Paper 1, TDC Part-1
Chapter– 1, Introduction to Passive Elements
Inductor Lecture 4

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So multiplying eqn (A) by $e^{\frac{R}{L}t}$ i.e. IF
we get,

$$e^{\frac{R}{L}t}\frac{di}{dt} + \frac{R}{L}e^{\frac{R}{L}t}i = \frac{E}{L}e^{\frac{R}{L}t}$$

$$\frac{d}{dt}\left(e^{\frac{R}{L}t}.i\right) = \frac{E}{L}e^{\frac{R}{L}t}$$

or, $$d\left(e^{\frac{R}{L}t}.i\right) = \frac{E}{L}e^{\frac{R}{L}t}dt$$

Now integrating both side we get:

$$\int d\left(e^{\frac{R}{L}t}.i\right) = \int \frac{E}{L}e^{\frac{R}{L}t}dt$$

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$$e^{\frac{R}{L}t} \cdot i = \frac{E}{L} \times \frac{e^{\frac{R}{L}t}}{\frac{R}{L}} + C$$

So, we get

$$i(t) = \frac{E}{R} + C e^{-\frac{R}{L}t} \quad \text{—— (B)}$$

Now at $t=0$ we know $i(t=0)=0$

So from eqn. (B) we have

$$0 = \frac{E}{R} + C e^{0}$$

or, $C = -\frac{E}{R}$

finally we have

$$i(t) = \frac{E}{R} - \frac{E}{R} e^{-\frac{R}{L}t}$$

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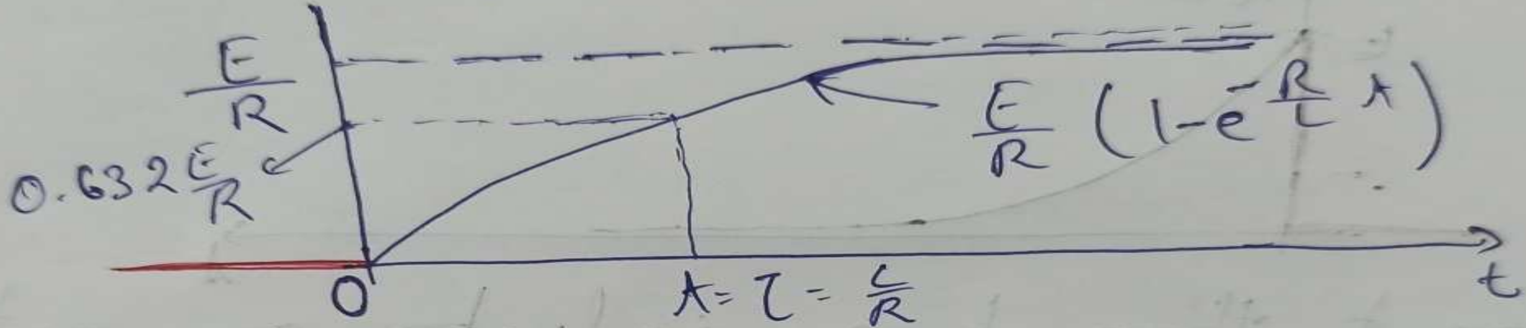
$$i(t) = \frac{E}{R}\left(1 - e^{-\frac{R}{L}t}\right)$$

$$i(t=\infty) = \frac{E}{R}$$



$$\frac{L}{R} = \tau = \text{time const.}$$

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

So,

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

$$= 0.632\,\frac{E}{R}$$

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R

So, After few time constant current will reach 99% i.e. it will reach steady state.

