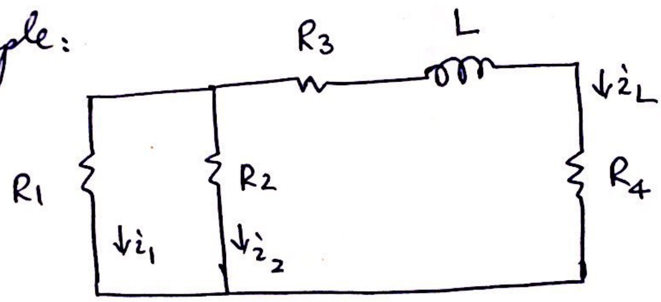
8.4 General RL/RC circuits

(PP 275 8th Ed HKD)

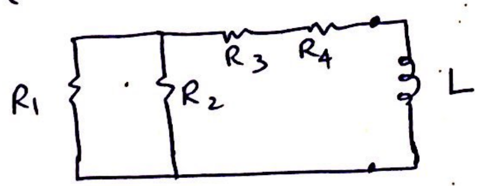
The results obtained for the series RL/RC circuits can be extended to any number of resistors and inductors/capacitors if these can be reduced to one equivalent inductor/capacitor and a resistor.

— It is even possible to consider dependent sources.

— For example:



— Now R_{eq} faced by inductor is:



$$R_{eq} = R_3 + R_4 + (R_1 // R_2)$$

— Time constant is:-

$$\tau = \frac{L}{R_{eq}} \quad \text{or} \quad \text{"}\frac{L}{R_{Th}}\text{"}$$

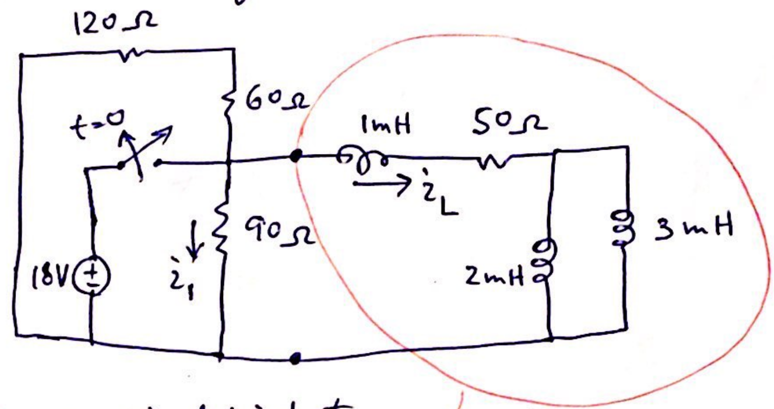
— Also $\tau = \dfrac{L_{eq}}{R_{eq}}$

(Important)

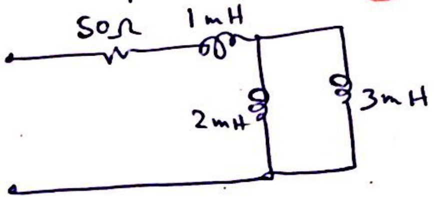
Example 8.4 General RL Circuit

(PP 277 8th Ed HKD)

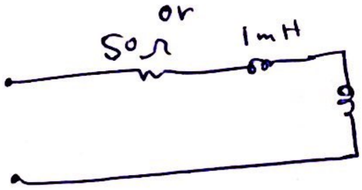
Determine i_1 and i_L for $t > 0$.



Solution: Can be simplified to:



or

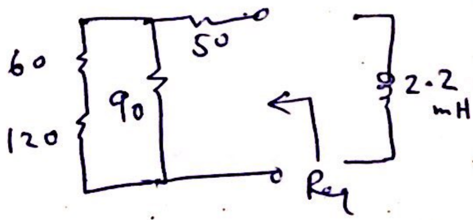


$\frac{2 \times 3}{2+3} = 1.2\ mH$

or

So at $t=0$ switch is opened and R_{eq} seen by 2.2mH is:-

$$R_{eq} = \frac{180 \times 90}{270} + 50$$
$$= 110\,\Omega$$



Hence $\tau = \frac{L_{eq}}{R_{eq}} = \frac{2.2}{110} = 20\mu s$

contd

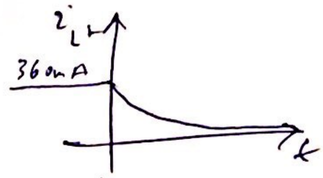
—— contd (278)

therefore $\quad i_L(t) = Ae^{-t/\tau} = Ae^{-50{,}000t}$ amp (form of the natural response)

