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:

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

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

- $i(t)$ 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 continous).

Coil connections

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

1. Series coils

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

2. Parallel coils

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

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

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

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

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:

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

- $V(t)$ 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 continous).

Capacitor connections

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

1. Series capacitors

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

2. Parallel capacitors

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

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

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

$$\because \text{The voltage is constant} \rightarrow I = C \times 0 = 0$$

Examples

1.

```
   1 20     3
|-+I-M--|--+I---|
+       L0.5    |
V50     I2      M100
-       -       |
|       M       |
|-------|---||--|
            40
```

```
   1 20     3
|-+I-M--|--+I---|
+       |       |
V50     I2      M100
-       -       |
|       M       |
|-------|--\  /-|
```

2.

```
-----/|
    / ||
   /   |
------|
```

$C_{\text{eq}} = \infty$

```
-----/|
    / L
   /   |
------|
```

$L_{\text{eq}} = 0$