*E*lectrical
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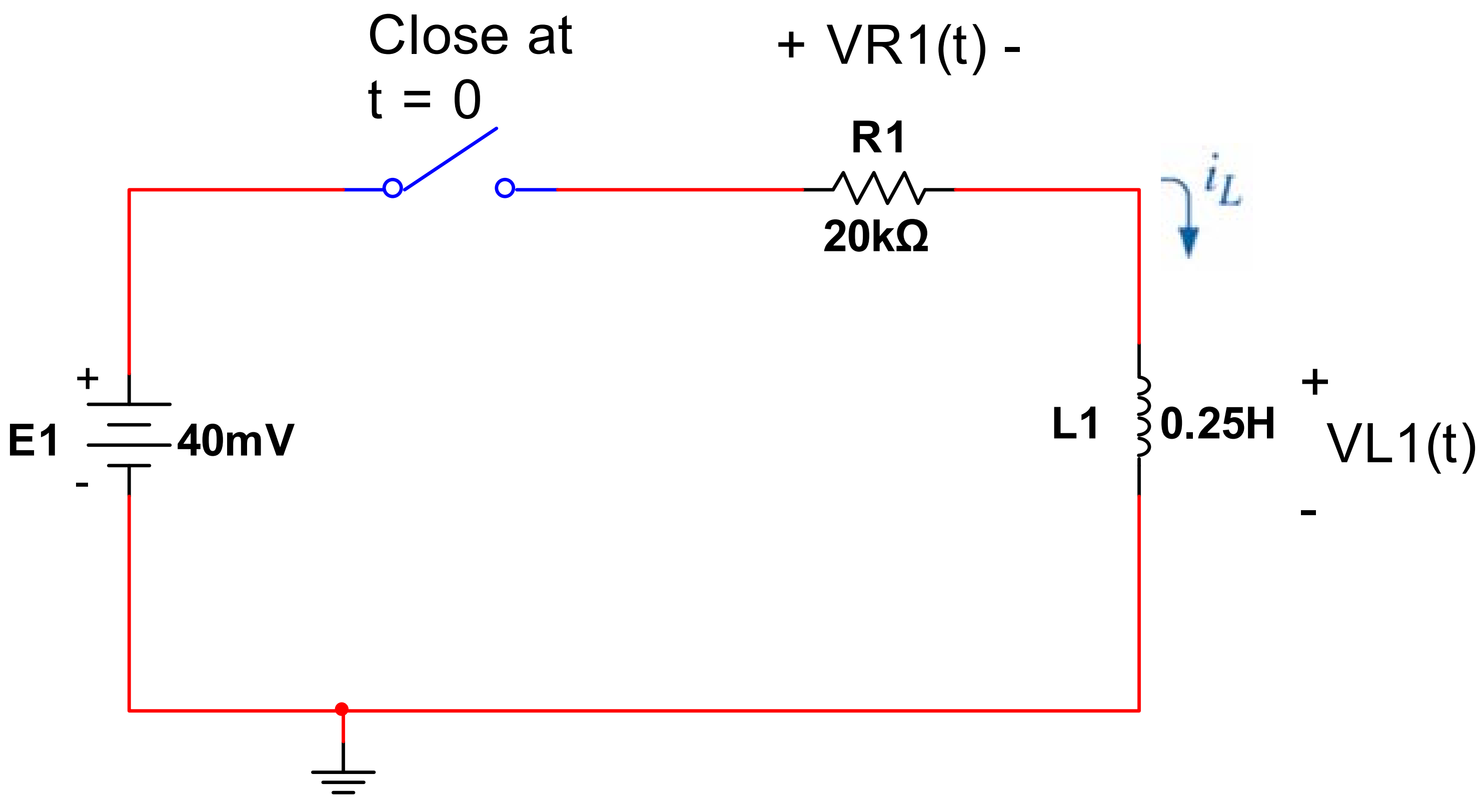
Inductors – Transient/Storage Phase and Decay Phase Intro

Fall 2018

R-L Storage Phase – In Class Problem



1. Find τ
2. Find $i_{L1}(t)$, $t \geq 0$ (eq)
3. Find $v_{L1}(t)$ and $v_{R1}(t)$, $t \geq 0$ (eq)
4. Find i_L and v_L for 1τ, 3τ, & 5τ
5. Sketch $i_{L1}(t)$, $v_{L1}(t)$, & $v_{R1}(t)$, $t \geq 0$

