Electrical Circuits Simulation Using Xcos

National Workshop on Scilab
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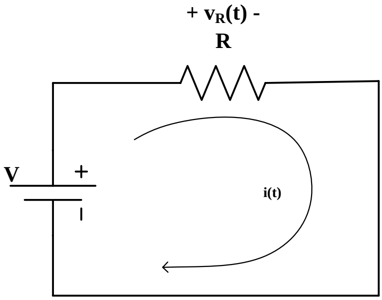
Outline

- DC source with R without switch.
- Switch logic in Scilab
- DC source with R, RL, RC, and RLC, with switch.
- AC source with RLC with switch.
- Demos of some more complicated ckts.

DC source with R

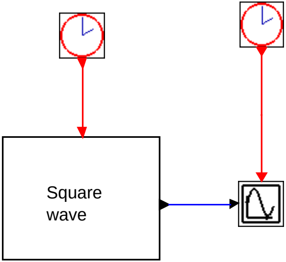
- We have

$$i(t) = \frac{V}{R}.$$



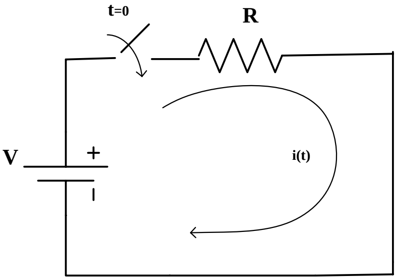
Switch Logic in Scilab

- Opening or closing of switch is an important operation.
- Useful in Power Electronics ckts.
- Adding a switch in the ckt makes the ODE stiff for solving.



DC source with R with Switch

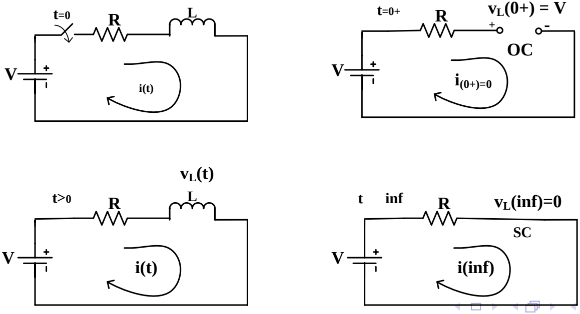
- Memory-less system. Current and voltage change instantaneously after the closing of switch at $t = 0$.



DC source with RL with Switch

- Current through the inductor cannot change instantaneously.
- At $t(0+)$, inductor $\rightarrow$ Open Circuit $\Rightarrow i_L(0+) = i(0+) = 0$. $v_L(0+) = V$.
- For general $t > 0$,

$$V = Ri(t) + L\frac{di(t)}{dt}.$$



DC source with RL with Switch

- Expression for current is

$$i(t) = \frac{V}{R} - \frac{V}{R} e^{-\frac{R}{L} t}.$$

- Expression for inductor voltage is

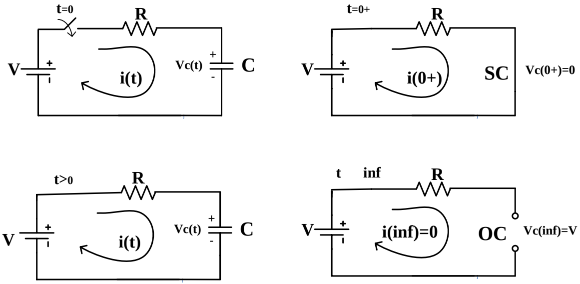
$$v(t) = V e^{-\frac{R}{L} t}.$$

- At steady-state ($t \rightarrow \infty$), inductor acts as a short-circuit, $v_L(\infty) = 0$ and $i(\infty) = \frac{V}{R}$.

DC source with RC with Switch

- Voltage across the capacitor cannot change instantaneously.
- At $t(0+)$, capacitor $\rightarrow$ Short Circuit $\Rightarrow v_C(0+) = 0$. $i_C(0+) = i(0+) = \frac{V}{R}$.
- For general $t > 0$,

