## (B) Charging RLC - circuits.

### (1) Charging - series - RLC - circuit

- $v(t) = V_\infty + \left[A_1 e^{s_1 t} + A_2 e^{s_2 t}\right] \rightarrow \alpha > \omega_0$ (over - damping)
- $v(t) = V_\infty + \left[A_1 + A_2 t\right] e^{-\alpha t} \rightarrow \alpha = \omega_0$ (critically - damping)
- $v(t) = V_\infty + e^{-\alpha t}\left[A_1 \cos(\omega_d t) + A_2 \sin(\omega_d t)\right] \rightarrow \alpha < \omega_0$ (under - damping)

$s_1 = -\alpha + \sqrt{\alpha^2 - \omega_0^2}$ ; $\omega_d = \sqrt{\omega_0^2 - \alpha^2}$ ; $\alpha = \frac{R}{2L}$

$s_2 = -\alpha - \sqrt{\alpha^2 - \omega_0^2}$ ; $I_c(0) = C \frac{dv}{dt}(0)$ ; $\omega_0 = \frac{1}{\sqrt{LC}}$

$v(\infty) \rightarrow$ after along time.

 → short circuit.

 → open circuit.

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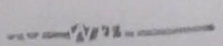
### (2) Charging - parrallel - RLC - circuit.

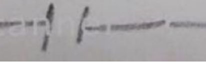
- $i(t) = i_\infty + \left[A_1 e^{s_1 t} + A_2 e^{s_2 t}\right] \rightarrow \alpha > \omega_0$ (over - damping)
- $i(t) = i_\infty + \left[A_1 + A_2 t\right] e^{-\alpha t} \rightarrow \alpha = \omega_0$ (critically - damping)
- $i(t) = i_\infty + \left[A_1 \cos(\omega_d t) + A_2 \sin(\omega_d t)\right] e^{-\alpha t} \rightarrow \alpha < \omega_0$ (under - damping)

$s_1 = -\alpha + \sqrt{\alpha^2 - \omega_0^2}$ ; $\omega_d = \sqrt{\omega_0^2 - \alpha^2}$ ; $\alpha = \frac{1}{2RC}$

$s_2 = -\alpha - \sqrt{\alpha^2 - \omega_0^2}$ ; $V_L(0) = L \frac{di}{dt}(0)$ ; $\omega_0 = \frac{1}{\sqrt{LC}}$

$i_\infty \rightarrow$ after very long time.

 → S.C

 → O.C

# CH8: RLC-ckT's

## (A) Discharging (source free) RLC ckt's.

### (1) Source free – series – RLC circuit.

- $i(t) = A_1 e^{s_1 t} + A_2 e^{s_2 t} \longrightarrow \alpha > w_0$ (over-damping)
- $i(t) = e^{-\alpha t}(A_1 + A_2 t) \longrightarrow \alpha = w_0$ (critically-damping)
- $i(t) = e^{-\alpha t}\left[A_1 \cos(w_d t) + A_2 \sin(w_d t)\right] \rightarrow \alpha < w_0$ (under-damping)

$s_1 = -\alpha + \sqrt{\alpha^2 - w_0^2}$, $s_2 = -\alpha - \sqrt{\alpha^2 - w_0^2}$

$w_d = \sqrt{w_0^2 - \alpha^2}$, $\frac{di}{dt}(0) = \frac{-1}{L}(R I_0 + V_0)$. ↳ حسب التيار وين داخل.

$\alpha = \frac{R}{2L}$, $w_0 = \frac{1}{\sqrt{LC}}$

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### (2) Source free – parallel – RLC-circuit.

