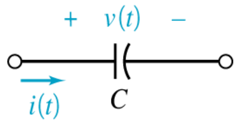
Capacitors



$$i(t) = C\frac{d}{dt}v(t) \quad \text{and} \quad v(t) = \frac{1}{C}\int_{-\infty}^{t} i(\tau)\,d\tau = v(0) + \frac{1}{C}\int_{0}^{t} i(\tau)\,d\tau$$

These equations describe an voltage and current that adhere to the passive convention.

All of the currents and voltages are constant in a dc circuit. When the capacitor voltage is constant, the capacitor current is zero.

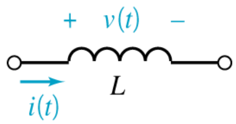
Capacitors act like open circuits in dc circuits.

$$v(t) = \begin{cases} 4.3 & t < 2.5 \\ 4.4 & t > 2.5 \end{cases} \Rightarrow \frac{dv}{dt} = \lim_{\Delta t \to 0} \frac{v(t+\Delta t) - v(t-\Delta t)}{(t+\Delta t)-(t-\Delta t)} = \lim_{\Delta t \to 0} \frac{4.4-4.3}{2\Delta t} = \infty$$

Consequently, discontinuous capacitor voltages require infinite capacitor currents. Infinite currents are physically impossible, so discontinuous capacitor voltages are physically impossible.

In the absence of infinite currents, capacitor voltages must be continuous.

Inductors



$$v(t) = L\frac{d}{dt}i(t) \quad \text{and} \quad i(t) = \frac{1}{L}\int_{-\infty}^{t} v(\tau)\,d\tau = i(0) + \frac{1}{L}\int_{0}^{t} v(\tau)\,d\tau$$

These equations describe a voltage and current that adhere to the passive convention.

All of the currents and voltages are constant in a dc circuit. When the inductor current is constant, the inductor voltage is zero.

Inductors act like short circuits in dc circuits.

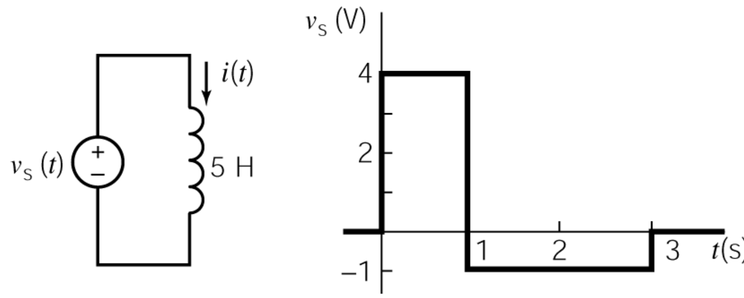
$$i(t) = \begin{cases} 4.3 & t < 2.5 \\ 4.4 & t > 2.5 \end{cases} \Rightarrow \frac{di}{dt} = \lim_{\Delta t \to 0} \frac{i(t+\Delta t) - i(t-\Delta t)}{(t+\Delta t)-(t-\Delta t)} = \lim_{\Delta t \to 0} \frac{4.4-4.3}{2\Delta t} = \infty$$

Consequently, discontinuous inductor currents require infinite inductor voltages. Infinite voltages are physically impossible, so discontinuous inductor currents are physically impossible.

In the absence of infinite voltages, inductor currents must be continuous.

Example:

Determine $i(t)$ for $t \geq 0$ for the circuit in (a) when $i(0) = -2$ A and $v_s(t)$ is the voltage in (b).



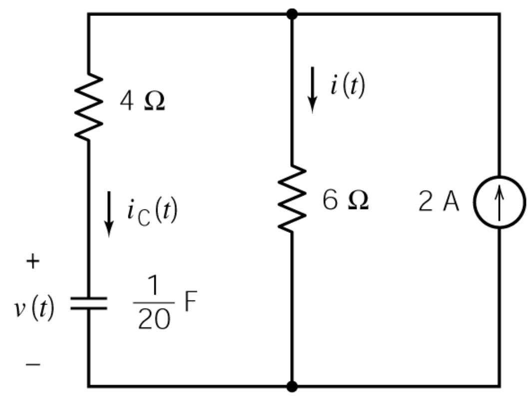
(a) (b)

Example:

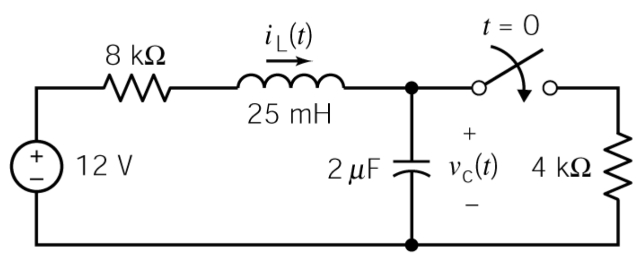
The capacitor voltage in this circuit is given by

$$v(t) = 12 - 10e^{-2t} \text{ V} \quad \text{for} \quad t \geq 0$$

Determine $i(t)$ for $t > 0$.

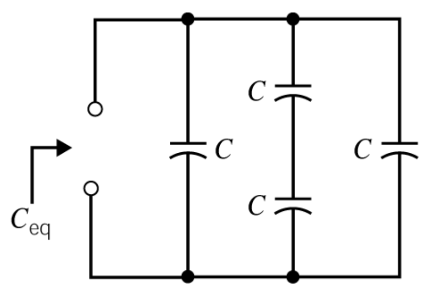


Example:



The switch in this circuit has been open for a long time before closing at time $t = 0$. Find $v_c(0^+)$ and $i_L(0^+)$, the values of the capacitor voltage and inductor current immediately after the switch closes. Let $v_c(\infty)$ and $i_L(\infty)$ denote the values of the capacitor voltage and inductor current after the switch has been closed for a long time. Find $v_c(\infty)$ and $i_L(\infty)$.

Example:



This circuit consists of four capacitors having equal capacitance, C.

a. Determine the value of the capacitance C, given that $C_{eq} = 50$ mF.
b. Determine the value of the equivalent capacitance C_{eq}, given that $C = 50$ mF.