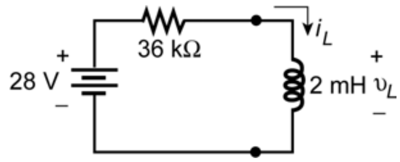
i_L = **1.3 mA(1 − $e^{-t/7.56\mu s}$)**
υ_L = **8.09 V$e^{-t/7.56\mu s}$**

b. 0.632(1.3 mA) = **0.822 mA**
0.368(8.09 V) = **2.98 V**

24. a. Source conversion: $E = IR$ = (4 mA)(12 kΩ) = 48 V, E_{Net} = 48 V − 20 V = 28 V



$$\tau = \frac{L}{R} = \frac{2\text{ mH}}{36\text{ k}\Omega} = 55.56\text{ ns}$$

$$i_L = \frac{E}{R}(1-e^{-t/\tau}) = \frac{28\text{ V}}{36\text{ k}\Omega}(1-e^{-t/\tau}) = \mathbf{0.778\text{ mA}(1-e^{-t/55.56ns})}$$

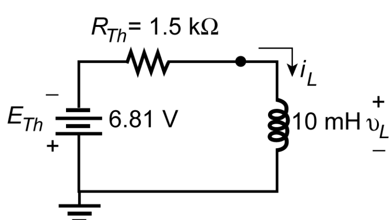
$\upsilon_L = Ee^{-t/\tau}$ = **28 V$e^{-t/55.56ns}$**

b. t = 100 ns:

$$i_L = 0.778\text{ mA}(1-e^{-100ns/55.56ns}) = 0.778\text{ mA}(\underbrace{1-e^{-1.8}}_{0.165}) = \mathbf{0.65\text{ mA}}$$

υ_L = 28 V$e^{-1.8}$ = **4.62 V**

25. a.



R_{Th} = 2.2 kΩ ∥ 4.7 kΩ = 1.50 kΩ

$$E_{Th} = -\frac{4.7\text{ k}\Omega(10\text{ V})}{4.7\text{ k}\Omega + 2.2\text{ k}\Omega} = -6.81\text{ V}$$

$$\tau = \frac{L}{R} = \frac{10\text{ mH}}{1.50\text{ k}\Omega} = 6.67\ \mu\text{s}$$

$$i_L = -\frac{E}{R}(1-e^{-t/\tau}) = -\frac{6.81\text{ V}}{1.5\text{ k}\Omega}(1-e^{-t/\tau}) = \mathbf{-4.54\text{ mA}(1-e^{-t/6.67\mu s})}$$

$\upsilon_L = Ee^{-t/\tau} = -E_{Th}e^{-t/\tau}$ = **−6.81 V$e^{-t/6.67\mu s}$**

b. t = 10 μs:

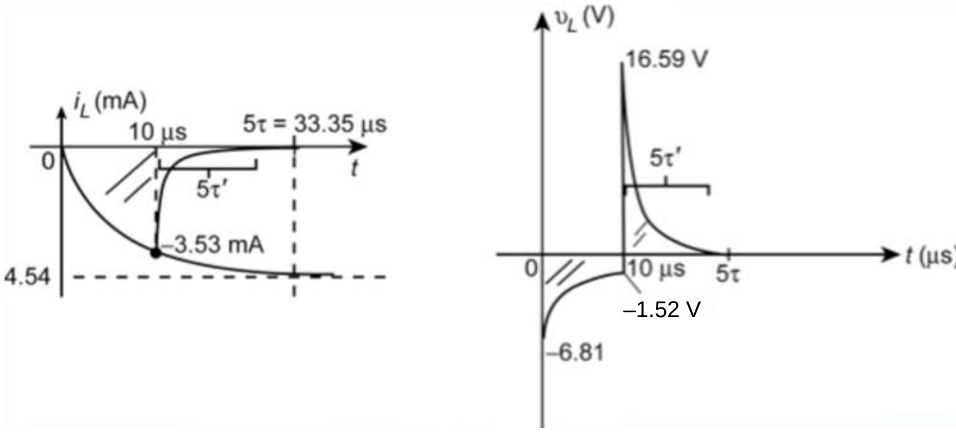
$$i_L = -4.54\text{ mA}(1-e^{-10\mu s/6.67\mu s}) = -4.54\text{ mA}(\underbrace{1-e^{-1.5}}_{0.223})$$

