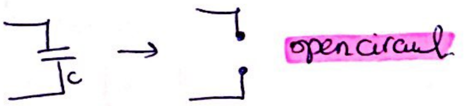
Chapter 7: RL and RC Circuits

Capacitors →

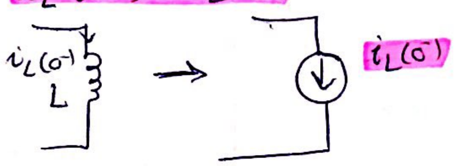
- $i_c(t) = C\dfrac{dv_c(t)}{dt}$
- $V_c(t) = V_c(0^-) + \dfrac{1}{C}\displaystyle\int_0^t i_c(t)\,dt$ for $t \geq 0$
- open circuit for dc voltage
- at $t = 0^+$:- $V_c(0^+) = V_c(0^-)$

- at $t = 0^-$ and $t \geq 0$



Inductors :

- $V_L(t) = L\dfrac{di_L(t)}{dt}$
- $i_L(t) = i_L(0^-) + \dfrac{1}{L}\displaystyle\int_0^t V_L(t)\,dt$ $t \geq 0$
- short circuit for dc
- at $t = 0^+$ $i_L(0^+) = i_L(0^-)$



- at $t = 0^-$ and $t > 0$

Note:

RL circuit
- to find initial Energy stored in: L: $W = \frac{1}{2}LI^2$
- Total Energy of a Resistor

$$W = \int_0^t P\,dt$$

بدلالة $\frac{V^2(t)}{R}$ أو $i(t)^2R$

RC circuit
- to find initial Energy stored in C:

$$W = \frac{1}{2}CV^2$$

- Total Energy of a Resistor (same as in RL circuit)

First order Circuit: • Natural Response • $(i(\infty), V(\infty)) = 0$

• first order differential equation (Non Homogenous or Homogenous)

RL Circuit

• $\tau = \cancel{\frac{R}{L}}\ \frac{L}{R}$ (for RL circuit)

• $i(t) = \frac{V_s}{R} e^{-t/\tau}$ $t > 0$

• $i_L(0^+) = i_L(0^+) = i_L(0^-) = \frac{V_s}{R}$

RC Circuit

• $V_C(0^-) = V_s = V_{\text{open circuit}}$

• $\tau = RC$

• $i(t) = -\frac{V}{R} e^{-t/\tau}$

• Note:
unbounded Response
when the circuit
is dead at ∞

• Step Response •

RL-Circuit

$V_s = Ri(t) + L\frac{di(t)}{dt}$

$i(t) = i_n(t) + i_f(t)$

natural Response

forced response

$= \frac{V_s}{R}\left(1 - e^{-t/\tau}\right)$

$\tau = \frac{L}{R}$

RC - Circuit

$V_c(t) = V_{cn}(t) + V_{cf}(t)$

$V_c(0) = Ae^{-t/\tau} + K(1 - e^{-t/\tau})$

$V(\infty) = V_s$

• use General form

$r(t) = r(\infty) + [r(0^+) - r(\infty)]e^{-t/\tau}$

$\tau = \frac{L}{R_{eq}}$ or $\tau = R_{eq}C$

as seen from C or L

Revise Sequential ~~Response~~ switching.