To determine coefficient 'A', at $t = 0^-$

$$i_L(0^-) = \frac{18}{50} = 360\,mA = i_L(0^+)$$

So $\quad i_L = \begin{cases} 360\,mA & t < 0 \\ 360\,e^{-50{,}000t} & t \geq 0 \end{cases}$

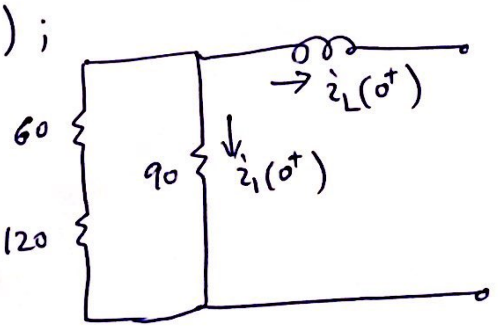


Now for i_1 for $t < 0$

$$i_1 = \frac{18}{90} = 200\,mA$$

Hence $\quad i_1 = \begin{cases} 200\,mA & t < 0 \\ ? & t \geq 0 \end{cases}$

For $i_1(0^+)$;



By CDR $\quad i_1(0^+) = -\,i_L(0^+)\left(\frac{180}{180+90}\right)$

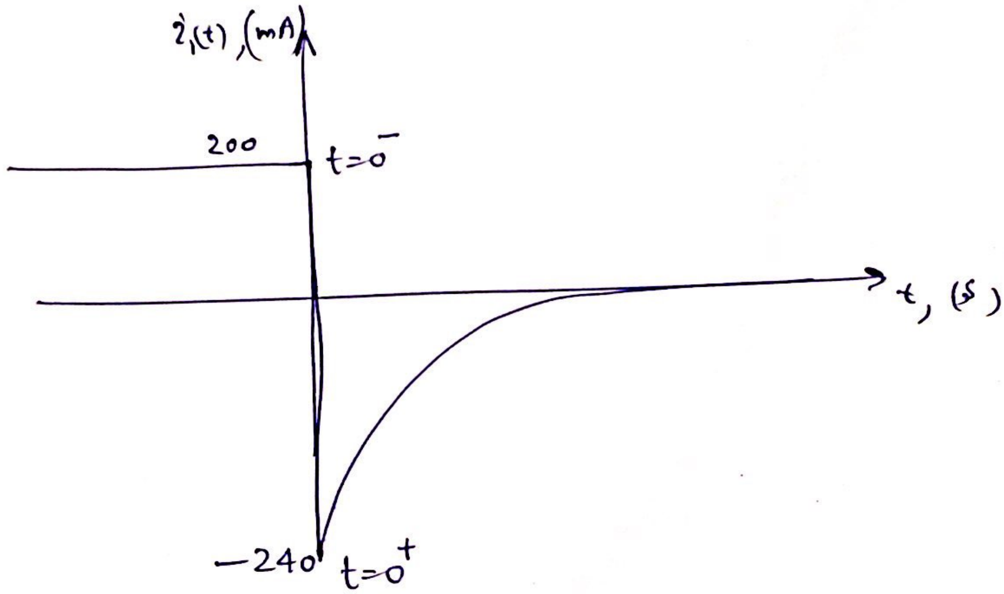
$$i_1(0^+) = -240\,mA$$

—————— contd

— contd (27B)

So $$i_1 = \begin{cases} 200 \text{ mA} & t < 0 \\ -240 e^{-50,000t} \text{ mA} & t \geq 0 \end{cases}$$

Graphically:



Imp:

Also :-

CDR

$$i_1(t) = -\left(\frac{180}{180+90}\right)\left(360\, e^{-50,000t}\right) \quad t \geq 0$$

$$i_1(t) = -240\, e^{-50,000t} \text{ mA}, \quad t \geq 0$$