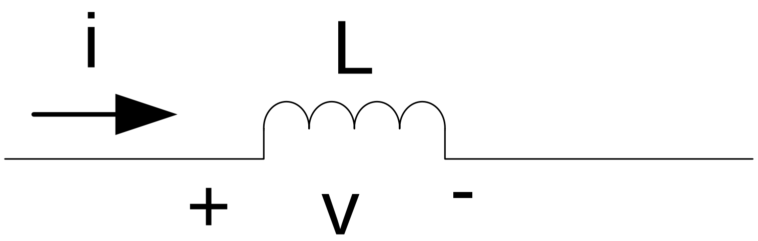
EE101ME – Electric Circuits

RL Circuit

The Inductor



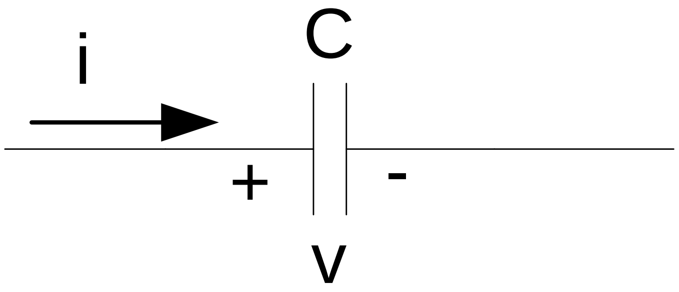
$$v = L\frac{di}{dt}$$

If current i is constant, voltage v is 0

So, inductor behaves as a short circuit to dc input current

Again, current through an inductor cannot change instantaneously (immediately)

The Capacitor



$$i = C\frac{dv}{dt}$$

If voltage v is constant, then i is 0

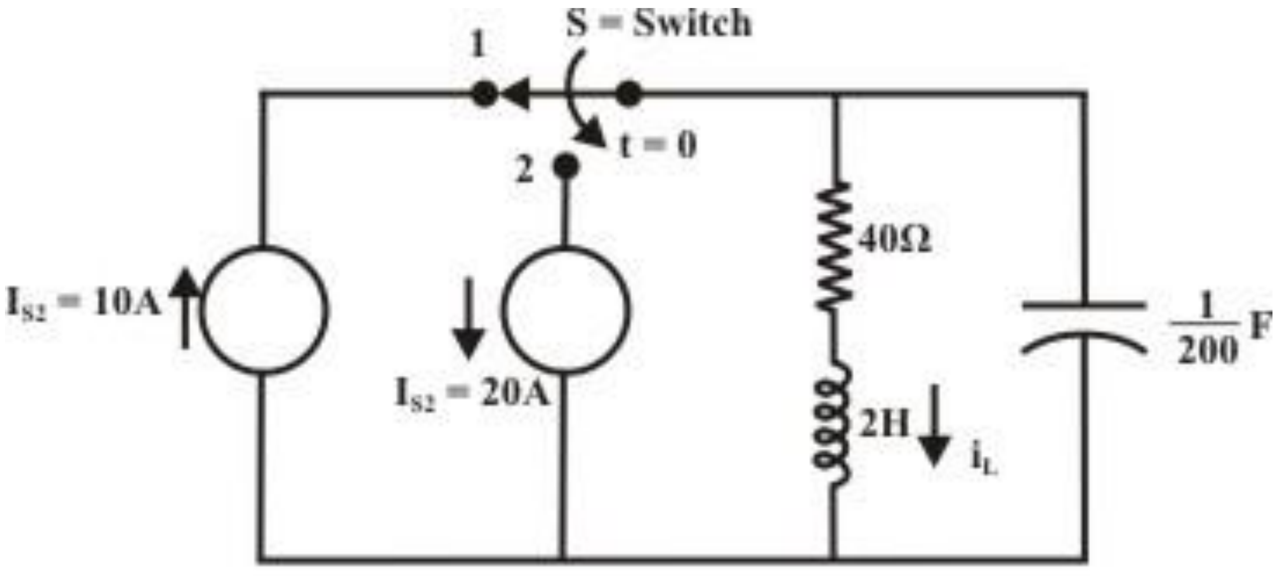
So, capacitor behaves as an open circuit to dc input voltage

