

Energy Storage Elements

AC

When an alternating source is connected to the circuit, the value of the voltage becomes $V(t)$ instead of V_s where:

$$V(t) = V_m \times \sin(\omega t)$$

$$; \omega = 2\pi f \rightarrow f = \frac{1}{T}$$

Coil (L)

- L: Inductance (measured in “Henry H”)

When a current of $i(t)$ moves inside a coil, a magnetic flux (φ) is generated and an induced voltage of $V(t)$ is found where:

$$V(t) = L \times \left(\frac{di(t)}{dt} \right)$$

$$\therefore i(t) = \frac{1}{L} \int_0^t V(H) \cdot dt + i(0)$$

- $i(t)$ is responsible for the energy (“W(t)”) inside the coil as well as the electromagnetic energy generated.

$$W(t) = \frac{1}{2} L (i(t))^2 + W(0)$$

In order for the energy to exist, the function of $i(t)$ must have only one value at a certain t (The function is continuous).

Coil connections

Coils are treated like resistors in either series or parallel. According to KVL:

1. Series coils

$$V(t) = L_{eq} \cdot \frac{di(t)}{dt} \rightarrow L_{eq} = \sum_{n=1}^r L_n$$

2. Parallel coils

$$V(t) = L_{eq} \cdot \frac{di(t)}{dt} \rightarrow \frac{1}{L_{eq}} = \sum_{n=1}^r \left(\frac{1}{L_n} \right)$$

If a coil is connected to a DC current, The Coil is replaced by a short circuit.

$$V = L \frac{di(t)}{dt}$$

$$\therefore \text{The current is constant} \rightarrow V = L \times 0 = 0$$

Capacitors (C)

C: Capacitance (measured in “Farad F”)

When a voltage of $V(t)$ is created around the plates of a capacitor, a current of $i(t)$ is generated where:

$$i(t) = C \frac{dv(t)}{dt}$$

- $V(t)$ is responsible for the electrostatic energy ($W_c(t)$) generated.

$$W_c(t) = \frac{1}{2}C(V(t))^2 + W(0)$$

In order for the energy to exist, the function of $V(t)$ must have only one value at a certain t (The function is continuous).

Capacitor connections

Capacitors are treated like the reciprocal of resistors in either series or parallel.

1. Series capacitors

$$\frac{1}{C_{eq}} = \sum_{n=1}^r \left(\frac{1}{C_n} \right)$$

2. Parallel capacitors

$$C_{eq} = \sum_{n=1}^r C_n$$

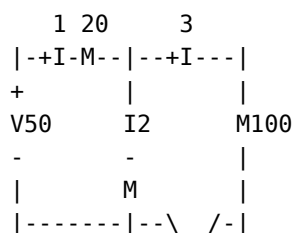
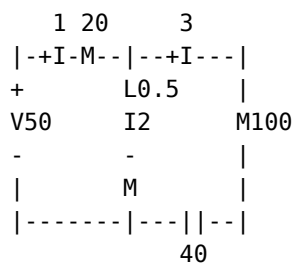
If a capacitor is connected to a DC voltage, the capacitor is replaced by an open circuit.

$$I = C \frac{dV(t)}{dt}$$

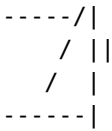
∴ The voltage is constant $\rightarrow I = C \times 0 = 0$

Examples

- 1.



2.



$C_{eq} = \infty$



$L_{eq} = 0$