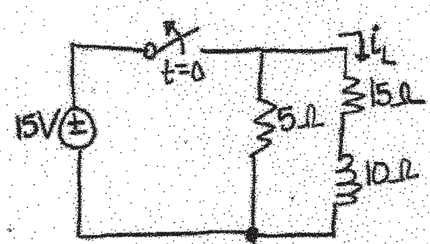
100

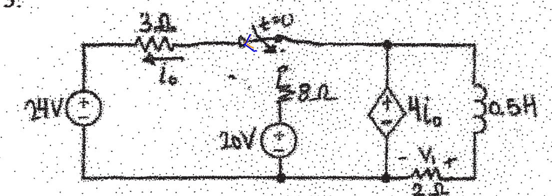
Homework #5 Example

2.



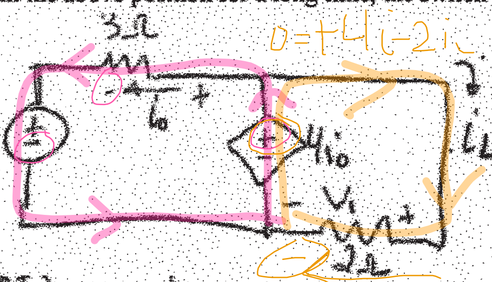
After being closed for a long time, the switch opens at t = 0. Find $i_L(t)$ for $t > 0$.

3.



After being in the above position for a long time, the switch changes at t=0. Find $v_1(t)$ for $t > 0$.

$(t=0^-)$:



$+4i_o - 3i_o - 24 = 0$

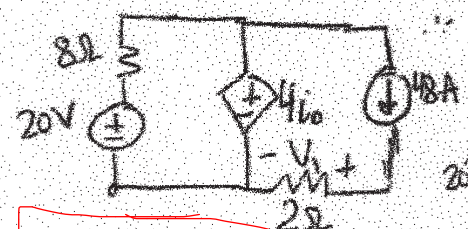
$i_o = +24V/\Omega$

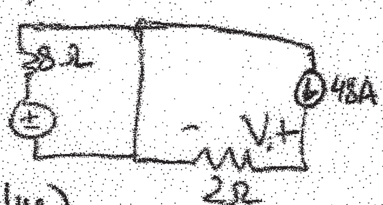
$i_L = \frac{4i_o}{2} = \frac{4(24)}{2} = 48A$

$(t=0^+)$: Inductor current stays the same ⇒

$i_L(t=0^-) = i_L(t=0^+) = 48A$ ← initial value

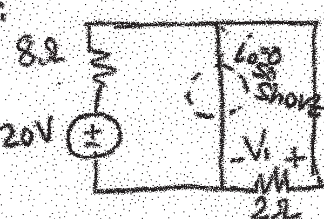
Note that V_1 changes from $t=0^-$ to $t=0^+$.



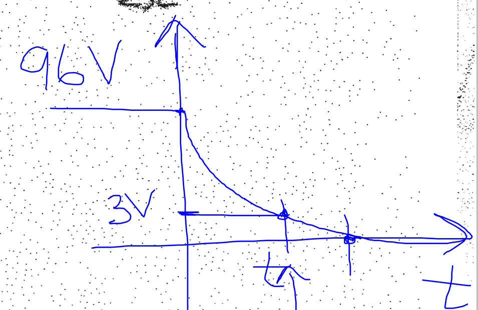


$\boxed{V_1(t=0^+)=48(2)}$ (initial value)

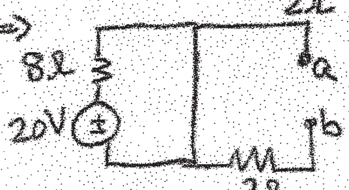
$(t=\infty)$:



$\boxed{V_1=0}$



τ ⇒



$\frac{L=0.5}{R_{th}=2} = \boxed{0.25}$

$3 = 96e^{-4t}$

$t = 0.87s$

$V_1(t) = 96 + (0-96)(1-e^{-t/0.25}) = \boxed{96e^{-4t}\ V}$

$V_1(t) = 0 + (96-0)e^{-t/0.25}\ V$

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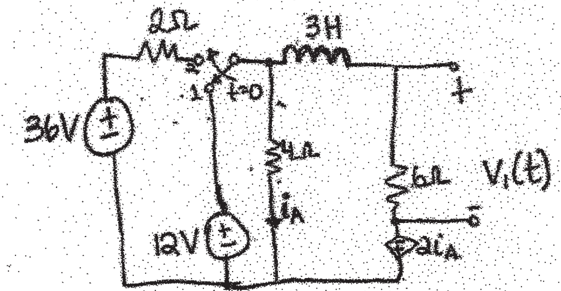
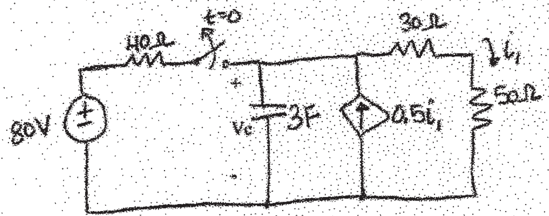
Homework #5 Example

3.



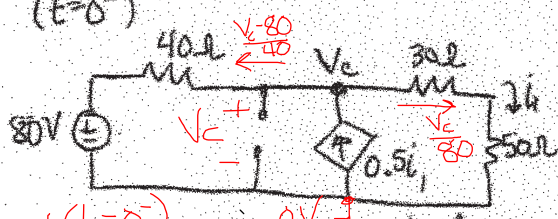
After being at position 1 for a long time, the switch moves to position 2 at t=0. Find $v_1(t)$ for $t > 0$.

4.