$$V = Ri(t) + \frac{1}{C}\int_0^t i(t)dt.$$



DC source with RC with Switch

- Expression for capacitor voltage is

$$v_C(t) = V - Ve^{-\frac{t}{RC}}.$$

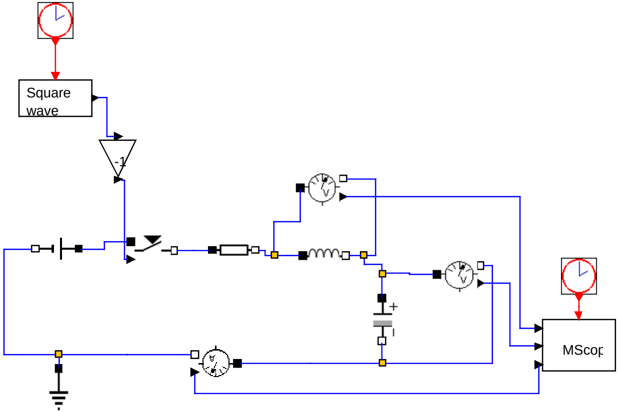
- Expression for capacitor current is

$$i(t) = \frac{V}{R}e^{-\frac{t}{RC}}.$$

- At steady-state $(t \to \infty)$, capacitor acts as a open-circuit, $v_C(\infty) = V$ and $i(\infty) = 0$.

DC source with RLC with Switch

- Two storing elements.
- Second-order system.



DC source with RLC with Switch

- KVL gives

$$V = Ri(t) + L\frac{di(t)}{dt} + \frac{1}{C}\int_0^t i(t)dt.$$

- The second-order ODE is

$$\frac{d^2 i(t)}{dt^2} + \frac{R}{L}\frac{di(t)}{dt} + \frac{1}{LC}i(t) = 0.$$

- At $t(0+)$, $i(0+) = 0$, $\frac{di}{dt}(0+) = \frac{V}{L} = \frac{v_L(0+)}{L}$.

- Using Laplace transform

$$I(s) = \frac{V/L^2}{s^2 + \frac{R}{L}s + \frac{1}{LC}}$$

- As $t \rightarrow \infty$, current $i(t)$ will decay to zero. But the way it will decay to zero will be decided by the value of R.
- Equating the denominator polynomial to zero,

$$s^2 + \frac{R}{L}s + \frac{1}{LC} = 0$$

- The roots are

$$s_{1,2} = \frac{-R/L \pm \sqrt{\frac{R^2}{L^2} - \frac{4}{LC}}}{2}$$

DC source with RLC with Switch

- The transient behaviour of $i(t)$ will be decided by the factor

$$D \doteqdot \frac{R^2}{L^2} - \frac{4}{LC}(<, >, =)0.$$

- If $D = 0$ then

$$R = 2\sqrt{\frac{L}{C}}.$$

  Response is overdamped.

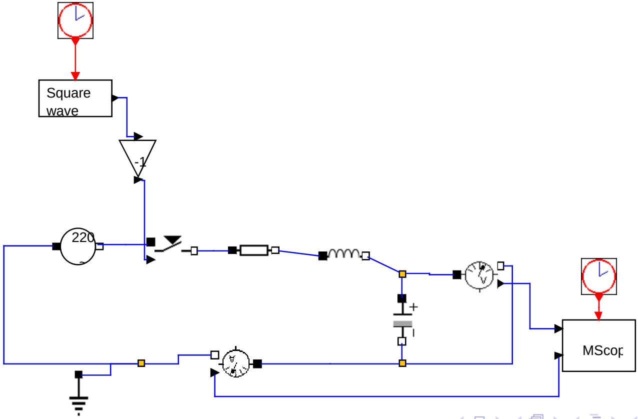
- If

$$R < 2\sqrt{\frac{L}{C}}.$$

  Response is underdamped.

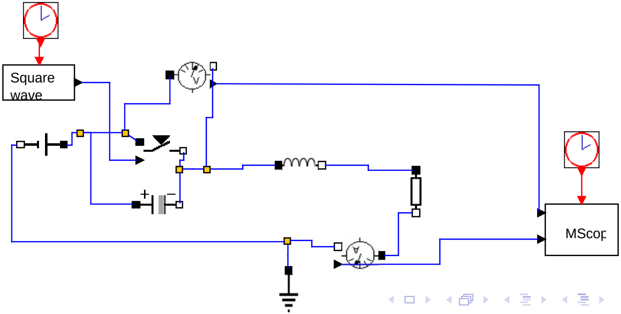
AC source with RLC with Switch

- Sinusoidal source connected to a series RLC ckt through the switch.
- Second-order system.



Complicated Networks

- Examples taken from the book: Network Analysis, by M.E. Van Valkenburg, PHI Publishers, New Delhi, 2006.
- Ex. 5-6, Page 132.
- Steady-state is reached with switch closed. At $t = 0$, the switch is opened. Find voltage across the switch and the value of its first time derivative at $t = 0+$.



Complicated Networks

- Ex. 4-1, Page 112.
- Steady-state is reached with switch in position 1. At $t = 0$, the switch moved from 1 to 2. Find $i(t)$.