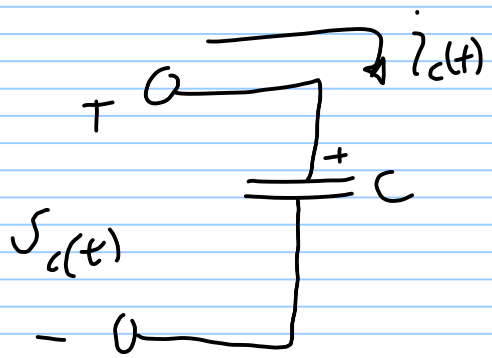
ch7

Response of first-order RL & RC circuits



$$\boxed{i_c(t) = C \frac{d}{dt} v_c(t)}$$

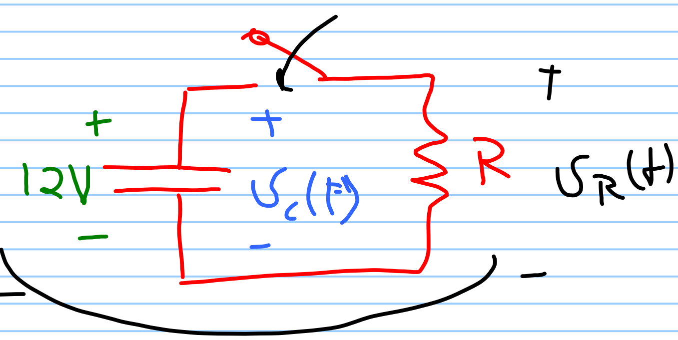
$$\therefore\ v_c(t) = \frac{1}{C}\int_0^t i_c(t)\,dt + \underbrace{v_c(0^-)}_{\text{initial voltage of the capacitor}}, \quad \text{for } t \geq 0$$

at $t = 0^+$

$$v_c(0^+) = \underbrace{\cancel{\frac{1}{C}\int_{0^-}^{0^+} i_c(t)\,dt}}_{\text{zero}} + v_c(0^-)$$

$$\boxed{v_c(0^+) = v_c(0^-)}$$

at $t=0$



$v_c(0^-) = 12\,V$

$v_c(0^+) = 12\,V$

$v_c(\infty) =$ zero $\rightarrow 0.00000001$

$v_R(0^-) =$ zero

$v_R(0^+) = 12\,V$

1. The current through a capacitor is zero if the voltage across it is not changing with time.

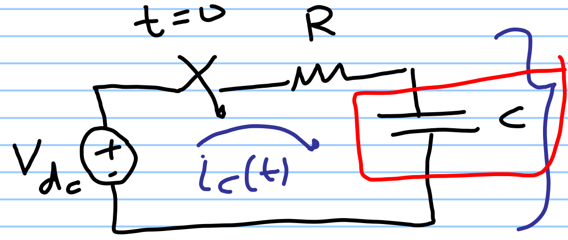
$$i_c(t) = C \frac{d}{dt} v_c(t)$$

↳ steady state

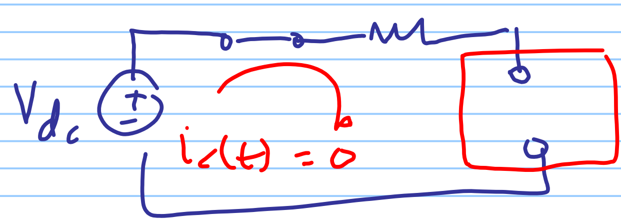
∴ at steady state

$\boxed{t \to \infty}$

$\boxed{i_c(\infty)}$ OR $i_c(\text{steady state}) = \text{zero}$



A capacitor is therefore an open circuit to dc!



