Capacitors

\[ i(t) = C \frac{dv(t)}{dt} \quad \text{and} \quad v(t) = \frac{1}{C} \int_{-\infty}^{t'} i(\tau) \, d\tau = v(0) + \frac{1}{C} \int_{0}^{t'} i(\tau) \, d\tau \]

These equations describe a 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.**

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

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

\[ v(t) = L \frac{di(t)}{dt} \quad \text{and} \quad i(t) = \frac{1}{L} \int_{-\infty}^{t'} v(\tau) \, d\tau = i(0) + \frac{1}{L} \int_{0}^{t'} v(\tau) \, d\tau \]

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.**

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

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).

Example:

The capacitor voltage in this circuit is given by

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

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 $C_{eq} = 50 \text{ mF}$.

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