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

$(t=0^-)$



$V_c(t=0^-)$

initial value

$$\boxed{64V = V_c(t=0^+)}$$

$$\frac{V_c-80}{40} - 0.5i_1 + \frac{V_c}{80} = 0$$

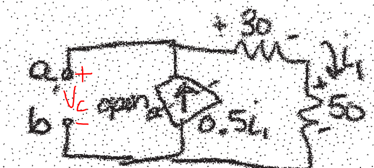
$$i_1 = \frac{V_c}{80}$$

$$\frac{V_c}{40} - 0.5\left(\frac{V_c}{80}\right) + \frac{V_c}{80} = \frac{80}{40}$$

$$V_c\left(\frac{4}{160} - \frac{1}{160} + \frac{2}{160}\right) = \frac{80}{40}$$

$$V_c = 2\frac{1}{\left(5/160\right)} = \frac{2(160)}{5}$$

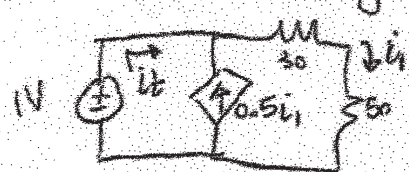
$(t \to \infty)$



$$0.5i_1 - i_1 = 0 \Rightarrow i_1 = 0$$

$V_c = 0V \leftarrow$ final

. Need to use a test supply since $V_{Th}=0$ and $R_{Th} \neq 0$ or the capacitor will not discharge. It must though since $V_c=0$ as a final value and it started with 64V initially.



$$i_t + 0.5i_1 - i_1 = 0$$

$$i_t = 0.5i_1$$

$$i_1 = \frac{1}{80}$$

$$i_t = 0.5\left(\frac{1}{80}\right) = \frac{1}{160}$$

$$R_{Th} = \frac{1V}{\frac{1}{160}} = 160\Omega$$

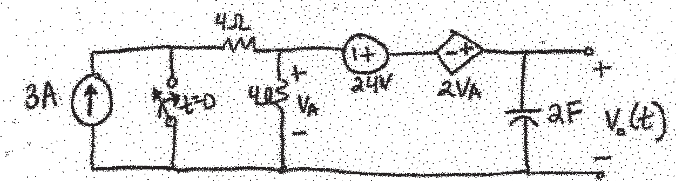
$$\boxed{V_c(t) = 64e^{-t/480}\ V}$$

$$\tau = R_{th}C = 160(3)$$

(104)

Homework #5 Example

4.



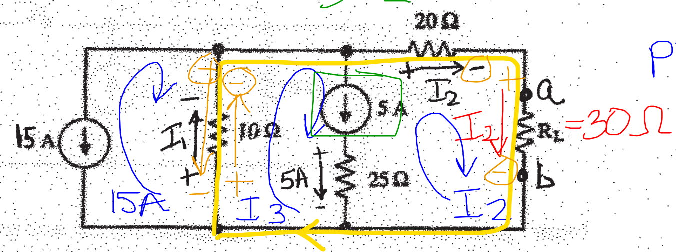
After being open for a long time, the switch closes at t=0. Find Vo(t) for t > 0.

(110)

Max Power Example

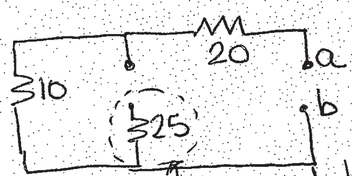
$5 = I_3 - I_2$ $10(15 - I_3) - 50 I_2 = 0$

$p = I_2^2 (30)$



Calculate the value of R_L that would absorb maximum power, and calculate that value of maximum power R_L could absorb.

- Maximum power is absorbed in element when R_L value = R_{Th} (equivalent resistance seen by R_L)
- Independent sources only in circuit. $R_{Th} = R_{eq}$. Set $V=0$, $I=0$ and redraw ⇒



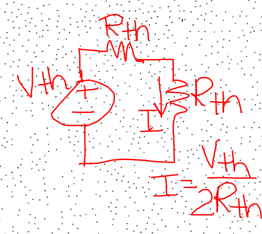
path from a back to b

$20 + 10 = 30 = R_{th}$

ignored because floating

$\therefore \boxed{R_L = 30\Omega}$

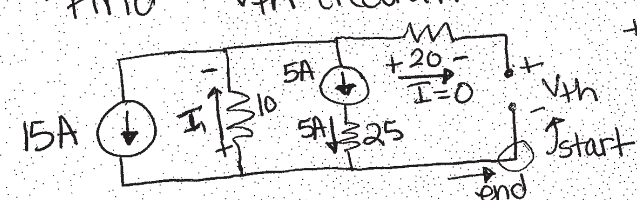
- $\text{power} = \dfrac{(V_{th})^2}{4(R_{th})}$



$p = I^2 R_{th} = \dfrac{V_{th}^2}{4R_{th}}$

$I = \dfrac{V_{th}}{2R_{th}}$

- Find V_{th} (redraw circuit)



$+V_{th} + 0 + I_1(10) = 0$

$-15 + I_1 - 5 - 0 = 0$

$I_1 = 20$

$\therefore V_{th} = -20(10) = -200$

$\text{power} = \dfrac{(-200)^2}{4(30)} = \boxed{333W}$

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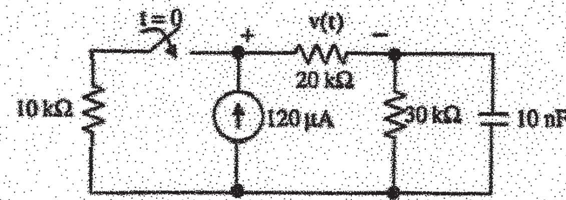
Energy Example

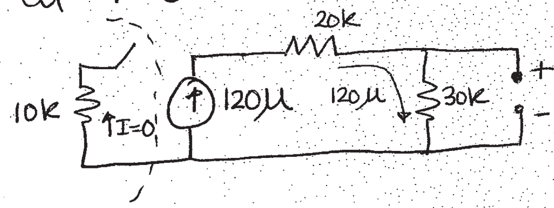


Cap ⇒ becomes open after a long time
- Stays V value at $t=0^+$ (Vsrc)
- $\tau = R_{eq} \cdot C$

