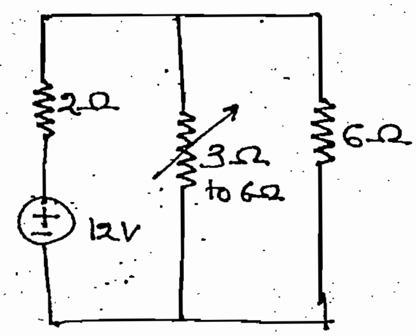
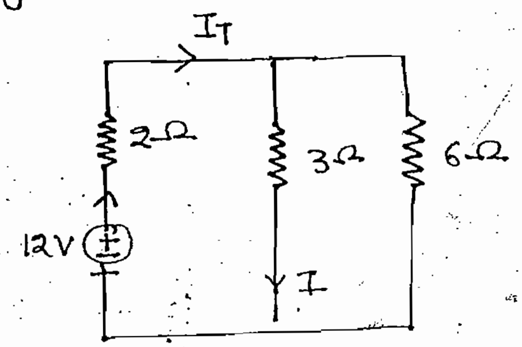
Ques:- Find change in current in the 2Ω and 6Ω resistor when resistance in the variable branch is changed from 3 to 6Ω

Soln:- Step-(I):-



Find original current circulating in the variable branch



$$R_{eq} = 2 + \frac{6 \times 3}{6+3} = 4$$

$$I_T = \frac{12}{4} = 3A$$

$$I = 3\,\frac{6}{6+3} = 2A$$

Step-(II):-

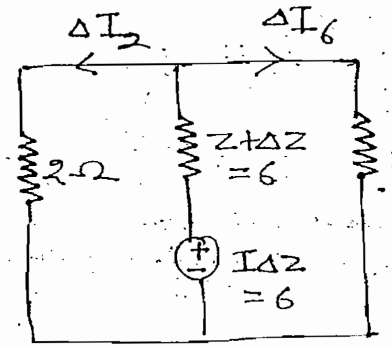
Find compensation emf

$$I\Delta Z = 2(6-3) = 6V$$

Step-(III):-

Develop modified ckt

→ While developing modified circuit deactivate all the original sources and connect the compensation emf in series to variable branch



$$R_{eq} = 6 + \frac{6 \times 2}{6+2}$$

$$I_T = \frac{6}{R_{eq}}$$

$$\Delta I_2 = I_T\,\frac{6}{6+2} = 0.6A$$

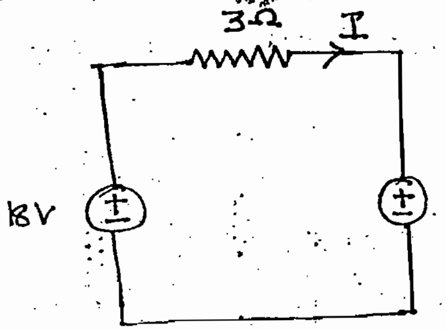
$$\Delta I_6 = I_T - \Delta I_2 = 0.2A$$

Note:-

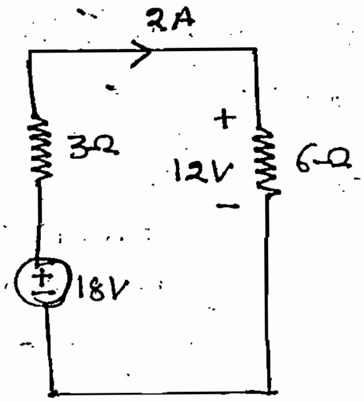
In the bridge circuit by using compensation theorem condition for null deflection in the galvanometer is obtain