R-L Decay Phase – Issue with our standard Thevenin equivalent circuit approach

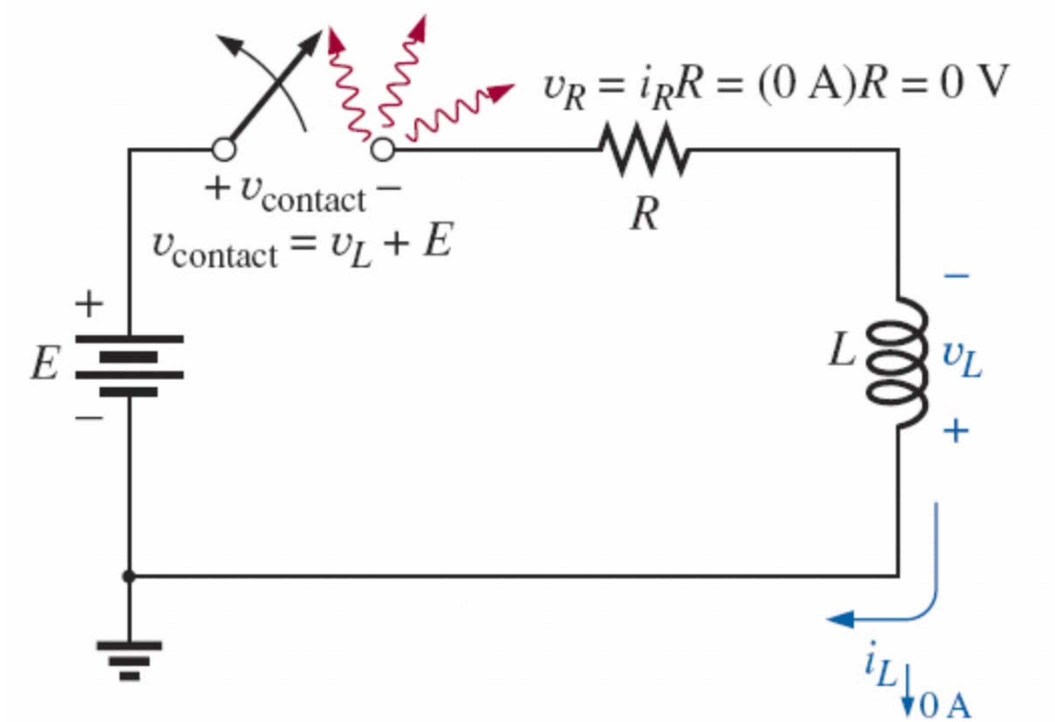


FIG. 11.41 *Demonstrating the effect of opening a switch in series with an inductor with a steady-state current.*

