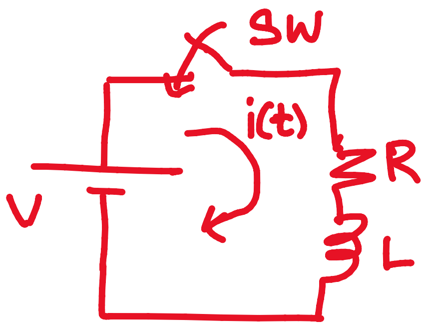
Problems on Transient Analysis with DC Excitation

RL Response Due to DC Excitation



Time Constant

$\tau = L/R$

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

V, R, L, t

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

$$V_R = V\left[1 - e^{-\left(\frac{Rt}{L}\right)}\right]$$

$$P_R = \frac{V^2}{R}\left[1 - 2e^{-\left(\frac{Rt}{L}\right)} + e^{-\left(\frac{2Rt}{L}\right)}\right]$$

$$P_L = \frac{V^2}{R}\left[e^{-\left(\frac{Rt}{L}\right)} - e^{-\left(\frac{2Rt}{L}\right)}\right]$$

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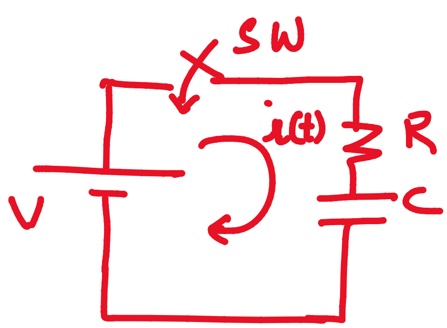
RC Response Due to DC Excitation



Time Constant

$\tau = RC$

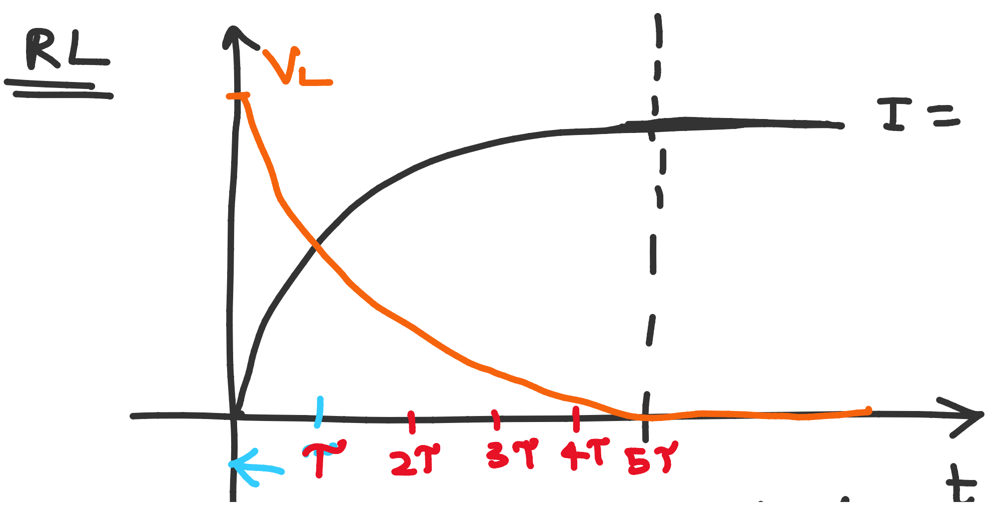
$$i(t) = \frac{V}{R}\left[e^{-\left(\frac{t}{RC}\right)}\right]$$

$$V_R = V\left[e^{-\left(\frac{t}{RC}\right)}\right]$$

$$V_C = V\left[1 - e^{-\left(\frac{t}{RC}\right)}\right]$$

$$P_R = \frac{V^2}{R}\left[e^{-\left(\frac{2t}{RC}\right)}\right]$$

$$P_C = \frac{V^2}{R}\left[e^{-\left(\frac{t}{RC}\right)} - e^{-\left(\frac{2t}{RC}\right)}\right]$$

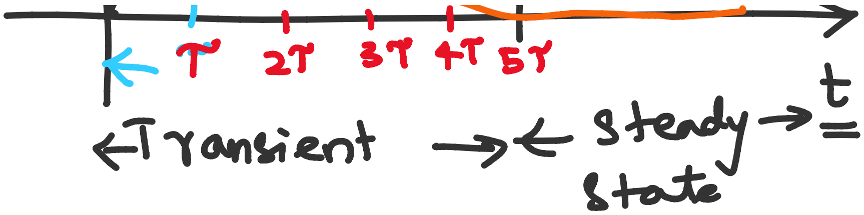


$I = \frac{V}{R}$ | $\frac{V}{R}\left(1 - e^{-Rt/L}\right)$

$\tau = L/R.$

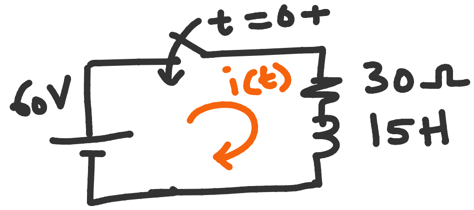
$1\tau = 37\%$

$1\tau - 63\%$



$1\tau = 63\%$

1. A series R-L Circuit with R = 30 Ω and L = 15 H is connected to a constant voltage of 60V applied at t = 0+. Determine the current i(t), Voltage across resistor and inductor at t = 10 sec