Application of comp. theorem

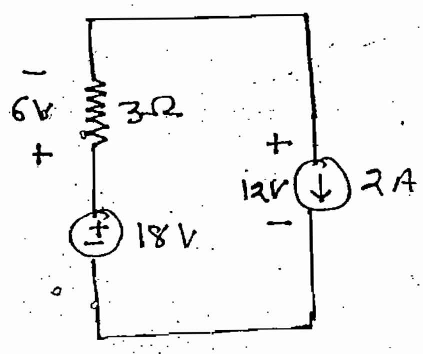
Substitution theorem :-

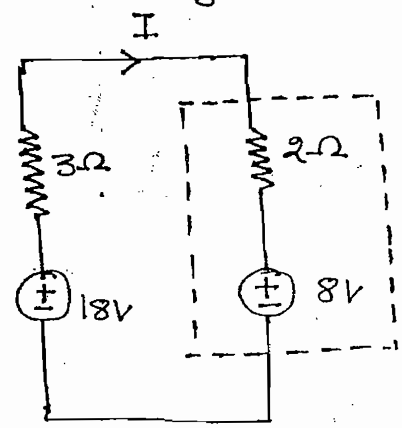


$$I = \frac{18-12}{3} = 2$$



$6\Omega \rightarrow 2\Omega + 4\Omega$

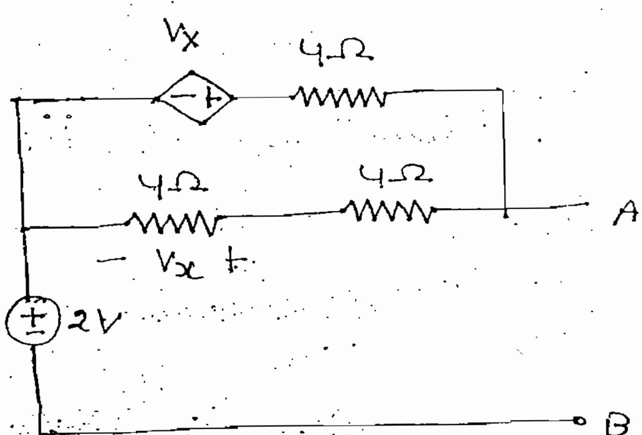




$$I = \frac{18-8}{3+2} = 2A$$

→ All circuits are equivalent

Ques:- Find R_{th} w.r.t A and B



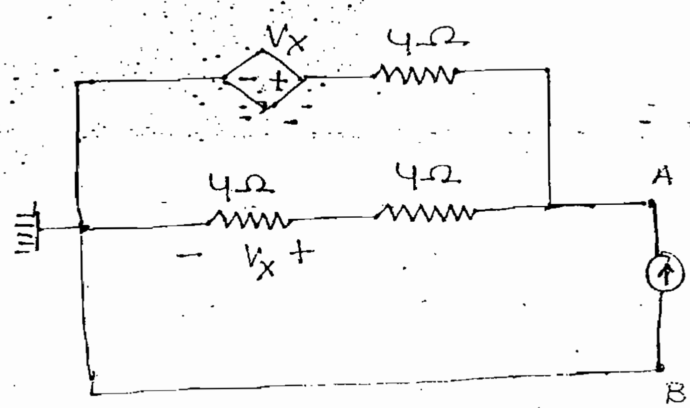
Soln:-

$$\frac{V_A}{8} + \frac{V_A - V_x}{4} = 1$$

$$V_x = \frac{V_A}{2}$$

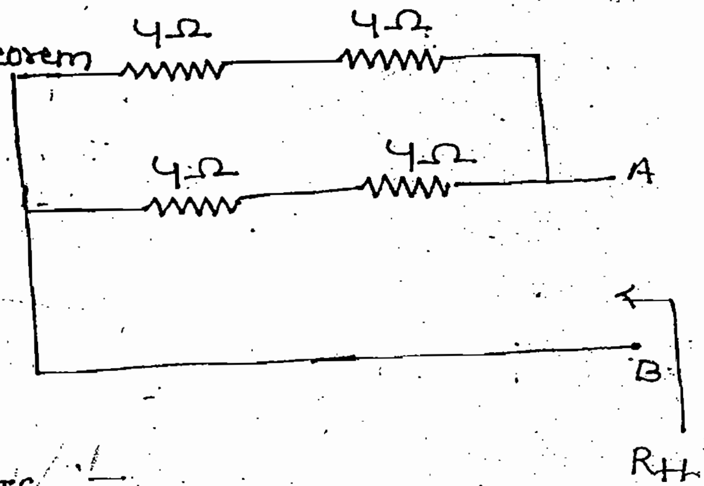
$$V_A = 4V$$

$$R_{th} = \frac{V_A}{I_S} = \frac{4}{1} = 4\Omega$$



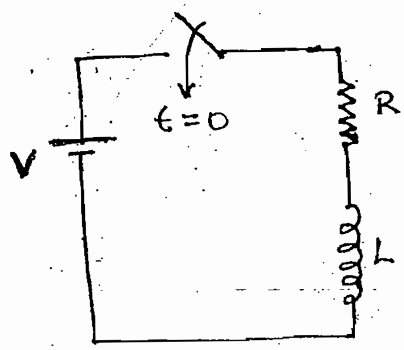
Alternate Way :-

By using substitution theorem



$$R_{th} = \frac{8 \times 8}{8+8} = 4$$

TRANSIENTS :-



$t = 0^-$, $i = 0$

$t = 0^+$, $i = 0$

$\downarrow$

(O.C)

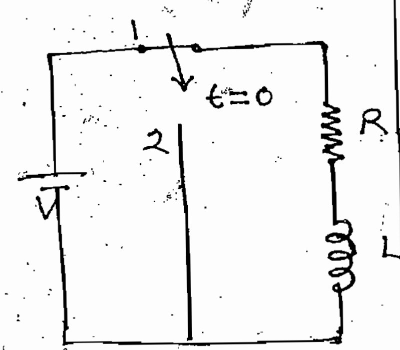
$t = \infty$, $V_L = L\frac{di}{dt}$

$= 0$

$\downarrow$

SC

$i = \frac{V}{R}$

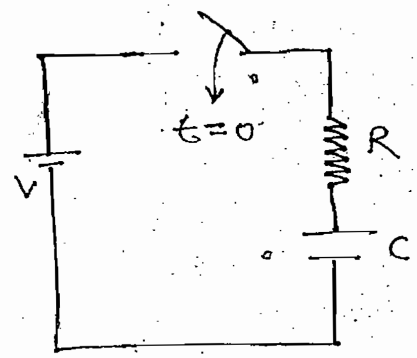


$t = 0^-$, $i = I_0$

$t = 0^+$, $i = I_0$

Inductor behaves as current source

