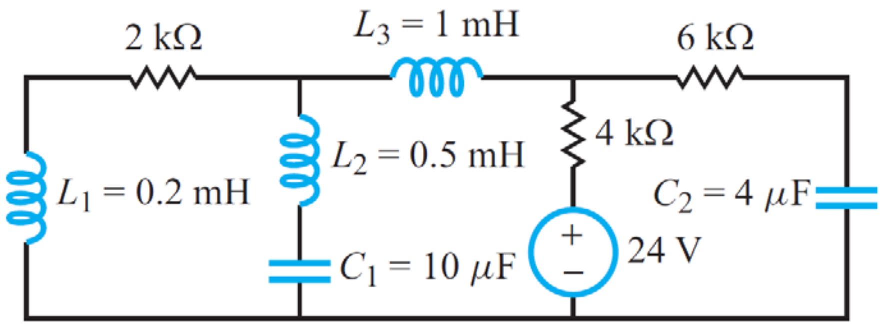
RL Circuits

Michel M. Maharbiz
Vivek Subramanian

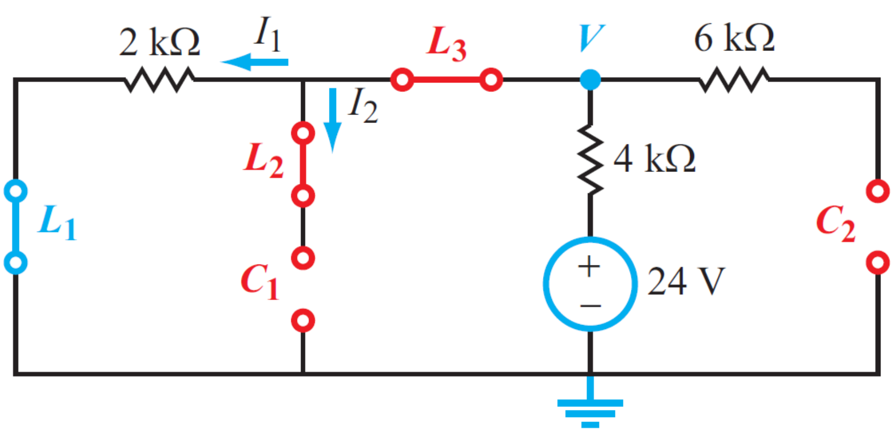
RL Circuits at dc

At DC no voltage across inductors: short circuit



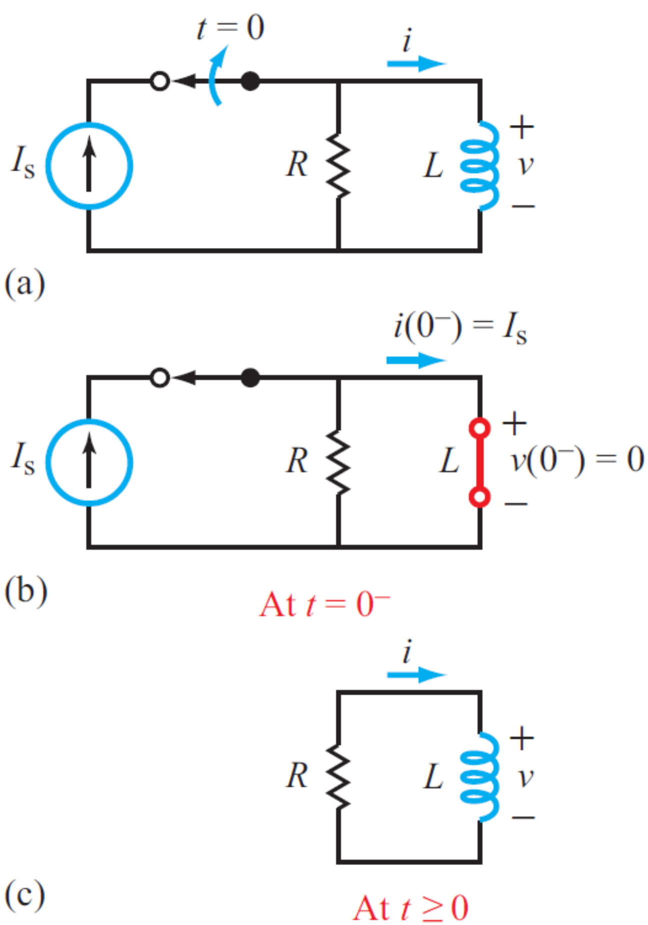
$$I_1 = \frac{24}{(2+4)\text{k}} = 4 \text{ mA},$$