= **−3.53 mA**
υ_L = −6.81 V(0.223) = **−1.52 V**

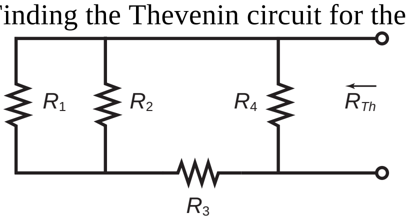
c. $$\tau' = \frac{L}{R} = \frac{10\text{ mH}}{4.7\text{ k}\Omega} = 2.13\ \mu\text{s}$$

i_L = **−3.53 mA$e^{-t/2.13\mu s}$**
At t = 10 μs
V_L = (3.53 mA)(4.7 kΩ) = 16.59 V
υ_L = **16.59 V$e^{-t/2.13\mu s}$**

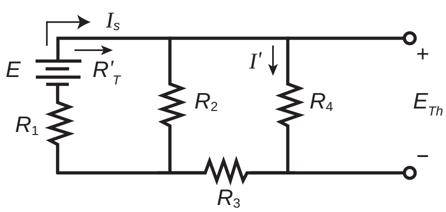
d.



26. a. Finding the Thevenin circuit for the inductor:



$R_{Th} = R_4 \parallel (R_3 + R_1 \parallel R_2)$
$= 1\text{ k}\Omega \parallel (2.7\text{ k}\Omega + 8.2\text{ k}\Omega \parallel 2.2\text{ k}\Omega)$
$= 1\text{ k}\Omega \parallel 4.43\text{ k}\Omega$
$= 0.816\text{ k}\Omega$

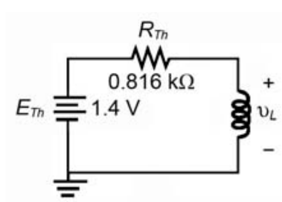


$R_T' = R_1 + R_2 \parallel (R_3 + R_4)$
$= 8.2\text{ k}\Omega + 2.2\text{ k}\Omega \parallel (2.7\text{ k}\Omega + 1\text{ k}\Omega)$
$= 8.2\text{ k}\Omega + 2.2\text{ k}\Omega \parallel 3.7\text{ k}\Omega$
$= 8.2\text{ k}\Omega + 1.38\text{ k}\Omega$
$= 9.58\text{ k}\Omega$

Then $I_s = \dfrac{E}{R_T'} = \dfrac{36\text{ V}}{9.58\text{ k}\Omega} = 3.76\text{ mA}$

and $I' = \dfrac{R_2(I_s)}{R_2 + R_3 + R_4} = \dfrac{2.2\text{ k}\Omega(3.76\text{ mA})}{2.2\text{ k}\Omega + 2.7\text{ k}\Omega + 1\text{ k}\Omega} = 1.4\text{ mA}$

and finally $E_{Th} = I'R_4 = (1.4\text{ mA})(1\text{ k}\Omega) = 1.4\text{ V}$

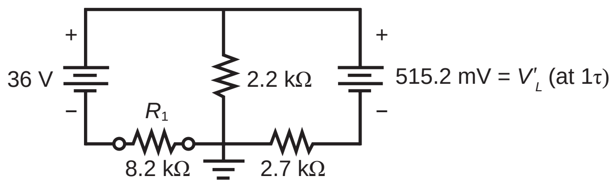


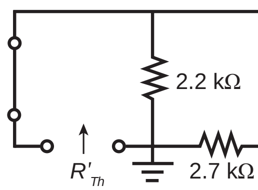
$\tau = \dfrac{L}{R} = \dfrac{10\text{ mH}}{0.816\text{ k}\Omega} = 12.25\ \mu\text{s}$
$\upsilon_L = 1.4\text{ V}e^{-t/12.25\mu\text{s}}$
$= 1.4\text{ V}e^{-25\mu\text{s}/12.25\mu\text{s}}$
$= 1.4\text{ V}e^{-2.05}$
$= 1.4\text{ V}(128.73 \times 10^{-3})$
$=$ **180 mV**

b. $\upsilon_L = 1.4\text{ V}e^{-t/12.25\mu\text{s}}$
$\upsilon_L = 1.4\text{ V}e^{-1\mu\text{s}/12.25\mu\text{s}}$
$= (1.4\text{ V})(e^{-0.082})$
$= (1.4\text{ V})(.0921)$
$=$ **1.29 V**

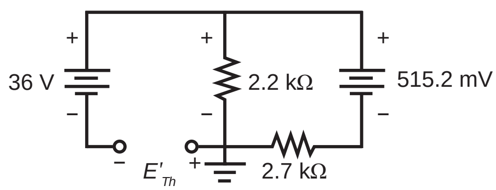
c. Finding the Thevenin equivalent for R_1 at 1τ