$t = \infty$, $i = 0$



$t = 0^-$, $V_c = 0$

$t = 0^+$, $V_c = 0$

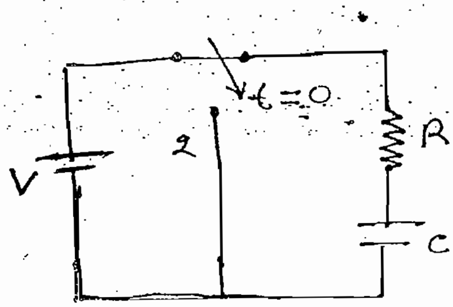
$\downarrow$

(S.C)

$t = \infty$, $V_c = V$

$i = 0$

(O.C)



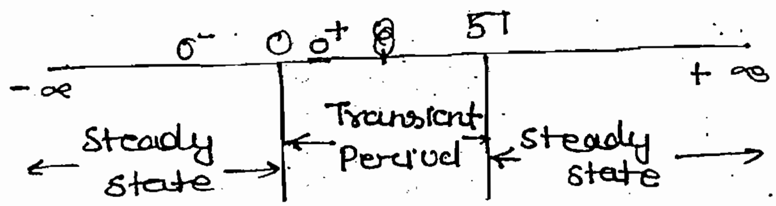
$t = 0^-$ $\quad V_c = V_0 (V)$

$t = 0^+$ $\quad V_c = V_0$

$\downarrow$

Acts as voltage source

$t = \infty$ $\quad V_c = 0$



→ Transients are present in the circuit when circuit is subjected to any changes either by changing source magnitude or by changing circuit element provided circuit consist of any energy storage element

→ When the ckt is having only resistive element then no transients are present in the N/w since
(i) Resistor allow sudden change of current and voltage
(ii) Resistor does not store any energy.

→ Transients are present in the N/w when the N/w is having any energy storage elements since
(i) Inductor does not allow sudden change of current and it stores energy in the form of magnetic field
(ii) Capacitor does not allow sudden change of voltage and it stores energy in the form of electric field.

