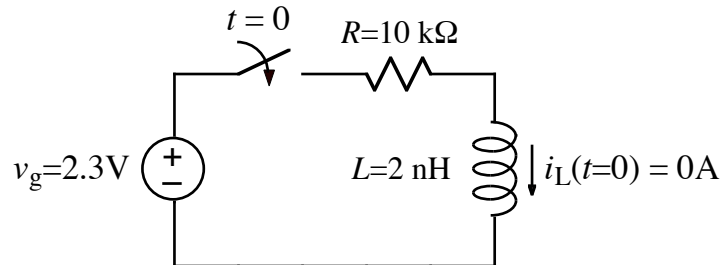


Ex:

- Find an expression for $i_L(t)$ for $t \geq 0$.
- Find the energy stored in the inductor at time $t = 30 \mu\text{s}$.

SOL'N: a) The following general form of solution applies to any RL circuit with a single inductor:

$$i_L(t \geq 0) = i_L(t \rightarrow \infty) + [i_L(t=0^+) - i_L(t \rightarrow \infty)]e^{-t/(L/R_{Th})}$$

The Thevenin resistance, R_{Th} , is for the circuit after $t = 0$ (with the L removed) as seen from the terminals where the L is connected. In the present case, we have $R_{Th} = 10 \text{ k}\Omega$.

$$L/R_{Th} = 2 \text{ nH}/10 \text{ k}\Omega = 0.2 \text{ ps}$$

The value of $i_L(t=0)$ is given in the problem as 0 V. Note that the L could not have any current before $t = 0$ in this circuit since there is no closed path to carry current.

As time approaches infinity, the L current will converge to its final value, and the voltage across the L will cease to change. Thus, $di_L/dt = 0$ and $v_L = 0$, meaning the L will act like a wire. It follows that the current through the L will equal the current through the R , which will equal $2.3 \text{ V}/10 \text{ k}\Omega = 0.23 \text{ mA}$.

$$i_L(t \rightarrow \infty) = 0.23 \text{ mA}$$

Substituting values, we have the following result:

$$i_L(t \geq 0) = 0.23 \text{ mA} + [0 - 0.23 \text{ mA}]e^{-t/0.2\text{ps}}$$

- The energy in an inductor is given by the following formula:

$$w_L = \frac{1}{2} L i_L^2$$

We use the solution to (a) to evaluate $i_L(t)$ at $t = 30 \mu\text{s}$.

$$i_L(t = 30\mu\text{s}) = 0.23 \text{ mA} - 0.23 \text{ mA} \cdot e^{-30\mu\text{s}/0.2\mu\text{s}} \approx 0.23 \text{ mA}$$

Using this voltage, we evaluate the energy on the capacitor.

$$w_L = \frac{1}{2} 2\text{nH} \cdot (0.23\text{mA})^2 = 0.053 \text{ fJ} = 53 \text{ aJ}$$