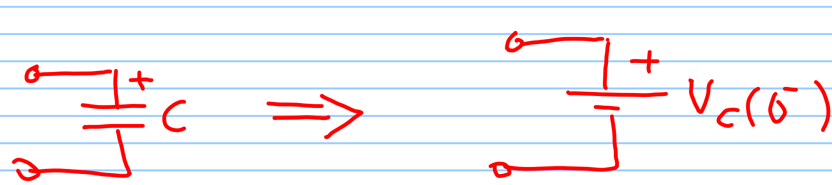
2. A finite amount of energy can be stored in a capacitor even if the current through the capacitor is zero.

3. The capacitor never dissipate energy, but only store it.

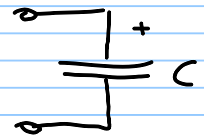
$$v_c(0^-) = v_c(0^+)$$

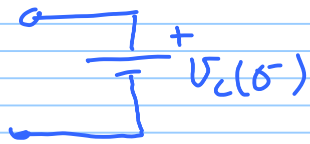
4. it is impossible to change the voltage across a capacitor by a finite amount in zero time,

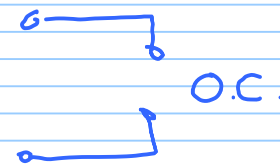
5. At $t = 0^+$



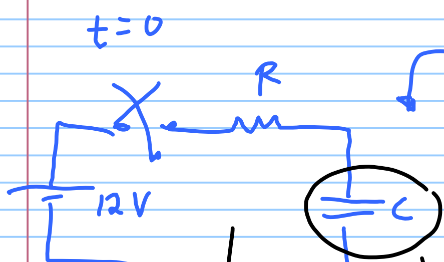
@ $t = 0^+$ @ $t = \infty$





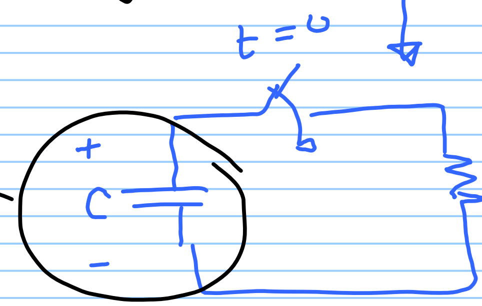


charging   discharging



@ $t = \infty$

O.C.



@ $t = \infty$

$v_c(\infty) = 12V$

$i_c(\infty) = $ zero

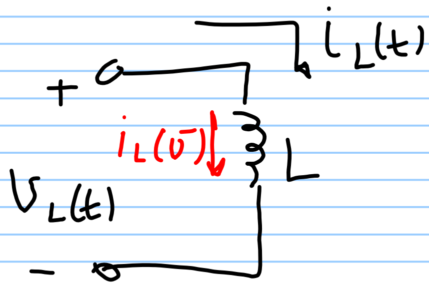
$v_c(0^-) = 12V$

$v_c(0^+) = 12V$

@ $t = \infty$

$v_c(\infty) = $ zero.

$i_c(\infty) = $ zero



$$v_L(t) = L \frac{d}{dt} i_L(t)$$

$$i_L(t) = i_L(0^-) + \frac{1}{L} \int_{0^-}^{t} v_L(t)\, dt \quad , \text{ for } t \geq 0$$

1. There is no voltage across an inductor if the current through it is not changing with time.

An Inductor is therefore a short circuit to dc.

@ $t=\infty$

$$v_L(\infty) = L \frac{d}{dt} i_L(\infty) \quad \text{const.}$$

$$= \text{zero}$$

2. A finite amount of energy can be stored in an Inductor even if the voltage across the inductor is zero.

3. The inductor never dissipate energy, but only store it.

4. $$i_L(t) = i_L(0^-) + \frac{1}{L}\int_{0^-}^{0^+} v_L(t)\,dt\,, \quad t \geq 0$$

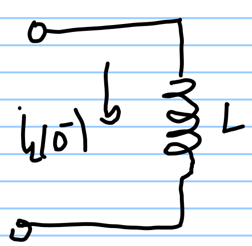
@ $t = 0^+$

$$i_L(0^+) = i_L(0^-) + \cancel{\frac{1}{L}\int_{0^-}^{0^+} v_L(t)\,dt} \quad \text{zero}$$

$$\boxed{i_L(0^+) = i_L(0^-)}$$

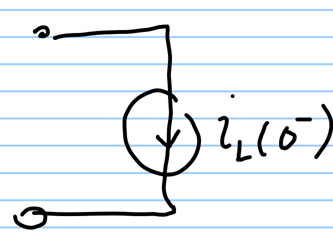
it is impossible to change the current through an inductor by a finite amount in zero time, for this requires an infinite voltage across the inductor.

