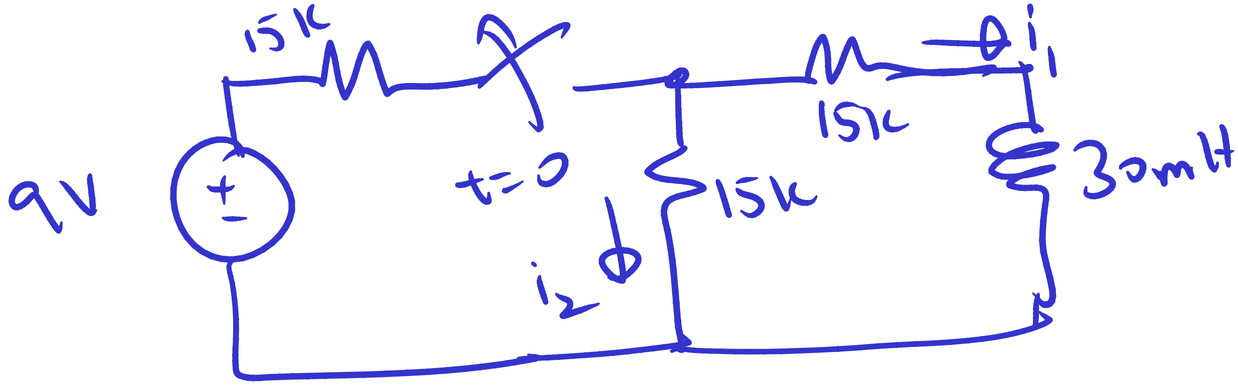
EE100Su08 Lecture #8 (July 11^{th} 2008)

- Outline
  - HW #1s will be returned on Monday
  - Questions?
  - Wrap up problem 7.2
  - Midterm review
  - TA review session: tomorrow (Saturday, 07/12 from 2 – 4 in 105 North Gate).
  - Start operational amplifiers*

Problem 7.2 on p. 265



Note:

$\iff v = L\frac{di}{dt}$

(a) Find $i_1(0^-)$, $i_2(0^-)$

(b) Find $i_1(0^+)$, $i_2(0^+)$

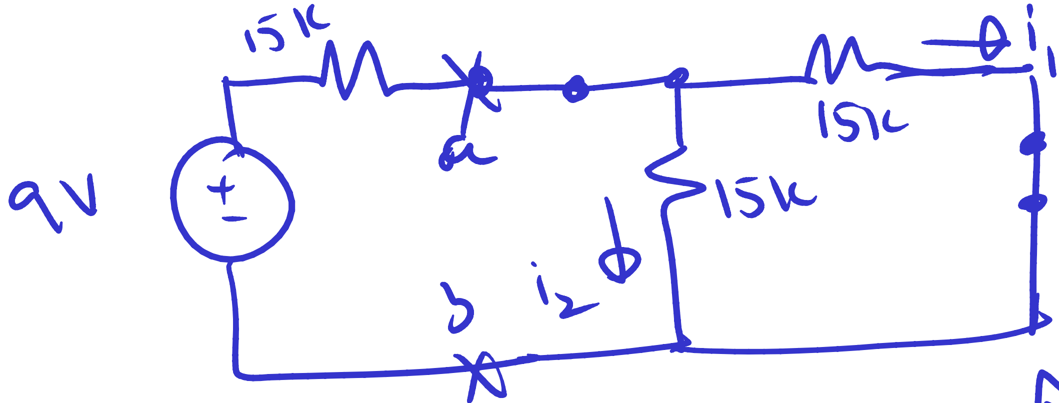
⋮

⇒ (1) Steady state, inductor is a short circuit

(2) Inductors maintain current across discontinuities

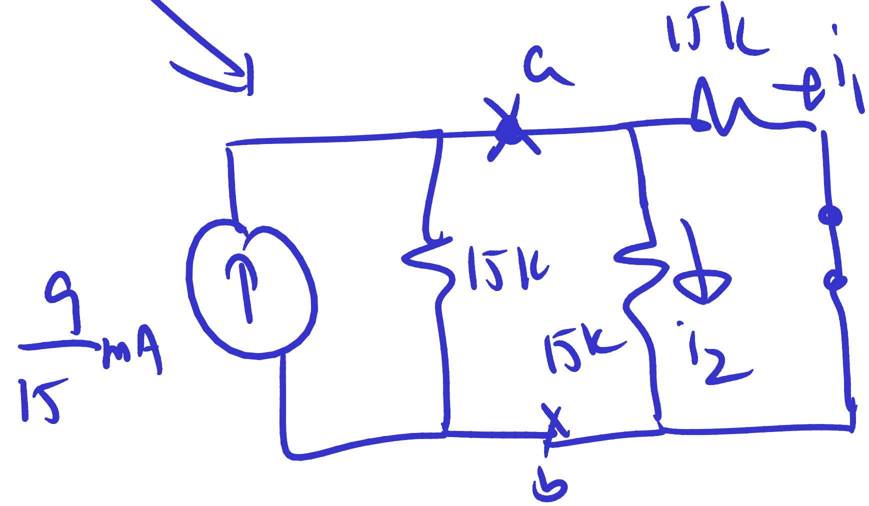
(3) $\tau = L/R$

Problem 7.2 on p. 265



$t = 0^-$

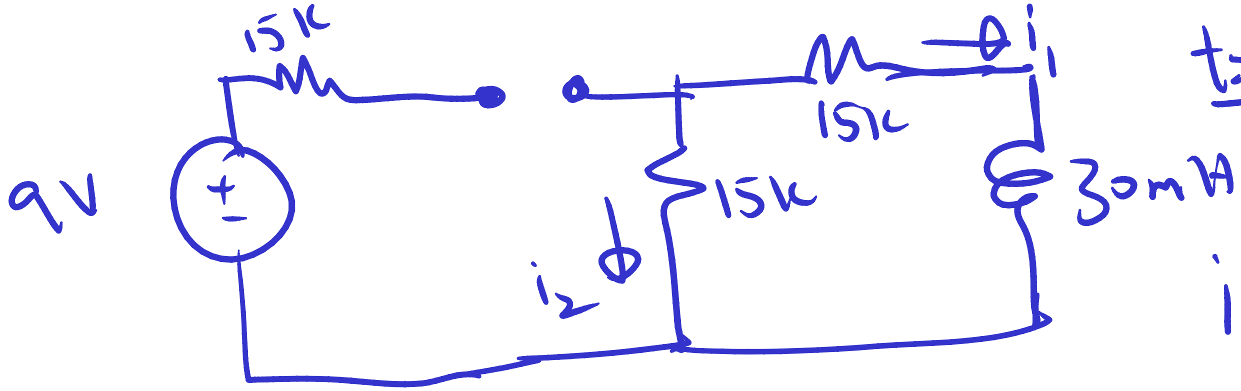
Norton at ab



(a) Find $i_1(0^-)$, $i_2(0^-)$

$$i_1(0^-) = i_2(0^-) = \frac{1}{5}\text{ mA}$$

Problem 7.2 on p. 265



$t = 0^+$

$i_1(0^+) = i_1(0^-)$