and node voltage V is



$$V = 24 - (4 \times 10^{-3} \times 4 \times 10^{3}) = 8 \text{ V}.$$

Natural Response of the RL Circuit



$$i(0) = i(0^-) = I_s$$

$$Ri + L\,\frac{di}{dt} = 0,$$

which can be cast in the form

$$\frac{di}{dt} + ai = 0,$$

where a is a temporary constant given by

$$a = \frac{R}{L}.$$

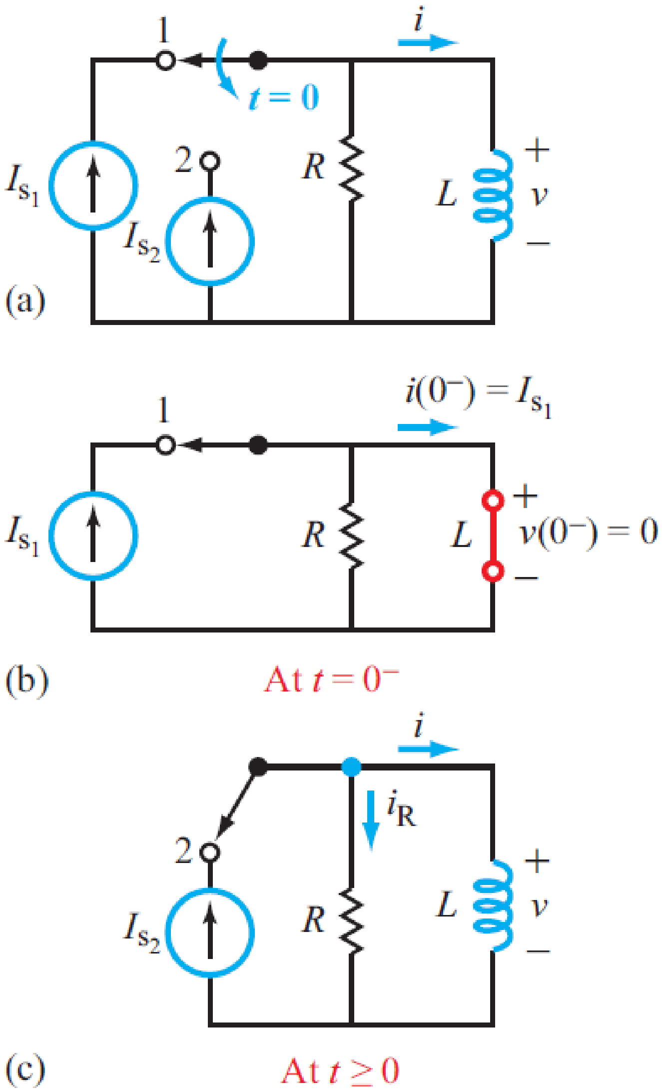
$$i(t) = i(0)\, e^{-t/\tau} \qquad (\text{for } t \geq 0)$$

(natural response),

where for the RL circuit, the ***time constant*** is given by

$$\tau = \frac{1}{a} = \frac{L}{R}.$$

General Response of the RL Circuit



$$-I_{s_2} + i_R + i = 0.$$

Since v is common to R and L, $i_R = v/R$, and by applying $v = L\,di/dt$, the KCL equation becomes

$$\frac{di}{dt} + ai = b, \quad (5.105)$$

where a is as given previously by Eq. (5.102) and

$$b = aI_{s_2} = \frac{R}{L}\,I_{s_2}. \quad (5.106)$$

$$i(t) = i(\infty) + [i(0) - i(\infty)]e^{-t/\tau} \qquad (\text{for } t \geq 0)$$

(switch action at $t = 0$),

If the sudden change in the circuit configuration happens at $t = T_0$ instead of at $t = 0$, the general expression for $i(t)$ becomes

$$i(t) = i(\infty) + [i(T_0) - i(\infty)]e^{-(t-T_0)/\tau} \qquad (\text{for } t \geq T_0)$$

(switch action at $t = T_0$),