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

$$= \frac{60}{30}\left[1 - e^{-\left(\frac{30 \times t}{15}\right)}\right]$$

$$= 2\left[1 - e^{-2t}\right]$$

$\therefore$ at $t = 10$ sec $\quad i(t) = 2A$

at $t = 10$ msec; $i(t) = 0.039A$

$e^{-2(10)} = 2.06 \times 10^{-9}$

$e^{-2(10 \times 10^{-3})} = e^{-0.02} = \underline{\underline{0.98019}}$

$$V_R = V\left[1 - e^{-\frac{Rt}{L}}\right] ; \tau = L/R$$

$$= V\left[1 - e^{-t/\tau}\right] \qquad = \frac{15}{30} = 0.5$$

$$= 60\left[1 - e^{-t/0.5}\right] = 60\left[1 - e^{-2t}\right]$$

@ $t = 10$ sec; $V_R = 60$ V

@ $t = 10$ msec; $V_R = 0.597$ V.

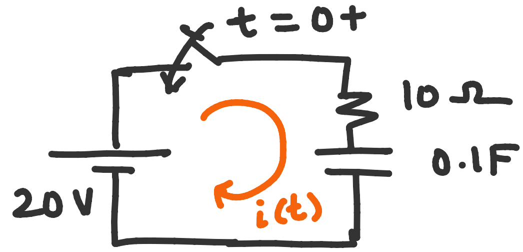
$$V_L : V e^{-Rt/L} \Rightarrow V e^{-t/\tau} = 60\, e^{-2t}$$

$V_L : V e \Rightarrow V e = 60 e$

@ $t = 10$ sec ; $V_L = 0$ V

@ $t = 10$ msec; $V_L = 58.811$ V

2. A series R-C Circuit with R = 10 Ω and C = 0.1 F is connected to a constant voltage source of 20V applied across it at t = 0+. Determine the current i(t), Voltage across resistor and capacitor at t = 20 sec and 20 msec.



$$i(t) = \frac{V}{R}\left[e^{-t/RC} \right]$$

$$= \frac{V}{R}\left[e^{-t/\tau} \right]$$

$\tau = RC = 10 \times 0.1$
$= 1$

$$= \frac{20}{10}\left[e^{-t/1} \right]$$

$$= 2(e^{-t})$$

@ $t = 20$ sec ; $i(t) = 0$.

@ $t = 20$ msec ; $i(t) = 1.96$ A.

$$V_R = V e^{-t/RC}$$

$$= 20 e^{-t}$$

@ $t = 20$ sec ; $V_R = 0$

@ $t = 20$ ms ; $V_R = 19.604$ V

$$V_C = V\left[1 - e^{-t/\tau}\right]$$

$[\quad e^{-t/1}]$

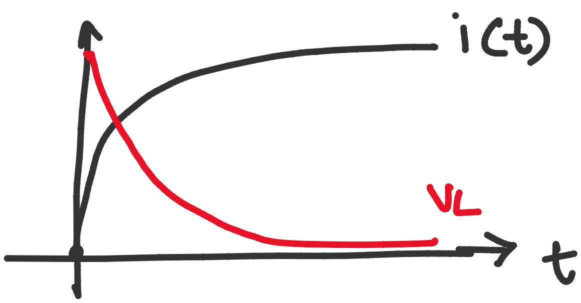
$$= 20\left[1 - e^{-t/1}\right]$$

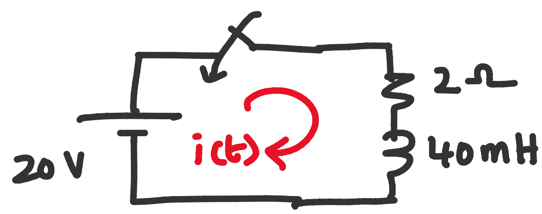
@ $t = 20$ sec ; $V_c = 20$ V.

@ $t = 20$ msec; $V_c = 0.396$ V

3. A Coil having an inductance of 40 mH and a resistance of 2 Ω is connected together to form an LR series circuit, with 20 V DC source across it.

a) Determine the final steady state current in the circuit
b) What will be the time constant of the RL series circuit
c) What will be the transient time of the RL series circuit
d) What will be the value of induced emf across the inductor after 10 ms
e) What will be the value of the circuit current 1 time constant after the switch is closed.





$$\tau = \frac{L}{R} = \frac{40}{2} = 20 \text{ msec}$$

(a) Current $i(t) = \frac{V}{R}\left[1 - e^{-t/\tau}\right]$

Steady state Current = 10 A.

(b) $\tau = \frac{L}{R} = \frac{40}{2} = 20$ msec

(c) Transient time $= 5\tau$

$= 5 \times 20$ msec

$= 5 \times 20$ msec

$= 100$ msec

(d) $V_L = V e^{-\frac{Rt}{L}}$

$= 20 e^{-t/\tau} =$

after 10 msec :

$V_L = 20 e^{-\frac{10 \times 10^{-3}}{20 \times 10^{-3}}} = 20 \times 0.6065$

$= 12.13 V$

(e) after 1 time constant $\}$ $t = 1\tau$.

$i(t) = \frac{20}{2} \left(1 - e^{-t/\tau}\right)$

$= 10 \, (1 - 0.368) = 6.32 A$