After being open for a long time, the switch is closed at t = 0. Calculate the energy stored on the capacitor at $t \to \infty$

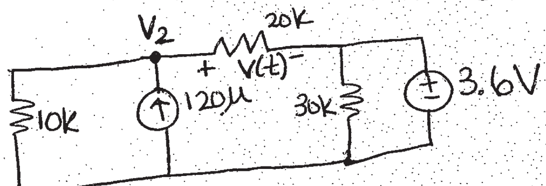
Write a numerical expression for $v(t)$, $t > 0$.

at $t=0^-$: (redraw circuit – cap acts as open)



$V_c = 120\mu(30k) = 3.6V$

at $t=0^+$: (redraw circuit – voltage on cap cannot change instantaneously : use vsource)



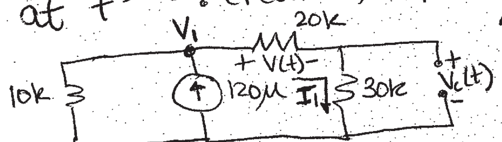
node-voltage: $\frac{V_2}{10k} - 120\mu + \frac{V_2 - 3.6}{20k} = 0$

$V_2\left(\frac{1}{10k} + \frac{1}{20k}\right) = +120\mu + \frac{3.6}{20k}$

$V_2 = \frac{300\mu}{150\mu} = 2V$

$V(t)_{t=0^+} = V_2 - 3.6 = -1.6V$ [Initial value]

at $t = \infty$: (redraw, cap open)



$\tau \Rightarrow 30k \| (20k + 10k) = 15k = R_{eq}$

$V(t)_{t=\infty} = I_1(20k)$ | $V_c(t)_{t\to\infty} = I_1(30k) = \frac{30k}{50k}$

node-voltage:

$\frac{V_1}{10k} - 120\mu + \frac{V_1}{50k} = 0 \Rightarrow V_1\left(\frac{1}{10k} + \frac{1}{50k}\right) = 120\mu \Rightarrow V_1 = 1V$

$I_1 = \frac{V_1}{50k} = \frac{1}{50k} \Rightarrow V(t)_{t=\infty} = \frac{20k}{50k} = 0.4V$ [Final Value]

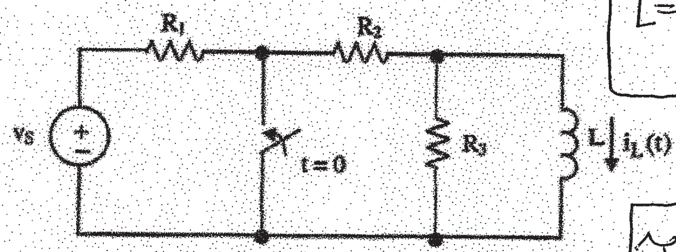
for $t>0$, $V(t) = \underset{(\text{Final})}{0.4} + \underset{(\text{Initial})-(\text{Final})}{(-1.6 - 0.4)} e^{-t/\underbrace{(15k \cdot 10n)}_{\tau}}$

$\boxed{V(t) = 0.4 - 2e^{-t/150\mu sec}\ V}$

$w_c(t\to\infty) = \frac{1}{2}(C)(V_c(t\to\infty))^2$

$w_c(t\to\infty) = \frac{1}{2}(10n)\left(\frac{3}{5}\right)^2 = \boxed{1.8nJ}$

Switch RL Example

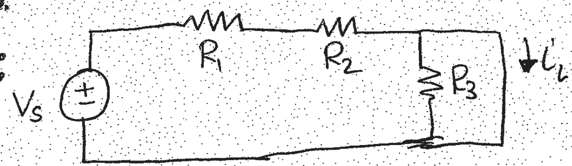


L => becomes wire after a long time.
· I stays same at $t=0^+$ (Isrc)

$\tau = L/R_{eq}$

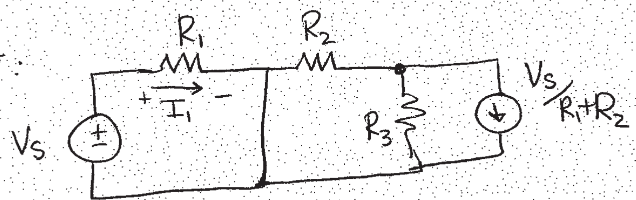
After being open for a long time, the switch is closed at t = 0. Write an expression for $i_L(t)$, $t > 0$.

at $t=0^-$:



$$i_L = \frac{V_s}{R_1+R_2}$$

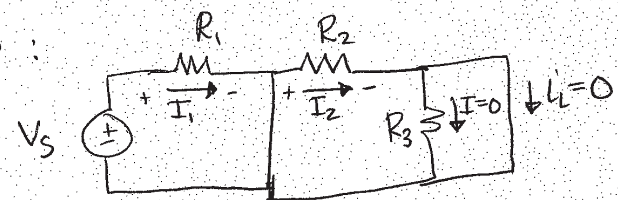
at $t=0^+$:



$$i_L(t=0^+) = \frac{V_s}{R_1+R_2}$$

[Initial Value]

at $t=\infty$:



$+I_2 R_2 = 0$

$I_2 = 0$

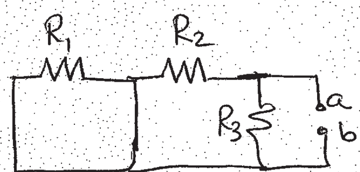
$I_2 = i_L = 0$

[Final Value]