R-L Decay Phase – Fix to overcome the high voltage problem

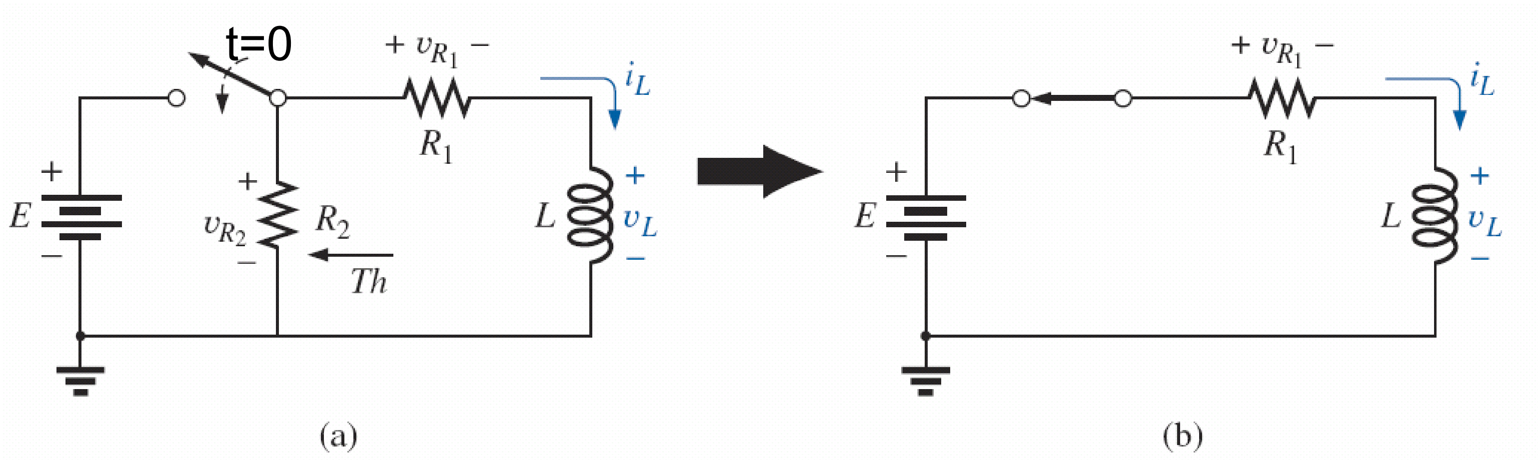


FIG. 11.42 *Initiating the storage phase for an inductor by closing the switch.*

*Note that R2 has no effect on the storage phase: $i_{L\ Final} = E/R_1$

R-L Decay Phase – Qualitative Discussion

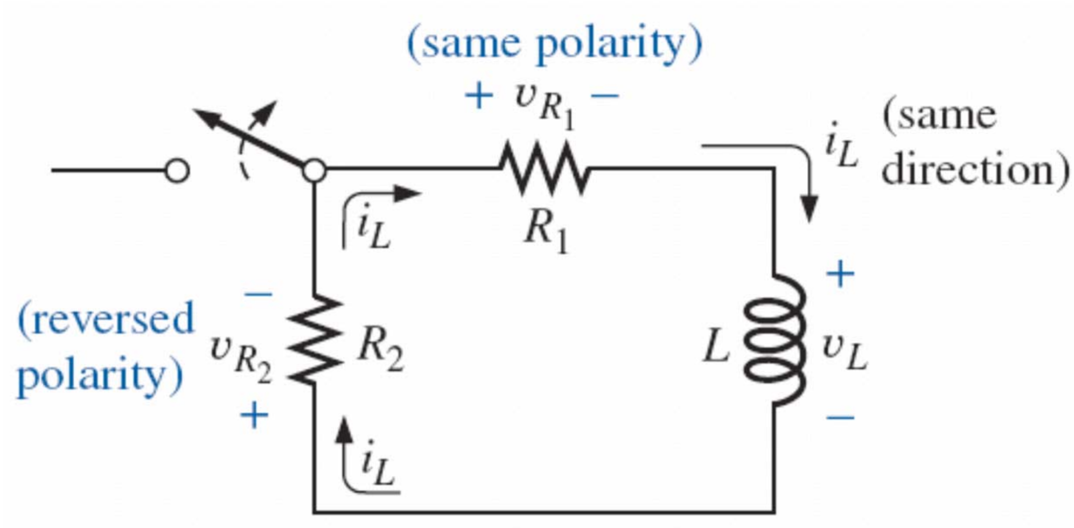
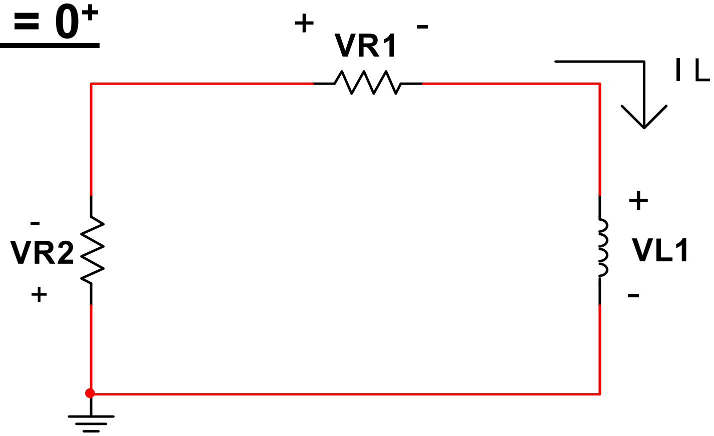


FIG. 11.43 *Network in Fig. 11.42 the instant the switch is opened.*

$t = 0^+$ so $i_L = i_{L\ Final}$ from the storage phase

R-L Decay Phase - Analysis

For t = 0^+



$i_L(0^+) = E / R_1$ <- Final value from storage phase

Finding $v_L(0^+)$:

$-v_{R2} - v_{R1} - v_L = 0$ (KVL)