- $v(t) = A_1 e^{s_1 t} + A_2 e^{s_2 t} \longrightarrow \alpha > w_0$ (over-damping)
- $v(t) = e^{-\alpha t}(A_1 + A_2 t) \longrightarrow \alpha = w_0$ (critically-damping)
- $v(t) = e^{-\alpha t}(A_1 \cos(w_d t) + A_2 \sin(w_d t)) \rightarrow \alpha < w_0$ (under-damping)

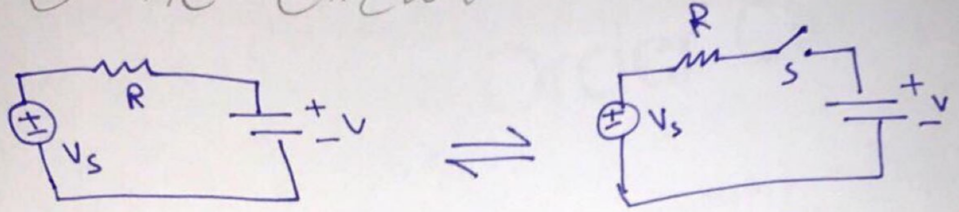
$s_1 = -\alpha + \sqrt{\alpha^2 - w_0^2}$, $s_2 = -\alpha - \sqrt{\alpha^2 - w_0^2}$

$w_d = \sqrt{w_0^2 - \alpha^2}$, $\frac{dv}{dt}(0) = \frac{-1}{RC}(V_0 + R I_0)$

$\alpha = \frac{1}{2RC}$, $w_0 = \frac{1}{\sqrt{LC}}$

③ # step response #

Ⓐ RC-circuit.




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

$V_o$ : initial voltage ] → Before the switch takes action.

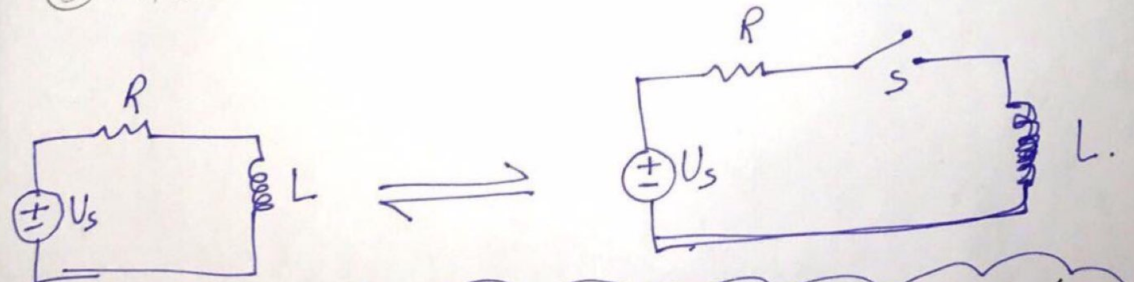
لما أجيبها ← $\tau = RC$
بحذف الـ source

$V_{\infty}$ : voltage after long time. ] → after the switch takes action.

$C \to$ O.C
$I \to$ S.C.

*Tip Ⓐ $V = V_o e^{-t/\tau}$
if the switch opened or closed at $t = 0$.

Ⓑ RL-circuit.




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

*Tip Ⓑ
$V = V_o e^{-(t-k)/\tau}$
if the switch opened or closed at $t = k$.

$I_o$ : Initial current.

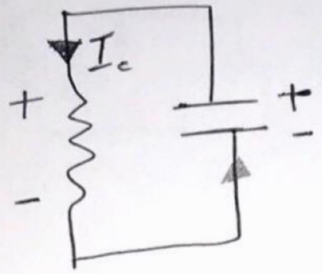
$\tau = \frac{L}{R}$

$I_{\infty}$ : current after along time. (I inductor ⇒ S.C. )

# CH 7 : first order circuits

$$W_C = \frac{1}{2} C V_o^2$$

## ① source free RC - circuit.




$$V(t) = V_o(t) e^{-t/\tau}$$

$\tau = RC$ ⇒ after switches takes action.

* discharging in opposite direction.

* DC - conditions ⇒ capacitor : O.C

$$I_c = C \frac{dv}{dt}$$

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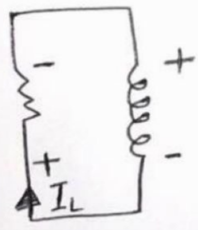
## ② Source free RL - circuit.




$$I(t) = I_o(t) e^{-t/\tau}$$

$$\tau = \frac{L}{R} \quad \text{o R} \quad \frac{L}{R_{th}}$$

* Discharging in the same direction.

* DC - conditions ⇒ Inductor S.C

$$V_L = L \frac{di}{dt}.$$

$$W_L = \frac{1}{2} L I_o^2$$

* وجود ال dependent source يلغي ال سيركت
source free.