Now Voltage across the inductor is,

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

$$= 0 - \frac{L \times E}{R}\frac{d e^{-t/\tau}}{dt}$$

$$= \frac{EL}{R} \times \frac{1}{\tau} e^{-t/\tau}$$

$$= E e^{-t/\tau} \quad \text{at } \tau = \frac{L}{R}$$

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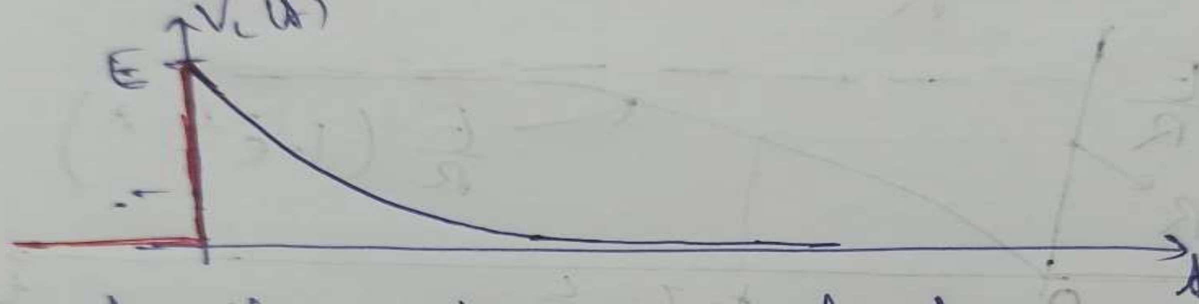
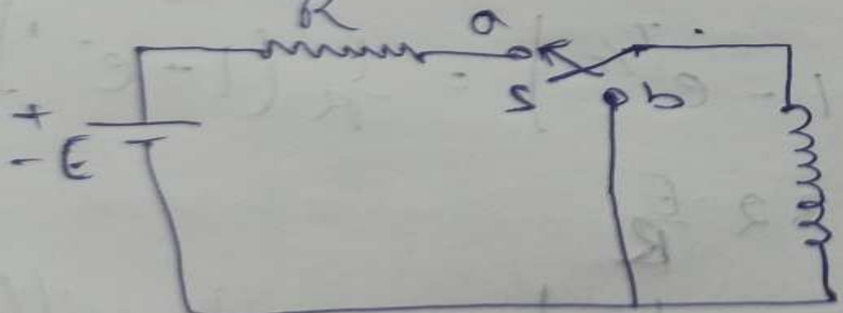
$V_L(0^-) = 0$

$V_L(0^+) = Ee^{-0/\tau} = E$

So,



Current through an inductor can not have a step jump however voltage can have a step jump.



at $t < 0$, switch is open and there is no current so $i(0^-) = 0$

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Now at $t = 0$ the switch is closed i.e. it moves to position 'a' then we have already seen that

$$i(t) = \frac{E}{R}\left(1 - e^{-t/\tau}\right) \quad \text{when } \tau = L/R$$

After few time constant the

$$i(t) = \frac{E}{R}$$

then energy stored in Inductor will be

$$= \frac{1}{2} L \left(\frac{E}{R}\right)^2$$

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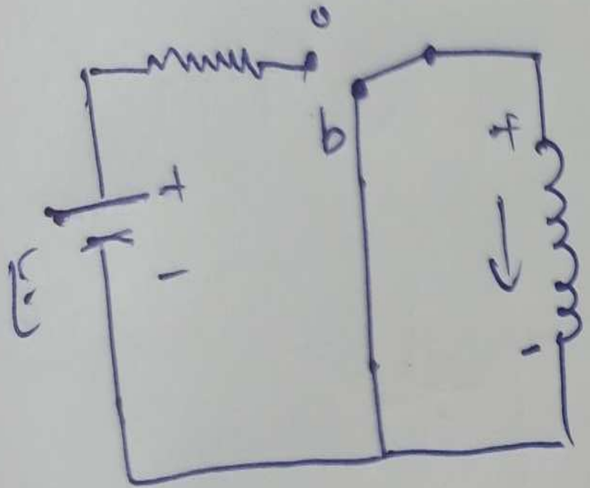
Now when the switch is moved to position 'b' we have ckt. like



$$V = 0 = L\frac{di(t)}{dt}$$

$$i(t) = \frac{E}{R}$$

So the energy is $\frac{1}{2}L\left(\frac{E}{R}\right)^2$

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For any query contact- 9771474020

Thank You

To be Contd..