At 1τ: $\upsilon_L = 1.4\text{ V}e^{-t/\tau} = 1.4\text{ V}e^{-\tau/\tau} = 1.4\text{ V}e^{-1} = 1.4\text{ V}(0.368) = 515.2\text{ mV}$





$R_{Th}{}' = 2.2\text{ k}\Omega \parallel 2.7\text{ k}\Omega = 1.21\text{ k}\Omega$

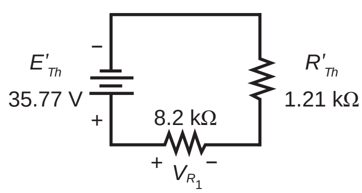


$-E_{Th}{}' + 36\text{ V} - \upsilon_{R_2} = 0$

$E_{Th}{}' = 36 - \upsilon_{R_2}$

$$\upsilon_{R_2} = \frac{2.2\text{ k}\Omega(515.2\text{ mV})}{2.2\text{ k}\Omega + 2.7\text{ k}\Omega} = 0.231\text{ V}$$

$\therefore E_{Th}{}' = 36\text{ V} - 0.231\text{ V} = 35.77\text{ V}$



$$\upsilon_{R_1} = \frac{8.2\text{ k}\Omega(35.77\text{ V})}{8.2\text{ k}\Omega + 1.21\text{ k}\Omega} = \mathbf{31.34\text{ V}}$$

d. $i_L = \dfrac{E_{Th}}{R_{Th}}(1 - e^{-t/\tau})$

$= \dfrac{1.4\text{ V}}{0.81\text{ k}\Omega}(1 - e^{-t/12.25\,\mu\text{s}})$

$= 1.72\text{ mA}(1 - e^{-t/12.25\mu\text{s}})$

$1\text{ mA} = 1.72\text{ mA}(1 - e^{-t/12.25\mu\text{s}})$

$0.581 = 1 - e^{-t/12.25\mu\text{s}}$

$0.419 = e^{-t/12.25\mu\text{s}}$

$t = 12.25\ \mu\text{s}\log_e 0.419$

$= 12.25\ \mu\text{s}(0.87)$

$= \mathbf{10.66\ \mu s}$

27. a. $I_i = \dfrac{16\text{ V}}{4.7\text{ k}\Omega + 3.3\text{ k}\Omega} = 2\text{ mA}$

$t = 0$ s: Thevenin:

$R_{Th} = 3.3\text{ k}\Omega + 1\text{ k}\Omega \parallel 4.7\text{ k}\Omega = 3.3\text{ k}\Omega + 0.82\text{ k}\Omega = 4.12\text{ k}\Omega$

$E_{Th} = \dfrac{1\text{ k}\Omega(16\text{ V})}{1\text{ k}\Omega + 4.7\text{ k}\Omega} = 2.81\text{ V}$

$i_L = I_f + (I_i - I_f)e^{-t/\tau}$

$$I_f = \frac{2.81\text{ V}}{4.12\text{ k}\Omega} = 0.68\text{ mA},\ \tau = \frac{L}{R} = \frac{2\text{ H}}{4.12\text{ k}\Omega} = 0.49\text{ ms}$$

$i_L = 0.68\text{ mA} + (2\text{ mA} - 0.68\text{ mA})e^{-t/0.49\text{ ms}}$

$i_L = \mathbf{0.68\text{ mA} + 1.32\text{ mA}e^{-t/0.49\text{ ms}}}$

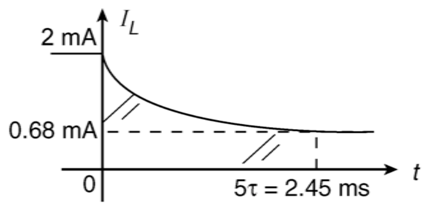
$\upsilon_R(0+) = 2\text{ mA}(4.12\text{ k}\Omega) = 8.24\text{ V}$

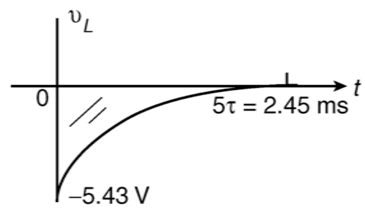
KVL(0+): $2.81\text{ V} - 8.24\text{ V} - \upsilon_L = 0$

$\upsilon_L = -5.43\text{ V}$

$\upsilon_L = \mathbf{-5.43\text{ V}e^{-t/0.49\text{ ms}}}$

b.