→ Due to energy storage property inductor and capacitor are known as dynamic elements (Memory elements)

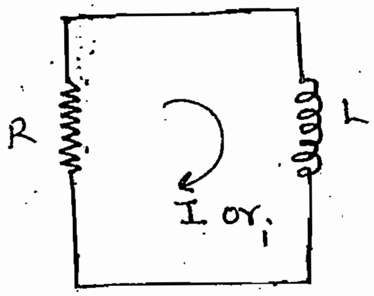
→ $t = 0^-$ indicates immediately before operate the switch

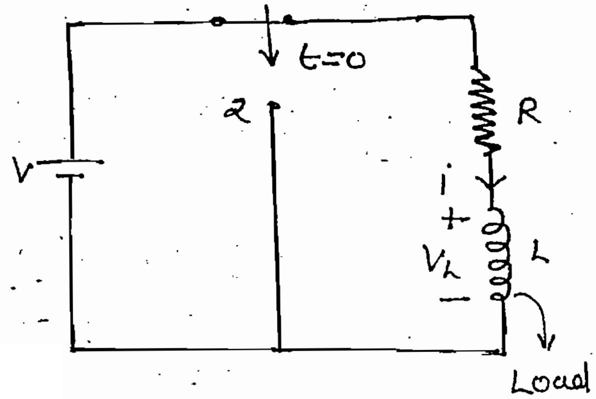
→ $t = 0^+$ indicates immediately after operating the switch

→ $t = \infty$ indicates steady state condition after operating the switch.

Source Free RL Circuit :-

$t>0$





$t = 0^-$, $i = I_0$

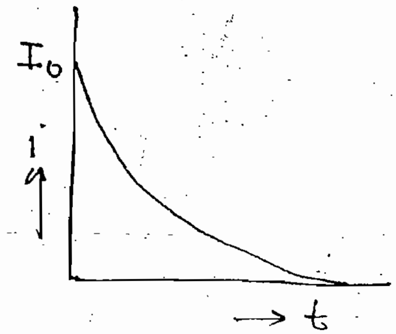
$t = 0^+$, $i = I_0$

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

$$iR = -L\frac{di}{dt}$$

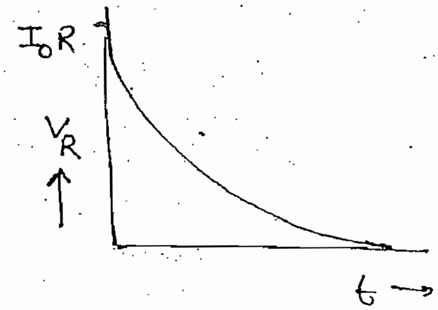
$$\int_0^t -\frac{R}{L}\,dt = \int_{I_0}^{i(t)} \frac{di}{i}$$

$$\Rightarrow \quad i(t) = I_0 e^{-\frac{Rt}{L}} \longrightarrow$$



$$V_R = iR$$

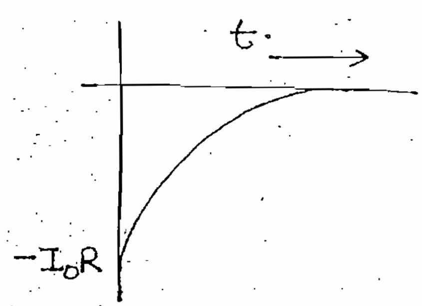
$$\Rightarrow \quad V_R = I_0 R e^{-\frac{Rt}{L}} \longrightarrow$$



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

$$V_L = L\frac{d}{dt}\left(I_0 e^{-\frac{Rt}{L}}\right)$$

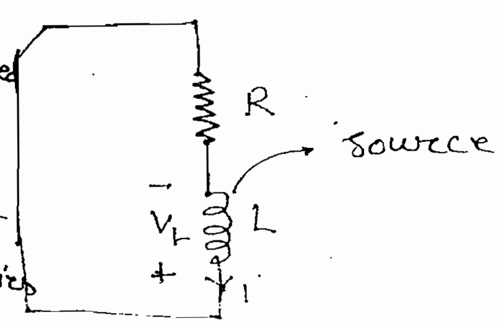
$$\Rightarrow \quad V_L = -I_0 R e^{-\frac{Rt}{L}} \longrightarrow$$