$= 0.2\ \text{mA}$

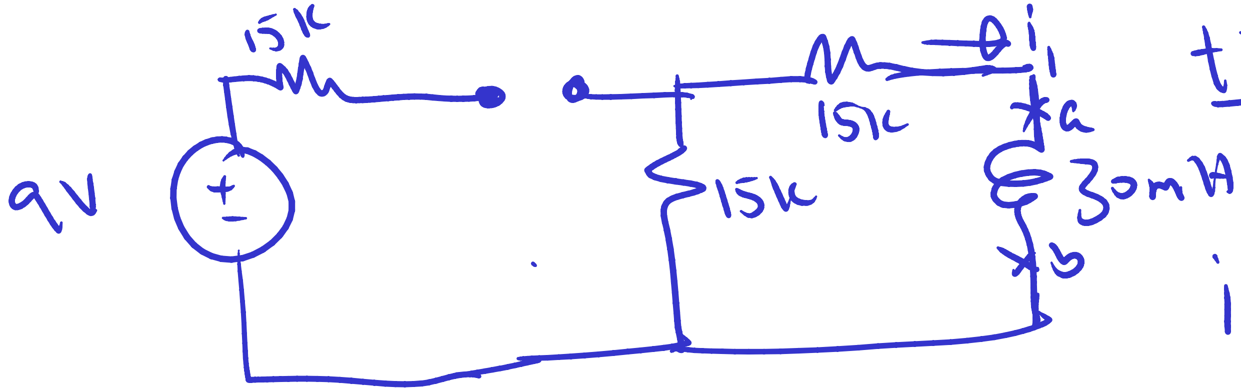
(b) Find $i_1(0^+)$, $i_2(0^+)$

Notice: $i_2(0^+) = -i_1(0^+)$

$= -0.2\ \text{mA}$

(c) $i_1(t) = i_{1_{final}} + (i_{1_{initial}} - i_{1_{final}})\, e^{-t/\tau}$, $\tau = L/R$

Problem 7.2 on p. 265



$t \geq 0$

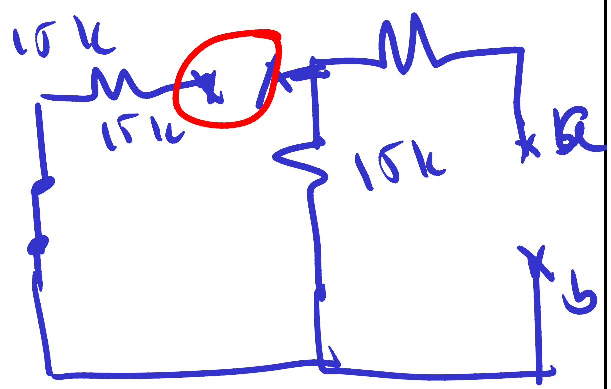
$i_1(0^+) = i_1(0^-)$

$= 0.2\ mA$

(c) $i_1(t) = i_{1_{final}} + (i_{1_{initial}} - i_{1_{final}}) e^{-t/\tau}$, $\tau = L/R$

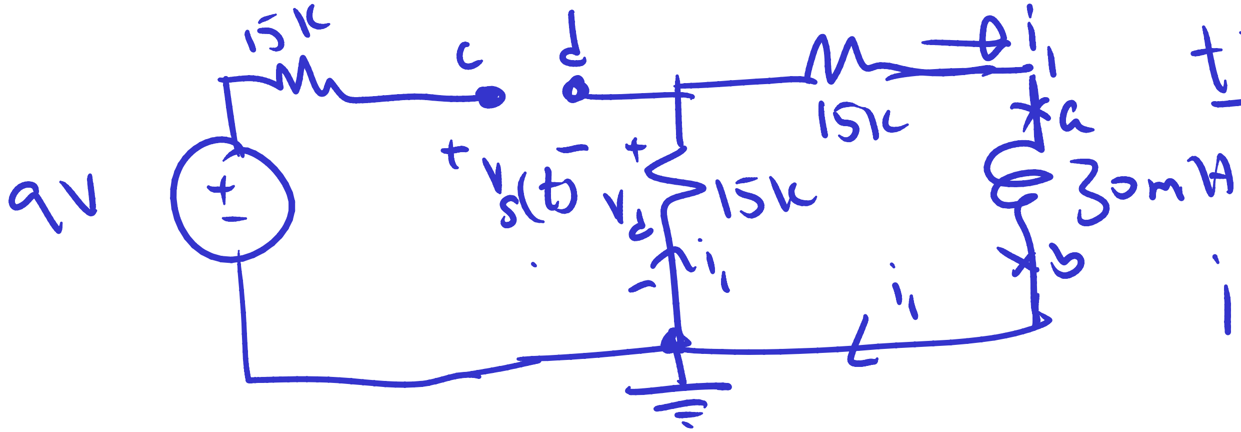
$i_{1_{initial}} = i_1(0^+) = i_1(0^-) = 0.2\ mA$