@ $\boxed{t = 0^+}$



$\Longrightarrow$

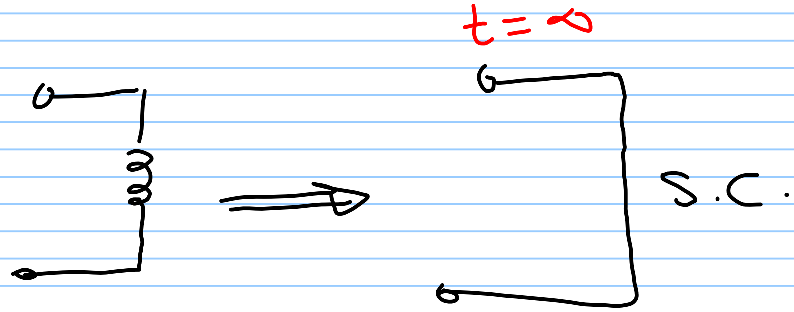
$t=0^+$



$\boxed{t=\infty}$

$$V_L(t) = L \frac{d}{dt} i_L(t)$$

An inductor is therefore a short circuit to dc.

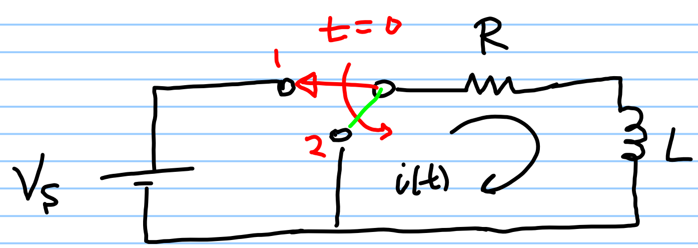


First Order Circuit

R + L } RL, RC circuits.
OR R + C }

Natural Response of 1st order circuit

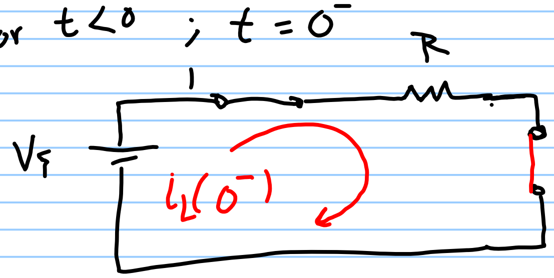
↳ discharging.



find $i(t)$ for $t>0$

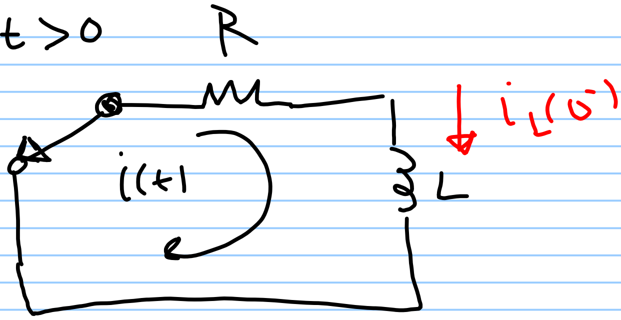
$$V_L = L\frac{di}{dt}$$

1) for $t<0$; $t=0^-$



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

2) for $t > 0$



KVL

$$R\, i(t) + L \frac{d}{dt} i(t) = 0$$

$$i(t) = A e^{st} \quad \text{for } t > 0$$