$t>0$

$$i_L(t) = 0 + \left[\left(\frac{V_s}{R_1+R_2}\right) - 0\right] e^{-t/\tau}$$

$\tau \Rightarrow R_{eq} = R_3 \| R_2$ (redraw)



$$\boxed{t>0 \quad i_L(t) = \left(\frac{V_s}{R_1+R_2}\right) e^{-t/\frac{L}{(R_2 \| R_3)}}}$$

HW #6 Examples

Dr. Gotter

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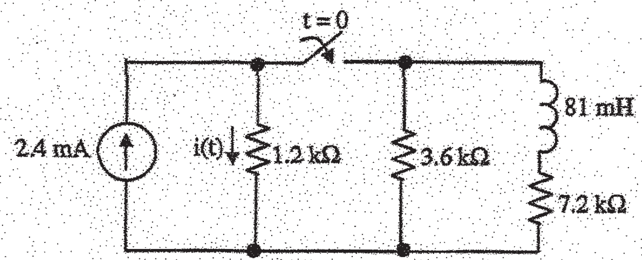
1.



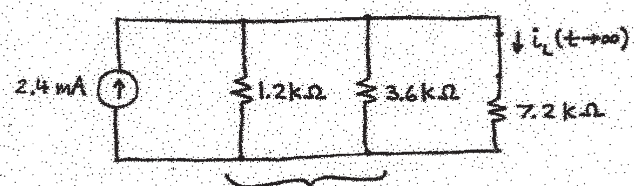
After being open for a long time, the switch is <u>closed</u> at t = 0.

Calculate the energy stored on the inductor at $t \to \infty$.

2. Write a numerical expression for $i(t), t > 0$.

Sol'n: 1. For $t \to \infty$, L acts like wire, switch is closed.

Find $i_L(t\to\infty)$. Energy, $w = \frac{1}{2} L i_L^2$.



$$R_{eq} = 1.2\,k\Omega \,\|\, 3.6\,k\Omega = 1.2\,k\Omega \cdot 1\|3 = 1.2\,k\Omega \cdot \frac{3}{4}$$

$$R_{eq} = 0.9\ k\Omega$$

We have current divider.

$$i_L(t\to\infty) = 2.4\,mA \cdot \frac{R_{eq}}{R_{eq} + 7.2\,k\Omega} = 2.4\,mA\ \frac{0.9\,k\Omega}{8.1\,k\Omega}$$

$$i_L(t\to\infty) = \frac{2.4\,mA}{9} = \frac{24}{90}\ mA = \frac{12}{45}\ mA = \frac{4}{15}\ mA$$

$$w = \frac{1}{2}\ 81\,mH \left(\frac{4}{15}\right)^2 mA^2 = \frac{1}{2}\ 81 \cdot \frac{16}{25\cdot 9}\ nJ$$

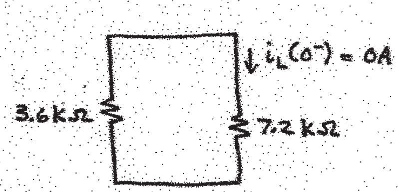
$$W = \frac{9(8)}{25}\ nJ = \frac{72\cdot 40}{25\cdot 40}\ nJ = 2.88\ nJ$$

$$\boxed{w_L(t\to\infty) = 2.88\ nJ}$$

soln: 2. We want to find $i(t=0^+)$. We start by finding $i_L(t=0^-)$ so we will know $i_L(t=0^+)$, since $i_L(t=0^+) = i_L(t=0^-)$.

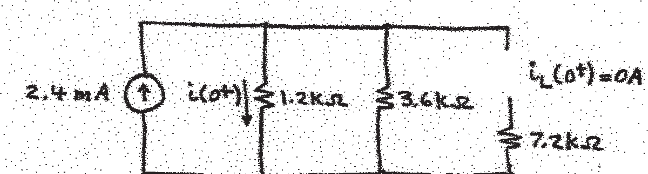
$t=0^-$: L acts like wire, switch is open.

No pwr src for L, so L discharges to give $i_L(0^-) = 0A$.



$t=0^+$: L acts like current src of value $i_L(0^+) = i_L(0^-) = 0A$ = open circuit

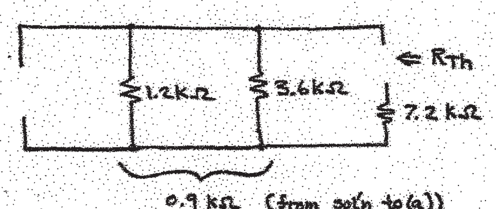
Switch is closed.



This is a current divider.

$$i(0^+) = 2.4\,mA \cdot \frac{3.6\,k\Omega}{1.2\,k\Omega + 3.6\,k\Omega} = 1.8\,mA$$

For time constant $\frac{L}{R_{Th}}$, we look into the terminals where L is connected. We turn off independent 2.4 mA src which becomes open circuit.



sol'n: 2. cont. $R_{Th} = 7.2k\Omega + 0.9k\Omega = 8.1k\Omega$

Our time constant is $\frac{L}{R_{Th}} = \frac{81\,mH}{8.1k\Omega} = 10\,\mu s$.

Find $i(t\to\infty)$ [see below].

Plug values into general solution.