$t>0$

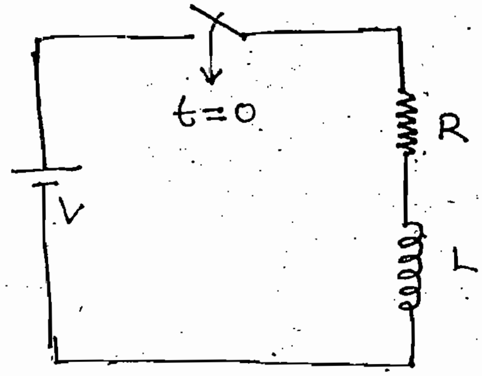
Note :-

When switch is transferred from position 1 to position 2 current direction of the inductor remains same but voltage across inductor polarities are reversed.



RL circuit with source :-

By KVL.



$$V = iR + L\frac{di}{dt}$$

Divide whole equation by L

$$\frac{V}{L} = \frac{iR}{L} + \frac{di}{dt}$$

$$\Rightarrow \boxed{\frac{di}{dt} + \frac{R}{L}i = \frac{V}{L}}$$

$$i(t) = C.F + P.I$$

C.F → Transient response or source free response or Natural Response

$$\frac{di}{dt} + \frac{R}{L}i = 0 \Rightarrow i(t) = Ae^{-\frac{Rt}{L}}$$

P.I → steady state response or final value or forced Response

$$i(t) = C.F + P.I$$

$$i(t) = Ae^{-\frac{Rt}{L}} + \frac{V}{R}$$

$t = 0^-$, $i = 0$

$t = 0^+$, $i = 0$

$$\Rightarrow 0 = A + \frac{V}{R} \Rightarrow A = 0 - \frac{V}{R}$$

$$\Rightarrow \boxed{A = i(0^+) - i(\infty)}$$

→ Applicable for RL or RC circuit with source.

