EEE104
Circuit Analysis I

Ankara University

Faculty of Engineering

Electrical and Electronics Engineering Department

Natural and Step Responses of RLC Circuits

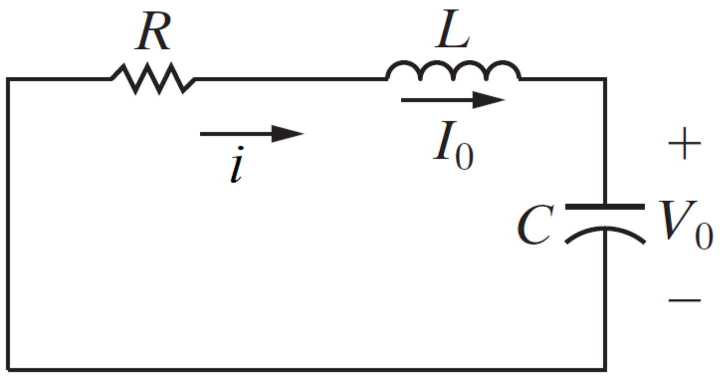
EEE104 Circuit Analysis I

Lecture 14

Agenda

- Natural Response of a Series RLC Circuit
- Step Response of a Series RLC Circuit

- Natural Response of a Series RLC Circuit



- Natural Response of a Series RLC Circuit

$$Ri + L\frac{di}{dt} + \frac{1}{C}\int_0^t i d\tau + V_0 = 0$$

$$R\frac{di}{dt} + L\frac{d^2i}{dt^2} + \frac{i}{C} = 0$$

$$\frac{d^2i}{dt^2} + \frac{R}{L}\frac{di}{dt} + \frac{i}{LC} = 0$$

- Natural Response of a Series RLC Circuit

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

$$s_{1,2} = -\frac{R}{2L} \pm \sqrt{\left(\frac{R}{2L}\right)^2 - \frac{1}{LC}}$$

$$s_{1,2} = -\alpha \pm \sqrt{\alpha^2 - \omega_0^2}$$

$$\alpha = \frac{R}{2L} \qquad \omega_0 = \frac{1}{\sqrt{LC}}$$

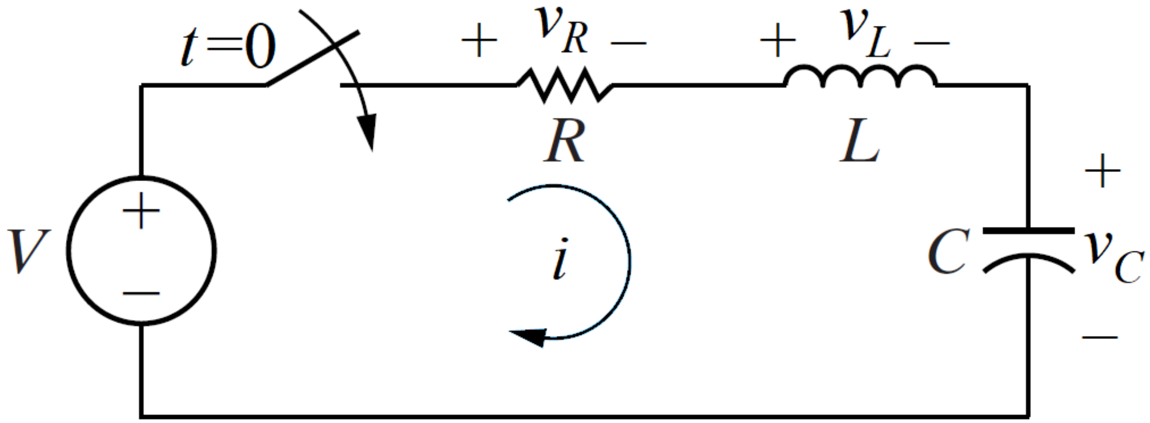
- Natural Response of a Series RLC Circuit

★ $i(t) = A_1 e^{s_1 t} + A_2 e^{s_2 t}$ Overdamped Response

★ $i(t) = B_1 e^{-\alpha t} cos\omega_d t + B_2 e^{-\alpha t} sin\omega_d t$ Underdamped Response

★ $i(t) = D_1 t e^{-\alpha t} + D_2 e^{-\alpha t}$ Critically Damped Response

- Step Response of a Series RLC Circuit



- Step Response of a Series RLC Circuit

$$V = Ri + L\frac{di}{dt} + v_C$$

$$\frac{d^2v_C}{dt^2} + \frac{R}{L}\frac{dv_C}{dt} + \frac{v_C}{LC} = \frac{V}{LC}$$

★ $v_C = V_f + A_1' e^{s_1 t} + A_2' e^{s_2 t}$ Overdamped Response

★ $v_C = V_f + B_1' e^{-\alpha t} \cos \omega_d t + B_2' e^{-\alpha t} \sin \omega_d t$ Underdamped Response

★ $v_C = V_f + D_1' t e^{-\alpha t} + D_2' e^{-\alpha t}$ Step Response

Reference

- Electric Circuits, Tenth Edition, James W. Nilsson, Susan A. Riedel Pearson, 2015