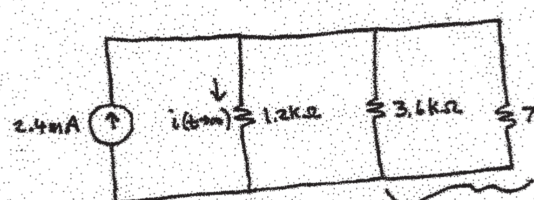
$$i(t>0) = i(t\to\infty) + \left[i(0^+) - i(t\to\infty)\right] e^{-t/\frac{L}{R_{Th}}}$$

$$i(t>0) = 1.6\,mA + \left[1.8\,mA - 1.6\,mA\right] e^{-t/10\mu s}$$

$$\boxed{i(t>0) = 1.6\,mA + 0.2\,mA\, e^{-t/10\mu s}}$$

$t\to\infty$: L acts like wire, switch closed

Find $i(t\to\infty)$ (not i_L).



$$3.6k \| 7.2k\Omega = 3.6k\Omega \cdot 1\|2$$
$$\text{"} = 3.6k\Omega \cdot \frac{2}{3}$$
$$\text{"} = 2.4k\Omega$$

i-divider: $i(t\to\infty) = 2.4\,mA \cdot \frac{2.4k\Omega}{2.4k + 1.2k\Omega} = 1.6\,mA$

Homework #6/Review Examples

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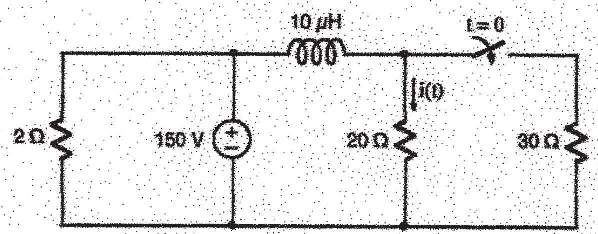
1.

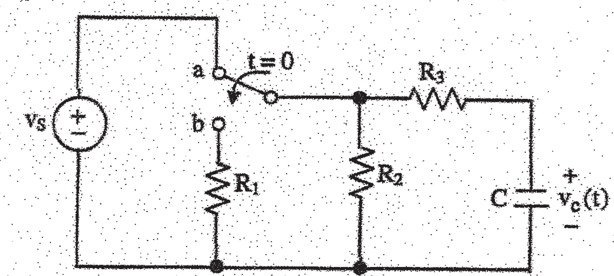


After being closed for a long time, the switch closes at t = 0.

Calculate the energy stored on the inductor as $t \to \infty$.

find i(t) for $t > 0$.

3.



After being at position **a** for a long time, the switch moves to position **b** at time $t = 0$.

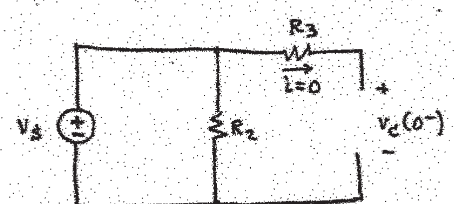
a. Write an expression for $v_c(t = 0^+)$.

b. Write an expression for $v_c(t)$, $t > 0$.

sol'n: a) $v_c(t=0^+) = v_c(t=0^-)$

At $t=0^-$, switch is in position a.

C acts like open circuit.



No current in R_3 means no v-drop for R_3.

$\therefore\ v_c(0^-) = V_s$

$\boxed{v_c(0^+) = V_s}$

b) Find $v_c(t\to\infty)$ and $R_{Th}C$ = time constant.

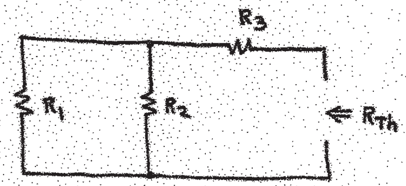
$t\to\infty$: Switch is in position b. No pwr src.

C discharges thru R's.

$\therefore\ v_c(t\to\infty) = 0V$

R_{Th} is resistance seen looking into terminals where C connected with switch in position b.

sol'n: 3.b) cont.



$$R_{Th} = (R_1 \| R_2) + R_3$$

Now plug values into general sol'n.

$$v_c(t>0) = v_c(t\to\infty) + \left[v_c(0^+) - v_c(t\to\infty)\right] e^{-t/R_{Th}C}$$

$$v_c(t>0) = 0V + \left[V_S - 0V\right] e^{-t/(R_1 \| R_2 + R_3)C}$$

$$\boxed{v_c(t>0) = V_S\, e^{-t/(R_1 \| R_2 + R_3)C}}$$

Homework #6/Review Examples

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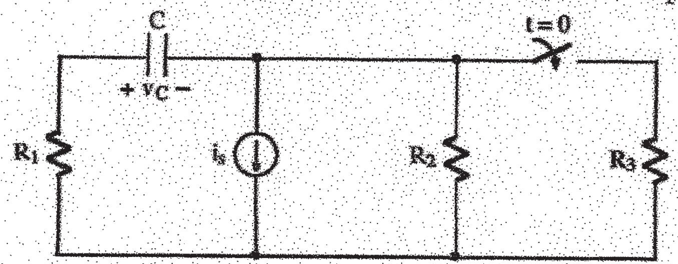
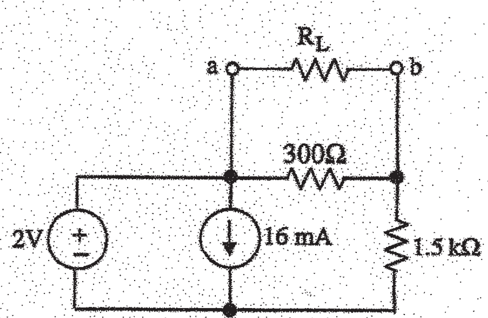
2.



After being open for a long time, the switch closes at $t = 0$. Write an expression for $v_c(t \geq 0)$ in terms of R_1, R_2, R_3, i_s, and C.

4.

