DC - Response of RL Series Circuit

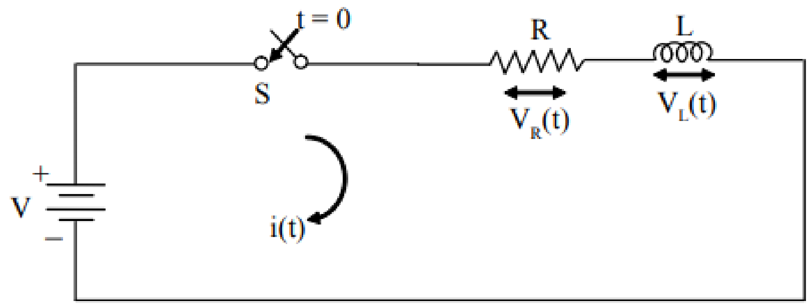

Fig.   RL Series Circuit

Consider the RL series circuit excited by a DC source as shown in above fig. At t = 0, switch s is closed. It is assumed that at the time of switching, the current is zero.

By applying kVL, $V = V_R(t) + V_L(t)$

$$V = Ri(t) + L\frac{di(t)}{dt} \qquad \text{-----------(5)}$$

Taking Laplace transform to equation (5), we get

$$\frac{V}{S} = RI(S) + L\left[SI(S) - i(0)\right]$$

Since i(0) = 0, the above equation becomes,

$$\frac{V}{S} = RI(S) + LSI(S)$$

$$\frac{V}{S} = I(S)[R + LS]$$

$$I(S) = \frac{V}{S(LS + R)} \qquad \text{------------(6)}$$

$$I(S) = \frac{V}{LS\left(S + \frac{R}{L}\right)}$$

By taking partial fraction to equation (6)

$$I(S) = \frac{V/L}{S\left(S + \frac{R}{L}\right)} = \frac{A}{S} + \frac{B}{S + R/L} \qquad \text{------------(7)}$$

$$A = V/R$$

$$\therefore\ B = -\frac{V}{R}$$

Substitute the value of A & B in equation (7), we get

$$I(S) = \frac{V/R}{S} - \frac{V/R}{S + R/L}$$

Applying Inverse laplace transform,

$$i(t) = \frac{V}{R}(1) - \frac{V}{R}e^{-R/L\,t} = \frac{V}{R}\left(1 - e^{-R/L\,t}\right)$$

$$\text{Let } \frac{R}{L} = a$$

$$\therefore\ i(t) = \frac{V}{R}\left(1 - e^{-at}\right) \qquad \text{-----------(9)}$$

The current response of RL series circuit is shown in fig. 4.2.

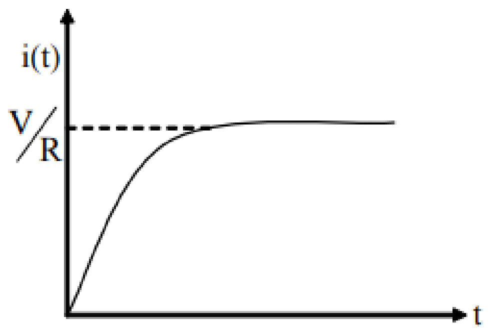

Fig. 3.2 Current response of RL series circuit

The transient voltages across the element of the circuit are obtained from the current. The voltage across the resistor is,

$$V_R = Ri = R\frac{V}{R}\left(1 - e^{\frac{-R}{L}t}\right)$$

$$= V\left(1 - e^{\frac{-R}{L}t}\right)$$

The voltage across the inductor is,

$$V_L = L\frac{di}{dt} = L\frac{d}{dt}\left[\frac{V}{R}\left(1 - e^{\frac{-R}{L}t}\right)\right]$$

$$= Ve^{\frac{-R}{L}t}$$