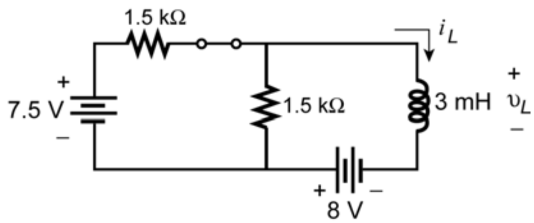




28. a. Steady-state: $I_L = \frac{8\text{ V}}{1.5\text{ k}\Omega} = 5.33\text{ mA},\ V_L = 0\text{ V}$

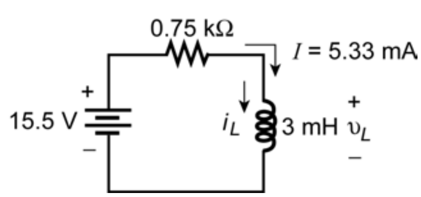
$R_{\text{Th}} = (3\text{ k}\Omega \parallel 12\text{ k}\Omega) \parallel 4\text{ k}\Omega = 1.5\text{ k}\Omega$

$$E_{Th} = \frac{2.4\text{ k}\Omega(20\text{ V})}{2.4\text{ k}\Omega + 4\text{ k}\Omega} = 7.5\text{ V}$$



$R'_{Th} = 1.5\text{ k}\Omega \parallel 1.5\text{ k}\Omega = 0.75\text{ k}\Omega$

$E'_{Th} = 8\text{ V} + 7.5\text{ V} = 15.5\text{ V}$



$$\tau = \frac{L}{R} = \frac{3\text{ mH}}{0.75\text{ k}\Omega} = 4\ \mu\text{s}$$

$I_f = \frac{15.5\text{ V}}{0.75\text{ k}\Omega} = 20.67\text{ mA} \qquad I_i = 5.33\text{ mA}$

$i_L = I_f + (I_i - I_f)e^{-t/\tau}$

$= 20.67\text{ mA} + (5.33\text{ mA} - 20.67\text{ mA})e^{-t/4\ \mu\text{s}}$

$i_L = \mathbf{20.67\text{ mA} - 15.34\text{ mA}e^{-t/4\mu s}}$

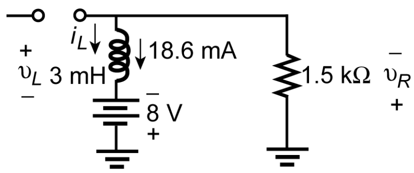
$\upsilon_L = \mathbf{15.5\text{ V}e^{-t/4\mu s}}$

b. $i_L(2\tau) = 20.67 \text{ mA} - 15.34 \text{ mA } \underbrace{e^{-2}}_{0.135}$

$= \mathbf{18.6 \text{ mA}}$

$\upsilon_L(2\tau) = 15.5 \text{ V}e^{-2} = 15.5 \text{ V}(0.135) = \mathbf{2.09 \text{ V}}$

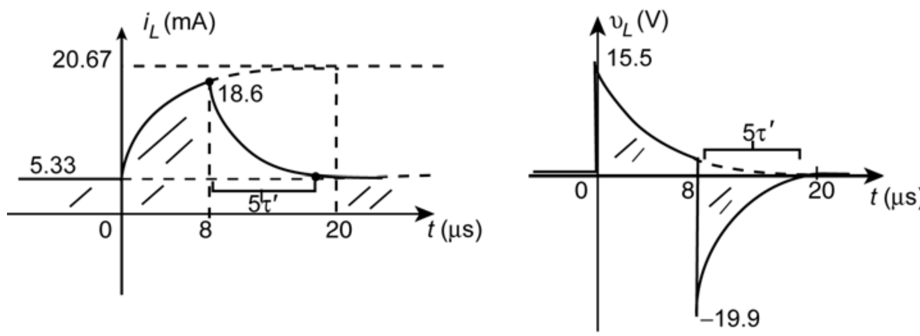
c. $I_i = 18.6$ mA



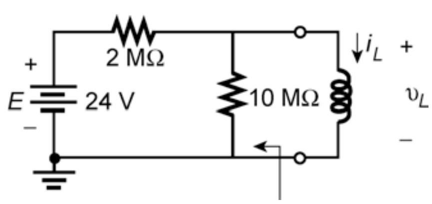
$\upsilon_L + \upsilon_R - 8 \text{ V} = 0$
$\upsilon_L = 8 \text{ V} - \upsilon_R = 8 \text{ V} - (18.6 \text{ mA})(1.5 \text{ k}\Omega)$
$= -19.9 \text{ V}$
$\tau' = \dfrac{L}{R} = \dfrac{3 \text{ mH}}{1.5 \text{ k}\Omega} = 2\ \mu\text{s}$