Again, voltage across a capacitor cannot change instantaneously (immediately)

Initial Conditions of RLC Circuit

Initial Conditions

Switch S is connected to Node 1 for a long time before connecting to Node 2 at time t = 0 sec

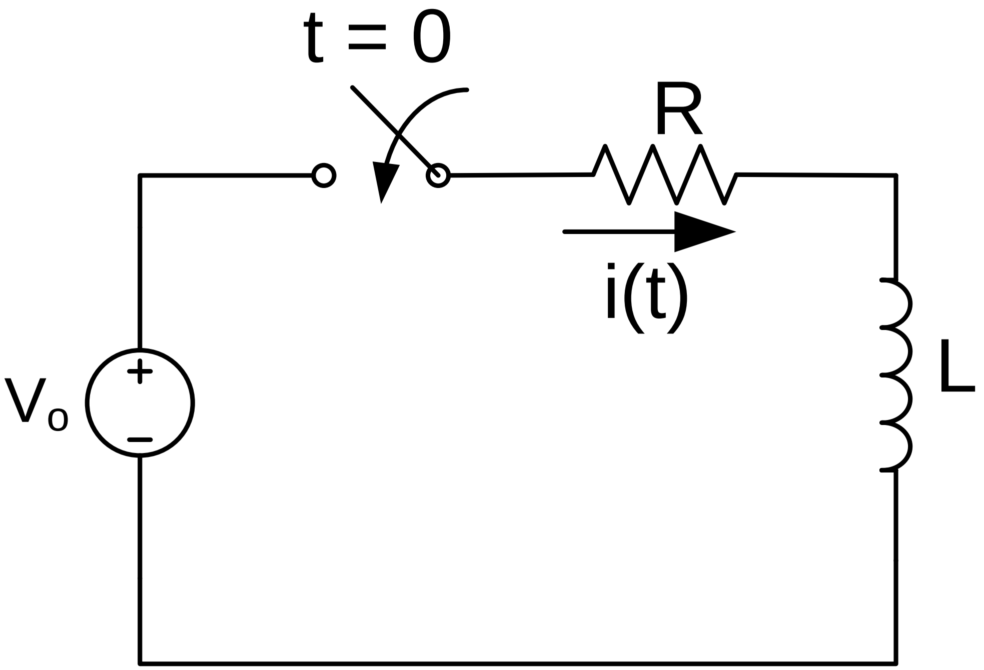


Values for:

$$(a)\ i_L(0^-);\ (b)\ v_c(0^+);\ (c)\ v_R(0^+);\ (d)\ i_L(\infty)$$

Values are 10 A, 400 V, 400 V, -20 A

Response of RL Series Circuit



Find i(t) for t > 0

$$Ri + L\frac{di}{dt} = V_0 \quad \text{for } t > 0$$

Solution -

Complimentary Function

+ Particular Integral

Solution -

Natural Response (i_n) from

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

Forced Response (i_f) from

$$Ri + L\frac{di}{dt} = V_0$$

Complete Solution is

$$i = i_n + i_f$$

For Natural Response

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

$$\text{or, } \frac{di}{dt} + \frac{R}{L}i = 0$$

$$or,\ \ i_n = Ae^{-\frac{R}{L}t}$$

For Forced Response

$$Ri + L\frac{di}{dt} = V_0$$

$$\textit{But} \quad L\frac{di}{dt} = 0$$

$$\text{So,} \quad i_f = \frac{V_0}{R}$$

$$i(t) = Ae^{-\left(\frac{R}{L}\right)t} + \frac{V_0}{R} \quad t > 0$$

For Finding A : Apply the condition

$i(t = 0) = i(t = 0^-) = i(t = 0^+)$

$$0 = A + \frac{V_0}{R}$$

$$A = -\frac{V_0}{R}$$

$$i(t) = \left(\frac{V_0}{R} - \frac{V_0}{R} e^{-\frac{R}{L}t} \right) \quad t > 0$$

$$or,\ i(t) = \frac{V_0}{R}\left(1 - e^{-\frac{t}{\tau}}\right) \quad t > 0 \qquad \tau = \frac{L}{R} \quad \text{Time Constant}$$