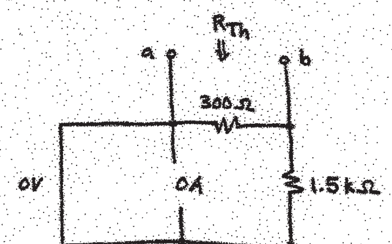


a. Calculate the value of R_L that would absorb maximum power.

b. Calculate that value of maximum power R_L could absorb.

sol'n: a) $R_L = R_{Th}$ yields max pwr transfer

We find R_{Th} by removing R_L, turning independent src's off, and seeing what resistance we have looking into terminals a, b.



$$R_{Th} = 300\,\Omega \parallel 1.5\,k\Omega = 300\,\Omega \cdot 1 \parallel 5 = 300\,\Omega \cdot \frac{5}{6}$$

$$R_{Th} = 250\,\Omega$$

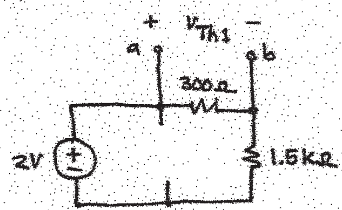
$$\therefore \boxed{R_L = 250\,\Omega}$$

soln: 4.b) Find Thevenin equivalent of circuit where R_L connected.

$V_{Th} = V_{a,b}$ with R_L removed.

use superposition (or other method such as node-voltage) to find V_{Th}.

case I: 2V src on, 16mA src off (open circuit)

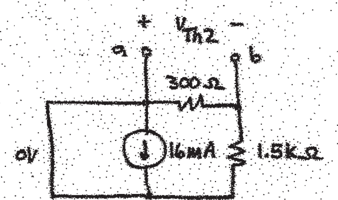


We have v-divider.

$$V_{Th1} = 2V \cdot \frac{300\,\Omega}{300\,\Omega + 1.5\,k\Omega}$$

$$V_{Th1} = \frac{2V}{6}$$

case II: 2V src off, = wire, 16 mA src on



We have i-divider. All current flows thru wire.

$\therefore V_{Th2} = 0V$

$$V_{Th} = V_{Th1} + V_{Th2} = \frac{2V}{6} + 0V = \frac{2V}{6} = \frac{1}{3}\,V$$

$$\text{max pwr} = \frac{V_{Th}^2}{4R_{Th}} = \frac{\left(\frac{1}{3}V\right)^2}{4 \cdot 250\,\Omega} = \frac{1}{9}\,\text{mW}$$

$$\boxed{\text{max pwr} = \frac{1}{9}\,\text{mW}}$$

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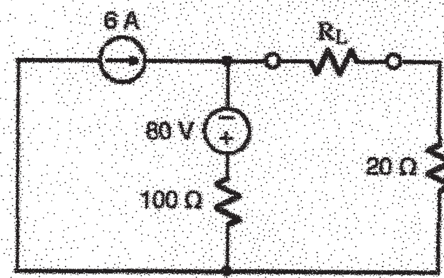
Homework #6/Review Examples

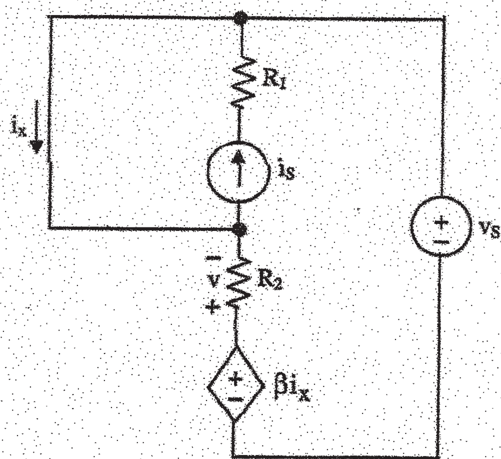
3.



a) Calculate the value of R_L that would absorb maximum power.

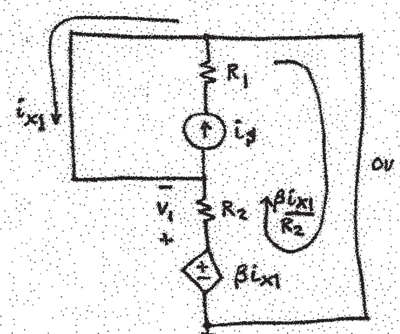
b) Calculate that value of maximum power R_L could absorb.

5.



Using superposition, derive an expression for v that contains no circuit quantities other than i_s, v_S, R_1, R_2, and β. Note: $\beta > 0$.

sol'n: case I: i_s on, v_s off = wire



$v_1 = \beta i_{x1}$ from outer v loop

Current summation at center node gives

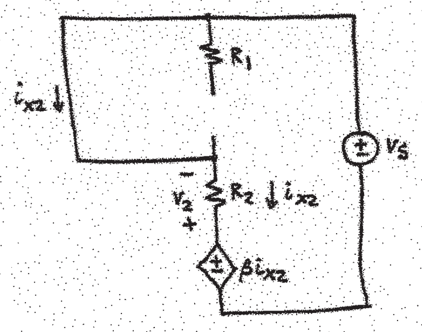
$$-i_s + i_{x1} + \frac{\beta i_{x1}}{R_2} = 0A$$

or $\quad i_{x1}\left(1 + \frac{\beta}{R_2}\right) = i_s$

$$i_{x1} = \frac{i_s}{1 + \frac{\beta}{R_2}} = i_s \cdot \frac{R_2}{R_2 + \beta}$$

$$v_1 = \beta i_{x1} = \beta i_s \frac{R_2}{R_2 + \beta} = i_s \cdot R_2 \| \beta$$

soln: 5. cont. case II: i_s off, v_s on
$= $ open



v loop around outside gives

$$\beta i_{x2} - - i_{x2} \cdot R_2 - v_s = 0V$$

$$i_{x2}(\beta + R_2) = v_s$$

$$i_{x2} = \frac{v_s}{\beta + R_2}$$

$$v_2 = -i_{x2} R_2 = -v_s \frac{R_2}{\beta + R_2} = -v_s \frac{R_2}{R_2 + \beta}$$

$$v = v_1 + v_2 = \beta i_s \frac{R_2}{R_2+\beta} - v_s \frac{R_2}{R_2+\beta} = (\beta i_s - v_s)\frac{R_2}{R_2+\beta}$$