$v_L = -v_{R2} - v_{R1}$

But: $v_{R2} = i_L * R2$, $v_{R1} = i_L * R1$

So, $v_L(0^+) = -i_L * R2 - i_L * R1$

$= -i_L * (R2 + R1)$

$= -(E / R1) * (R2 + R1)$

$v_L(0^+) = -E(R2 / R1 + 1)$

We can also use $i_L(0^+)$ to find $v_{R2}(0^+)$ and $v_{R1}(0^+)$

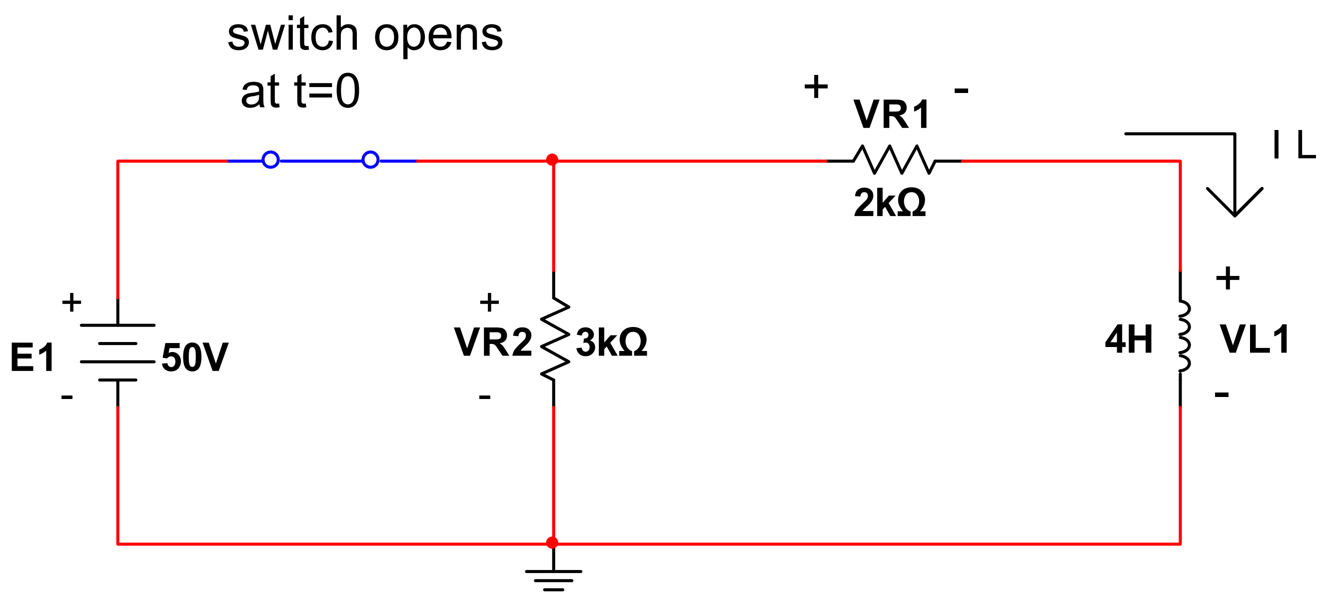
For t >> τ

i_L will exponentially decrease from its max value of (E/R1) to zero

v_L will exponentially decrease to 0

Example – Decay Phase

Assume the circuit was in the storage phase for > 5τ and find $i_L(t)$, $v_L(t)$, $v_{R1}(t)$, & $v_{R2}(t)$ for the decay phase (switch opens at t=0)



Vth = 50V, Rth = 2k-Ohms (for t<0)

Example – Decay Phase

$$i_{LMax} = \frac{50V}{2k\Omega} = 25mA, t = 0$$

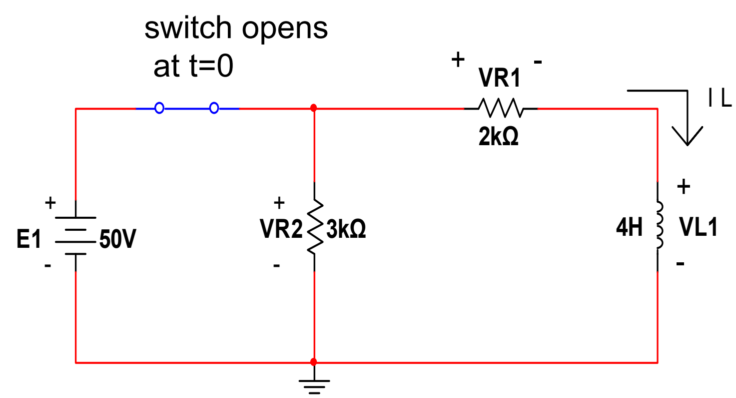
L1 acts as a s/c once steady state conditions are met

$$i_L(t) = i_{LMax}e^{-t/\tau}A \qquad \tau = L/R = L/R_{Th}, R_{Th} = R_1 + R_2 = 5k\Omega$$

$$\boxed{i_L(t) = (25 \cdot 10^{-3})e^{-t/0.8\cdot 10^{-3}}A}$$

Exponential decay to 0

Rth = 5k-Ohms (for t>0)