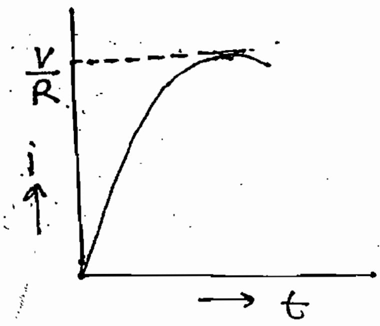
$$i(t) = C.F + PI$$

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

$$\Rightarrow \boxed{i(t) = [i(0^+) - i(\infty)] e^{-Rt/L} + i(\infty)}$$

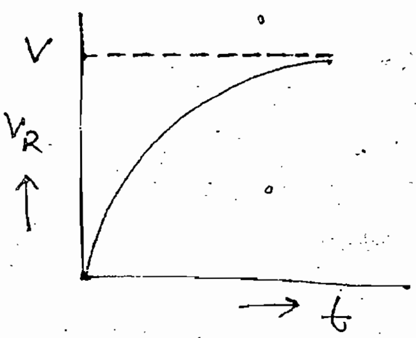
→ Valid for RL and RC circuit

$$i(t) = \frac{V}{R}(1 - e^{-Rt/L}) \rightarrow$$



$$V_R = iR$$

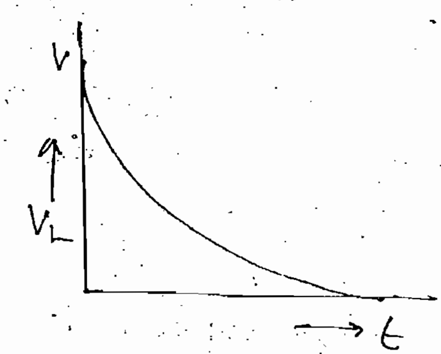
$$\Rightarrow V_R = V(1 - e^{-Rt/L})$$



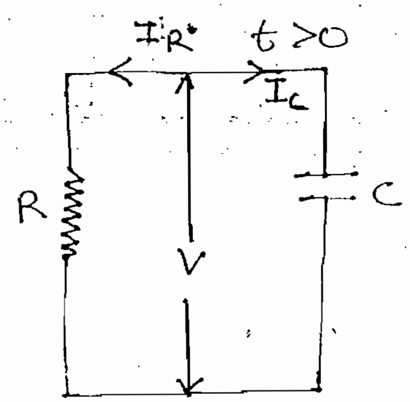
$$V_L = L\frac{di}{dt}$$

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

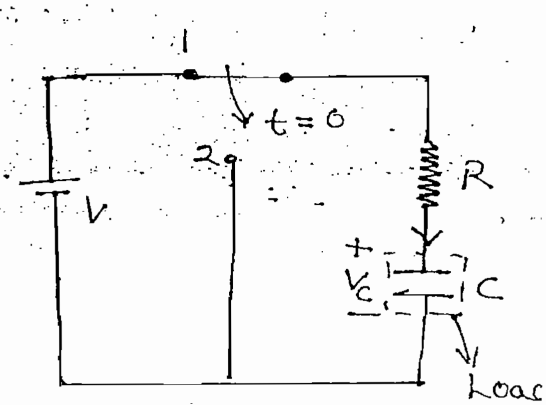
$$V_L = V_0 e^{-Rt/L}$$



Source Free RC Circuit :-



←



$t = 0^-$, $V_c = V_0$

$t = 0^+$, $V_c = V_0$

V= Virtual voltage source

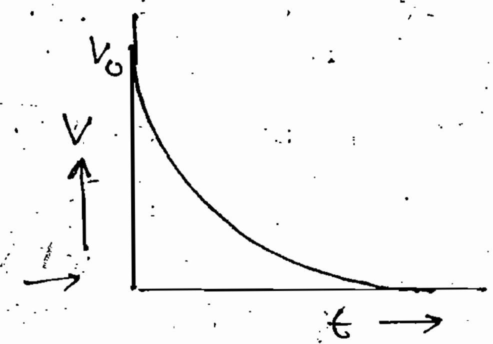
$$I_R + I_C = 0$$

$$\Rightarrow \frac{V}{R} + C\frac{dV}{dt} = 0$$

$$\Rightarrow \frac{V}{R} = -C\frac{dV}{dt}$$

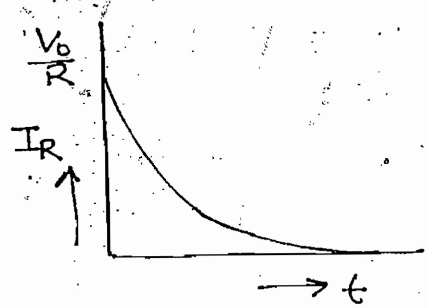
$$\Rightarrow \int_0^t -\frac{1}{RC}\,dt = \int_{V_0}^{V(t)} \frac{dV}{V}$$

$$\Rightarrow V(t) = V_0 e^{-t/RC}$$



$$I_R = \frac{V}{R}$$

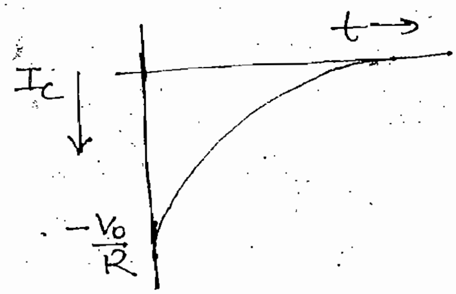
$$\Rightarrow I_R = \frac{V_0}{R} e^{-t/RC}$$



$$I_C = C\frac{dV}{dt}$$

$$I_C = C\frac{d}{dt}\left(V_0 e^{-t/RC}\right)$$

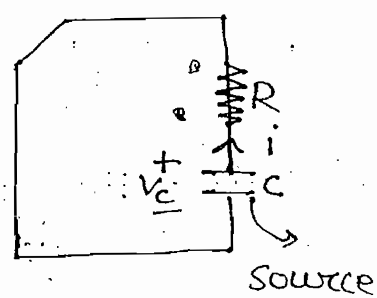
$$\Rightarrow I_C = -\frac{V_0}{R} e^{-t/RC}$$



$t > 0$

Note:-

When switch is transferred from position 1 to position 2 voltage across the capacitor will remain same but current direction of the capacitor is reversed.



$I_R = -I_C$