$I_i = 18.6$ mA $\qquad I_f = \dfrac{8 \text{ V}}{1.5 \text{ k}\Omega} = 5.33$ mA

$i_L = I_f + (I_i - I_f)e^{-t/\tau} = 5.33 \text{ mA} + (18.6 \text{ mA} - 5.33 \text{ mA})e^{-t/2\mu\text{s}}$
$= \mathbf{5.33 \text{ mA} + 13.27 \text{ mA}e^{-t/2\mu s}}$
$\upsilon_L = \mathbf{-19.9 \text{ V}e^{-t/2\mu s}}$



29. a.



$R_{Th} = 2 \text{ M}\Omega \parallel 10 \text{ M}\Omega = 1.67 \text{ M}\Omega$
$E_{Th} = \dfrac{10 \text{ M}\Omega(24 \text{ V})}{10 \text{ M}\Omega + 2 \text{ M}\Omega} = 20 \text{ V}$

$I_L(0^-) = \dfrac{E_{Th}}{R_{Th}} = \dfrac{20 \text{ V}}{1.67 \text{ M}\Omega} = \mathbf{12\ \mu A}$

$\tau' = \dfrac{L}{R_{\text{meter}}} = \dfrac{5 \text{ H}}{10 \text{ M}\Omega} = 5\mu\text{s}$

$i_L = 12\ \mu\text{A}e^{-t/5\ \mu\text{s}}$
$10\ \mu\text{A} = 12\ \mu\text{A}e^{-t/5\ \mu\text{s}}$

$0.833 = e^{-t/5\,\mu s}$

$\log_e 0.833 = -t/5\ \mu s$

$0.183 = t/5\ \mu s$

$t = 0.183(5\ \mu s) = \mathbf{0.92\ \mu s}$

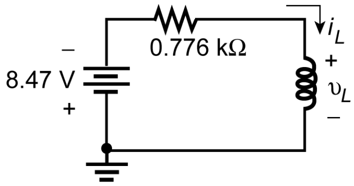
b. $\upsilon_L(0^+) = i_L(0^+)R_m = (12\ \mu A)(10\ M\Omega) = 120\ V$
$\upsilon_L = 120\ Ve^{-t/5\mu s} = 120\ Ve^{-10\mu s/5\mu s} = 120\ Ve^{-2} = 120\ V(0.135) = \mathbf{16.2\ V}$

c. $\upsilon_L = 120\ Ve^{-5\tau/\tau} = 120\ Ve^{-5} = 120\ V(6.74 \times 10^{-3}) = \mathbf{0.81\ V}$

30. a. Closed Switch:

$R_{Th} = 1.2\ k\Omega \parallel 2.2\ k\Omega = 0.776\ k\Omega$

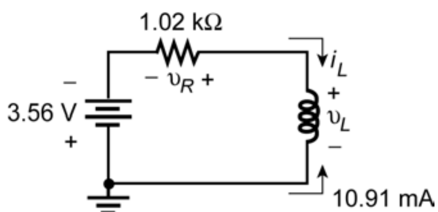
$$E_{Th} = \frac{1.2\ k\Omega(24\ V)}{1.2\ k\Omega + 2.2\ k\Omega} = 8.47\ V$$



Open Switch:

$R'_{Th} = 6.9\ k\Omega \parallel 1.2\ k\Omega = 1.02\ k\Omega$

$$E'_{Th} = \frac{1.2\ k\Omega(24\ V)}{8.1\ k\Omega} = -3.56\ V$$



$-3.56\ V + \upsilon_R - \upsilon_L = 0$

$\upsilon_L = -3.56\ V + (10.91\ mA)(1.02\ k\Omega)$

$= 7.57\ V$

$\upsilon_L = 7.57Ve^{-t/1.18\ ms}$

$$\tau = \frac{L}{R} = \frac{1.24\ H}{1.02\ k\Omega} = 1.18\ ms$$

$$I_{ss} = \frac{3.56\ V}{1.02\ k\Omega} = 3.49\ mA = I_f$$

$i_L = I_f + (I_i - I_f)e^{-t/t}$

$= -3.49\ mA + ((-10.91\ mA - (-3.49\ mA))e^{-t/1.18\ ms}$

$i_L = \mathbf{-3.49\ mA - 7.42\ mAe^{-t/1.18\ ms}}$