$$\boxed{v_{R_1}(t) = i_L(t) \cdot R_1 = 50e^{-t/0.8\cdot 10^{-3}}V}$$

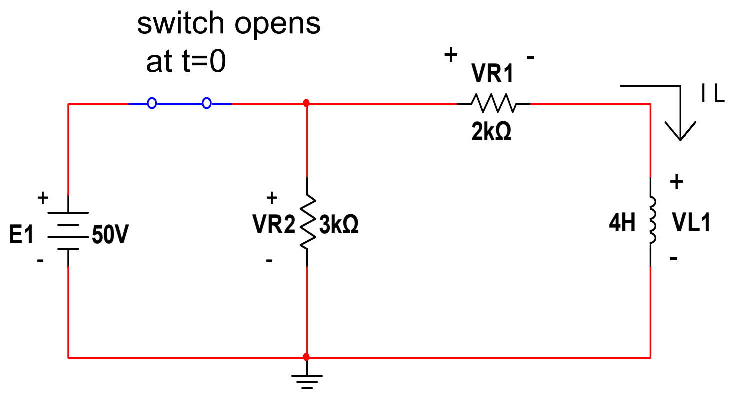
$$\boxed{v_{R_2}(t) = -i_L(t) \cdot R_2 = -75e^{-t/0.8\cdot 10^{-3}}V}$$

$$KVL : v_L(t) = v_{R_2}(t) - \text{VR1(t)}$$

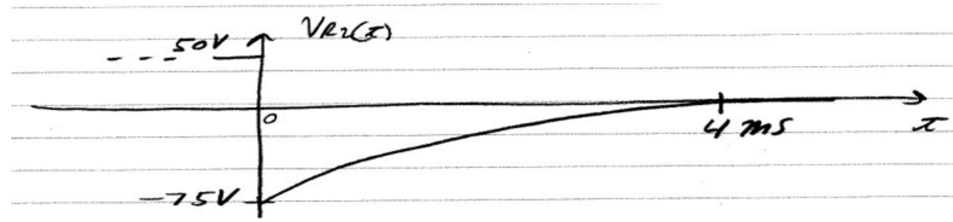
$$v_L(t) = -75e^{-t/0.8\cdot 10^{-3}} - 50e^{-t/0.8\cdot 10^{-3}}$$

$$\boxed{v_L(t) = -125e^{-t/0.8\cdot 10^{-3}}V}$$

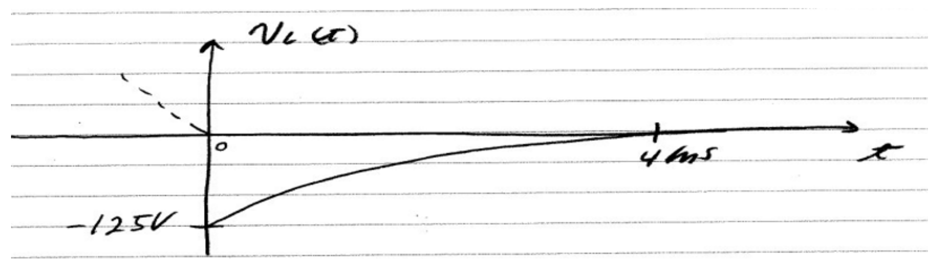
Example – Decay Phase (sketches)



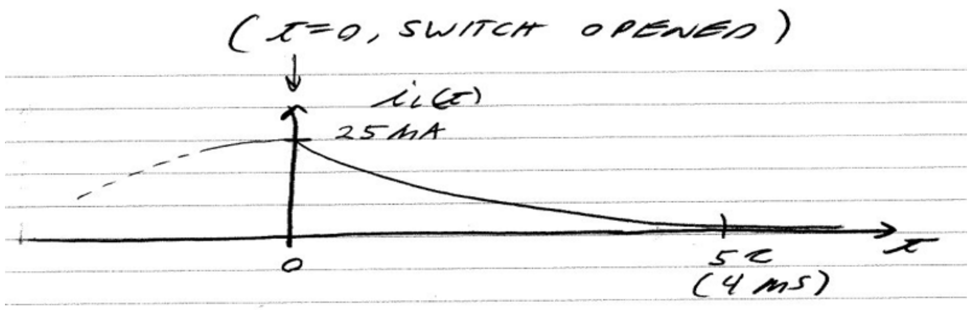
$$\boxed{v_{R_2}(t) = i_L(t) \cdot R_2 = -75e^{-t/0.8 \cdot 10^{-3}} V}$$



$$\boxed{v_L(t) = -125e^{-t/0.8 \cdot 10^{-3}} V}$$



$$\boxed{i_L(t) = (25 \cdot 10^{-3})e^{-t/0.8 \cdot 10^{-3}} A}$$



$$\boxed{v_{R_1}(t) = i_L(t) \cdot R_1 = 50e^{-t/0.8 \cdot 10^{-3}} V}$$