$$\boxed{v = (\beta i_s - v_s)\frac{R_2}{R_2+\beta}}$$

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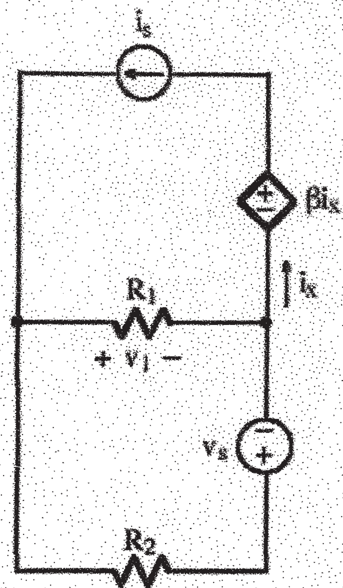
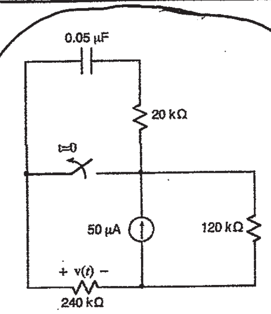
Homework #6/Review Examples

4.



Using superposition, derive an expression for v_1 that contains no circuit quantities other than i_s, v_s, R_1, R_2, and β, where $\beta > 0$.

EX:



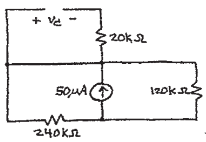
Calculate the energy stored on the capacitor at $t = 0^+$.

Sol'n: Energy $w_C = \frac{1}{2} C v_C^2(t=0^+)$

Since capacitor voltage cannot change instantly, $v_C(0^+) = v_C(0^-)$.

At $t=0^-$, C acts like open circuit and switch is closed.

$t=0^-$:



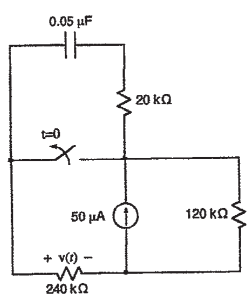
The short created by the switch creates a voltage loop on top left with 0V across C and across the 20kΩ resistor.

Thus $v_C(0^-) = 0V = v_C(0^+)$.

$\therefore w_C(0^+) = 0 J$

Note: The units for energy are Joules.

EX:



Write a numerical expression for v(t) for $t > 0$.

Sol'n: We use general form of solution for RC circuits.

$$v(t>0) = v(t\to\infty) + [v(0^+) - v(t\to\infty)]e^{-t/R_{Th}C}$$

We find $v(0^+)$, $v(t\to\infty)$, and R_{Th}.

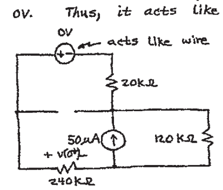
We start at $t=0^-$ to find voltage on C at $t=0^+$.

$t=0^-$: C acts like open circuit. Switch is closed.

Switch creates a short circuit, and $v_C(0^-) = 0V$.

$t=0^+$: $v_C(0^+) = v_C(0^-) = 0V$ since v_C can't change instantly.

We model C as voltage source of 0V. Thus, it acts like a wire.



This is a current-divider circuit with $20k\Omega + 240k\Omega = 260k\Omega$ on one side and $120k\Omega$ on the other side.

The current thru the $240k\Omega$ is

$$i(0^+) = 50\mu A \cdot \frac{120k\Omega}{20k\Omega + 240k\Omega + 120k\Omega}$$

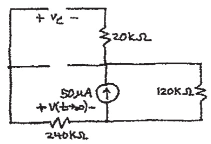
$$i(0^+) = 50\mu A \cdot \frac{120k\Omega}{380k\Omega}$$

$v(0^+)$ from Ohm's Law is

$$v(0^+) = 50\mu A \cdot \frac{120k\Omega}{380k\Omega} \cdot 240k\Omega$$

$v(0^+) = 6V \cdot \frac{12}{19}$

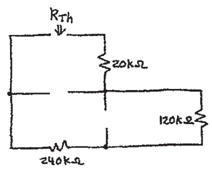
$t \to \infty$: Switch is open. C = open circuit.



No current can flow thru the 240 kΩ resistor.

$\therefore v(t \to \infty) = 0V$

R_{Th}: We look in from the terminals where C is connected, and we turn off the current source.



$R_{Th} = 20k\Omega + 120k\Omega + 240k\Omega = 380k\Omega$

The time constant is $R_{Th}C$:

$\tau = 380\,k\Omega \cdot 0.05\,\mu F = 19\,ms$

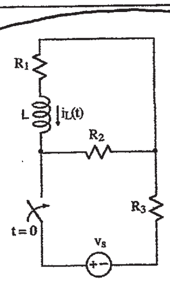
Putting results together:

$v(t>0) = 0V + \left(6V \cdot \frac{12}{19} - 0V\right) e^{-t/19ms}$

or

$v(t>0) = 6V \cdot \frac{12}{19} e^{-t/19ms} \doteq 3.8V e^{-t/19ms}$

Ex:

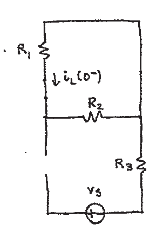


a) Write an expression for $i_L(t = 0^+)$

b) Write an expression for $i_L(t > 0)$ in terms of R_1, R_2, R_3, v_s, and L.

Sol'n: a) $i_L(0^+) = i_L(0^-)$

At $t = 0^-$, L acts like wire. Switch is open at $t = 0^-$.



There is no power source in the R_1, R_2 loop, and v_s is disconnected.

