Inductance and Capacitance

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February 15, 2023

- What is an inductor?
  - An electrical component that opposes change in electric current
    * Unlike a resistor, which opposes the flow of current
  - Made by putting a coil of wire around a magnetic or non-magnetic core
  - Source of inductance is change in magnetic field
  - Current causes magnetic field and change in current causes change in magnetic field, which induces voltage in conductors (inductance)
  - Mathematical Relation

$$\boxed{v = L\frac{di}{dt}}$$

  - L is the inductance and its SI unit is Henry (H)
  - Notice the direction of current and voltage drop
  - Mathematical Relation[1]

$$\boxed{i(t) = \frac{1}{L}\int_{t_0}^{t} vdt + i(t_0)}$$

  - Energy is given by $E = \frac{1}{2}Li^2$

- What is a capacitor?
  - Separation of charge produces voltage which causes electric field
  - The amount of current produced by time varying electric field depends on the physical properties of dielectric materials

[1] If voltage is given

- This is called capacitance

- Mathematical Relation for Capacitors

$$\boxed{i = C\frac{dv}{dt}}$$

  - Current is induced due to change in voltage with time
  - C is the conductance and its SI unit is Farad(F)
  - Notice the direction of current and voltage drop
  - If current flows in opposite direction then there will be a minus sign in the equation
  - The energy stored is $E = \frac{1}{2}cv^2$

- Inductors in Series and Parallel

  - For a serially connected inductor, the equivalent inductance is:

$$\boxed{L_{eq} = L_1 + L_2 + \cdots + L_n}$$

  - For inductors in parallel, the equivalent inductance is:

$$\boxed{\frac{1}{L_{eq}} = \frac{1}{L_1} + \frac{1}{L_2} + \cdots + \frac{1}{L_n}}$$

- Capacitors in Series and Parallel

  - For a serially connected capacitor, the equivalent capacitance is:

$$\boxed{\frac{1}{C_{eq}} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots + \frac{1}{C_n}}$$

  - For capacitors in parallel, the equivalent capacitance is:

$$\boxed{C_{eq} = C_1 + C_2 + \cdots + C_n}$$

- Summary Table

Property	R	L	C
$i - v$ relation	$i = \dfrac{v}{R}$	$i = \dfrac{1}{L}\displaystyle\int_{t_0}^{t} v\,dt + i(t_0)$	$i = C\dfrac{dv}{dt}$
$v - i$ relation	$v = iR$	$v = L\dfrac{di}{dt}$	$v = \dfrac{1}{C}\displaystyle\int_{t_0}^{t} i\,dt + v(t_0)$
p (power transfer in)	$p = i^2R$	$p = Li\dfrac{di}{dt}$	$p = Cv\dfrac{dv}{dt}$
w (stored energy)	0	$w = \frac{1}{2}Li^2$	$w = \frac{1}{2}Cv^2$
Series Combination	$R_{eq} = R_1 + R_2$	$L_{eq} = L_1 + L_2$	$\dfrac{1}{C_{eq}} = \dfrac{1}{C_1} + \dfrac{1}{C_2}$
Parallel Combination	$\dfrac{1}{R_{eq}} = \dfrac{1}{R_1} + \dfrac{1}{R_2}$	$\dfrac{1}{L_{eq}} = \dfrac{1}{L_1} + \dfrac{1}{L_2}$	$C_{eq} = C_1 + C_2$
DC Behavior	No change	Short circuit	Open circuit
Instantaneous v change?	Yes	Yes	No
Instantaneous i change?	Yes	No	Yes