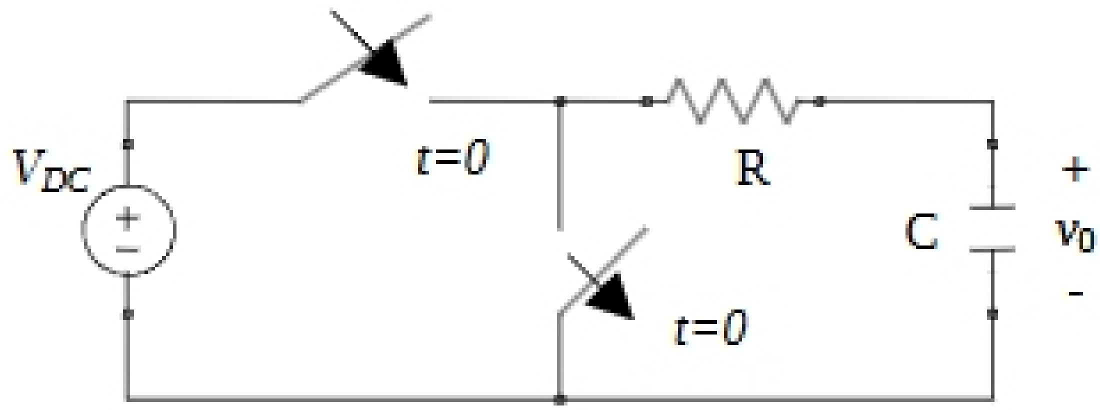
Time Domain Response of First-Order Circuit:

A phasor analysis of a circuit only provides a description of voltage and current steady-state behavior. When the source waveform changes at some time t_0, a transient response is produced, which dies out over a period of time leaving the new steady state behavior. The circuit's differential equation must be used to determine complete voltage and current responses.

Example: Describe v_0 for all t. Identify transient and steady-state responses.



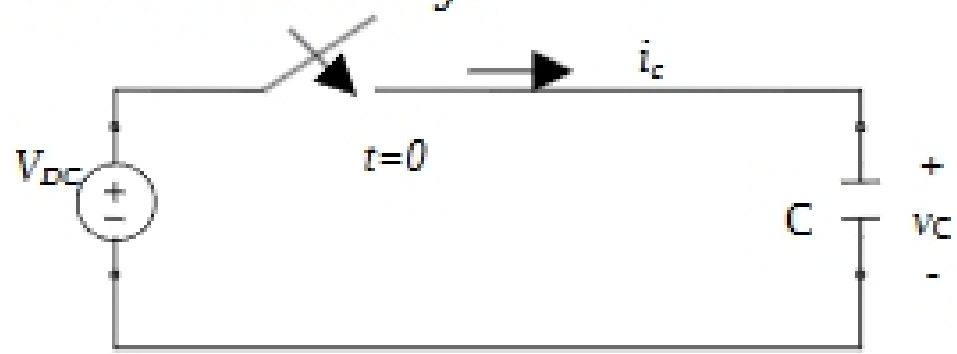
Show:

$$v_o(t) = \begin{cases} V_{DC}\left[1 - \exp\left(\frac{-t}{RC}\right)\right] \text{ volts} & \text{for } t \geq 0 \\ 0 \text{ volts} & \text{for } t < 0 \end{cases}$$

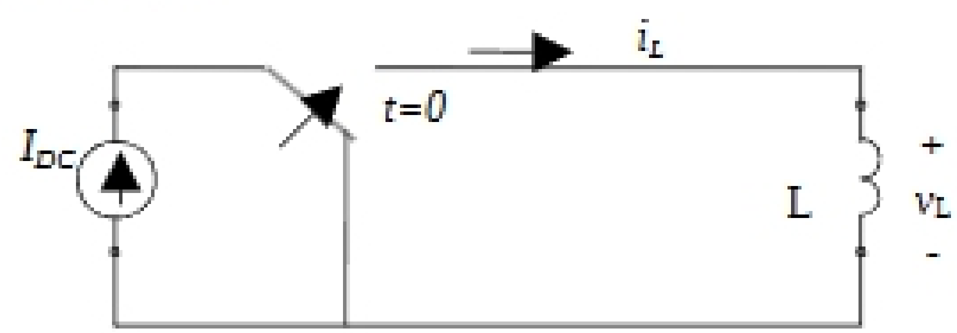
For steady-state response, let $t \rightarrow \infty$, for transient response subtract {complete response - steady-state response} in each t-interval.

Instantaneous Voltage and Current Change in Capacitors and Inductors:

What would be the required current, i_c, in this circuit for the voltage on the capacitor to change instantaneously?



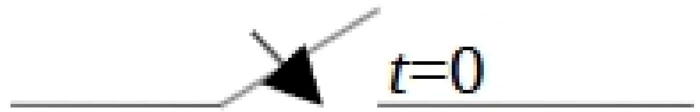
What would be the required voltage, v_L , in this circuit for the current in the inductor to change instantaneously?



Conclusion: If the source cannot produce infinite instantaneous power, then neither the capacitor voltage, nor the inductor current can change instantaneously.

Switch Notation and Initial Conditions:

In order to denote the time right before *t*=0 (limit from the left as *t*□0), and the time right after *t*=0 (limit from the right as *t*□0), the following notation will be used:



where $t=0^+$ is the moment after the switch is thrown and $t=0^-$ is the moment before the switch is thrown.

In order to determine initial conditions for solving the differential equations, the following statement can be used:

For circuits with practical sources:

□ **The voltage across a capacitor cannot change instantaneously:**

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

□ **The current in an inductor cannot change instantaneously:**

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

Finding the Complete Solution:

There are 5 major steps in finding the complete solution: