v = L \frac{di}{dt} \longleftrightarrow i = \frac{1}{L} \int v\, dt$$

$$W = \frac{1}{2} L\, i^2$$

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