$\therefore i_L(0^-) = 0A$

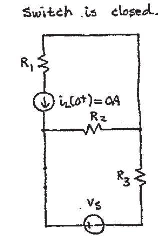
Thus, $i_L(0^+) = i_L(0^-) = 0A$

b) For $i_L(t>0)$, we use the general form of sol'n for RL problems:

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

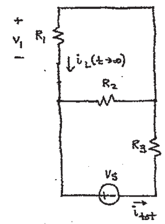
$t = 0^+$: We model L as i-src with value $i_L(0^+) = i_L(0^-) = 0A$.

Switch is closed.



Since the quantity we are looking for is $i_L(0^+)$, we do not have to solve the circuit, but this is the circuit we would use.

$t \to \infty$: L acts like wire. Switch is closed.



We can calculate i_{tot} as

$$i_{tot} = \frac{-v_s}{R_1\|R_2 + R_3}$$

Then we can use a current divider to find $i_L(t\to\infty)$:

$$i_L(t\to\infty) = i_{tot}\cdot\frac{R_2}{R_1+R_2}$$

$$i_L(t\to\infty) = \frac{-v_s}{R_1\|R_2+R_3}\cdot\frac{R_2}{R_1+R_2}$$

Another way to calculate i_{tot} is to write $R_1\|R_2$ in a different way:

$$R_1\|R_2 = \frac{R_1}{1+\frac{R_1}{R_2}}$$

Then we use a voltage divider formula:

$$v_1 = -v_s\,\frac{\frac{R_1}{1+R_1/R_2}}{\frac{R_1}{1+R_1/R_2}+R_3}$$

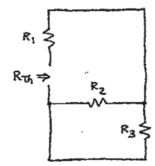
$$v_1 = -v_s\,\frac{R_1}{R_1+R_3(1+R_1/R_2)}$$

We divide v_1 by R_1 to find $i_L(t\to\infty)$:

$$i_L(t\to\infty) = -\frac{v_s}{R_1+R_3(1+R_1/R_2)}$$

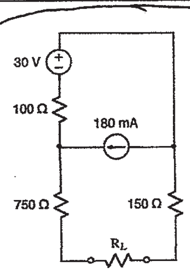
This answer is equivalent to our previous answer

R_{Th}: We turn off the v_s source and look in from the terminals where L is connected. Switch is closed.



$$R_{Th} = R_1 + R_2\|R_3$$

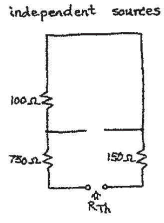
EX:



a) Calculate the value of R_L that would absorb maximum power.
b) Calculate that value of maximum power R_L could absorb.

Sol'n: a) $R_L = R_{Th}$ for max power transfer

We find R_{Th} by looking into the terminals where R_L is connected (but without R_L) with the two independent sources turned off.



$R_{Th} = 750\Omega + 100\Omega + 150\Omega$

$R_{Th} = 1k\Omega$

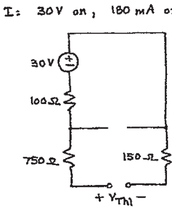
$\therefore \boxed{R_L = 1k\Omega}$

b) max pwr $= \dfrac{\left(\frac{V_{Th}}{2}\right)^2}{R_{Th}}$

We find V_{Th} as the open circuit voltage across the terminals where R_L is connected.

We find V_{Th} by using superposition.

case I: 30V on, 180 mA off



Since no current flows, there is no v-drop across the R's.

$\therefore V_{Th1} = -30V$ (− v src)

Note: Since we will square V_{Th}, the polarity we choose for measuring V_{Th} doesn't matter.

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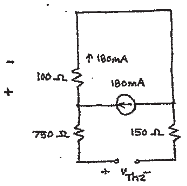
case II: 30V off, 180 mA on



No current flows in the 750 Ω and 150 Ω. Thus, there is no v-drop across these R's.

The v-drop across the 100 Ω is equal to v_{Th2}.

$$v_{Th2} = 180\,mA \cdot 100\,\Omega = 18V$$

We sum results to find v_{Th}.

$$v_{Th} = v_{Th1} + v_{Th2}$$

$$v_{Th} = -30V + 18V = -12V$$

$$\text{max pwr} = \frac{\left(\frac{v_{Th}}{2}\right)^2}{R_{Th}} = \frac{6^2}{1k} = 36\,mW$$

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$$\text{or } i_{12} = i_s \frac{\frac{R_2/\alpha}{R_2 + 1/\alpha}}{\frac{R_2/\alpha}{R_2 + 1/\alpha} + R_1}$$

$$\text{or } i_{12} = i_s \frac{R_2/\alpha}{R_2/\alpha + R_1(R_2 + 1/\alpha)}$$

$$\text{or } i_{12} = i_s \frac{R_2}{R_2 + R_1(\alpha R_2 + 1)}$$

We sum i_{11} and i_{12} to get i_1:

$$i_1 = i_{11} + i_{12}$$

$$\text{or } i_1 = -\frac{v_s}{R_1 + R_2 \| \frac{1}{\alpha}} + i_s \frac{R_2}{R_2 + R_1(\alpha R_2 + 1)}$$

Note: When a current source is off it becomes an open circuit.
When a voltage source is off it becomes a wire.

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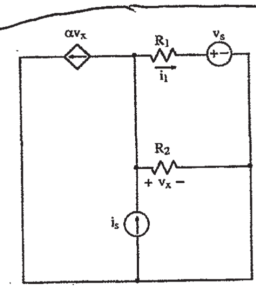
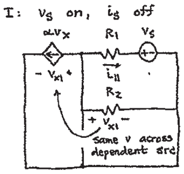
Ex:



Using superposition, derive an expression for i_1 that contains no circuit quantities other than i_s, v_S, R_1, R_2, and α, where $\alpha > 0$.

Sol'n: We turn on one source at a time.
(Never turn off dependent source.)
case I: v_s on, i_s off



The dependent source is equivalent to $R_{eq} = \frac{v}{i} = \frac{v_{x1}}{\alpha v_{x1}} = \frac{1}{\alpha}$.