Ex:

After being closed for a long time, the switch opens at \( t = 0 \).

a) Calculate the energy stored on the inductor as \( t \to \infty \).

b) Write a numerical expression for \( i(t) \) for \( t > 0 \).

**Sol'n:**

a) As \( t \) approaches infinity, the switch is open and the inductor acts like a wire. The 3 k\( \Omega \) and 15 k\( \Omega \) sum to act like an 18 k\( \Omega \) resistor. This 18 k\( \Omega \) resistor is in parallel with the 2 k\( \Omega \) resistor, forming a current divider. The current in the inductor is the same as the current in the 3 k\( \Omega \) and 15 k\( \Omega \) resistors:

\[
i_L(t \to \infty) = 300 \, \mu A \frac{2 \, k\Omega}{2 \, k\Omega + 18 \, k\Omega} = 30 \, \mu A
\]

The energy for an inductor is the current squared times half the inductance:

\[
w_L(t \to \infty) = \frac{1}{2} L i_L^2(t \to \infty)
\]

Using the final current we have the energy:

\[
w_L(t \to \infty) = \frac{1}{2} 20 \, mH (30 \, \mu A)^2 = 9 \, pJ
\]

b) We use the general form of solution for RL circuits:
\[ i(t > 0) = i(t \to \infty) + [(i(0^+) - i(t \to \infty)]e^{-t/(L/R_{Th})} \]

We find the initial condition for \( i \) by determining the inductor current at \( t = 0^+ \). With the switch closed for a long time, the 15 kΩ resistor on the right side is bypassed, and the inductor looks like a wire. The circuit becomes a current divider, with the 2 kΩ and 3 kΩ resistors in parallel. The current flowing through \( L \) is the same as the current flowing through the 3 kΩ resistor:

\[ i_L(t = 0^-) = 300 \, \mu A \cdot \frac{2 \, k\Omega}{2 \, k\Omega + 3 \, k\Omega} = 120 \, \mu A \]

Because the energy stored by the inductor cannot change instantly, the value of \( i_L \) at time \( t = 0^+ \) is the same as at time \( t = 0^- \):

\[ i_L(t = 0^+) = i_L(t = 0^-) = 120 \, \mu A \]

Since the 15 kΩ resistor is in series with the inductor, it carries the same current as the inductor:

\[ i(0^+) = i_L(t = 0^+) = 120 \, \mu A \]

Finally, we find the value of \( R_{Th} \) for time \( t > 0 \). We remove the \( L \) and look into the terminals to find \( R_{Th} \). Here, we may simply turn off the current source, leaving a resistance of 3 kΩ + 2 kΩ + 15 kΩ:

\[ R_{Th} = 20 \, k\Omega \]

Our time constant is \( L/R_{Th} \):

\[ \tau = \frac{L}{R_{Th}} = 20 \, \text{mH} \cdot \frac{20 \, \text{kΩ}}{20 \, \text{kΩ}} = 1 \, \mu s \]

Substituting values yields our final answer:

\[ i(t > 0) = 30 \, \mu A + [120 \, \mu A - 30 \, \mu A]e^{-t/1 \, \mu s} \]

or

\[ i(t > 0) = 30 \, \mu A + 90 \, \mu A e^{-t/1 \, \mu s} \]