$i_{1_{final}} = i_1(t \to \infty) = 0$



$\therefore\ \boxed{i_1(t) = 0.2 e^{-t/\tau}\ mA}$, $\tau = \dfrac{L}{R_{eq}} = \dfrac{30\,mH}{30\,k} = \underline{1\ \mu s}$

Problem 7.2 on p. 265

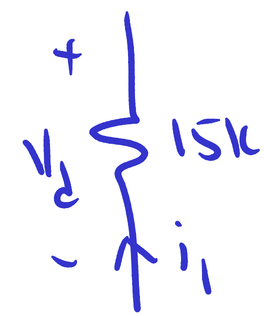


$t \geq 0$

$i_1(0^+) = i_1(0^-) = 0.2\text{ mA}$

(a) Find $v_s(t)$ [voltage across the switch for $t \geq 0$] ?

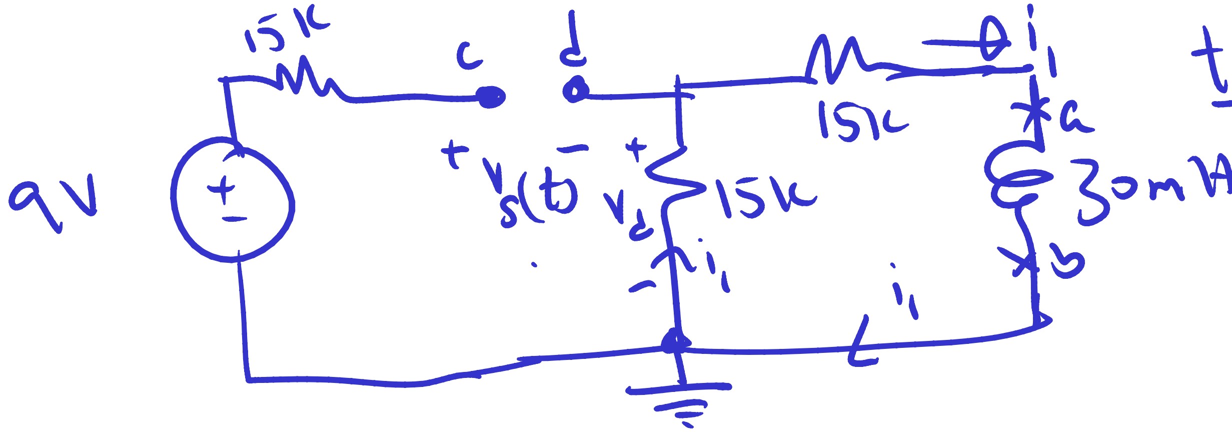
$$V_s(t) = V_{s_f} + (V_{s_i} - V_{s_f})e^{-t/\tau} \qquad \tau = L/R_{Th}$$



$$V_{s_i} = V_{c_i} - V_{d_i} = 9 - [-i_1(0^+)(15k)]$$

$$= 9 + 3 = \underline{12\text{ V}}$$

Problem 7.2 on p. 265

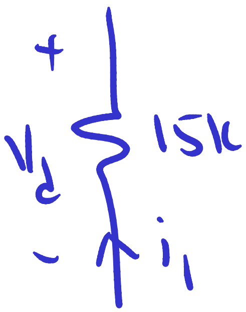


$t \to \infty$

$i_1(t \to \infty) \to 0$

(a) Find $V_s(t)$ [voltage across the switch for $t \geq 0$] ?

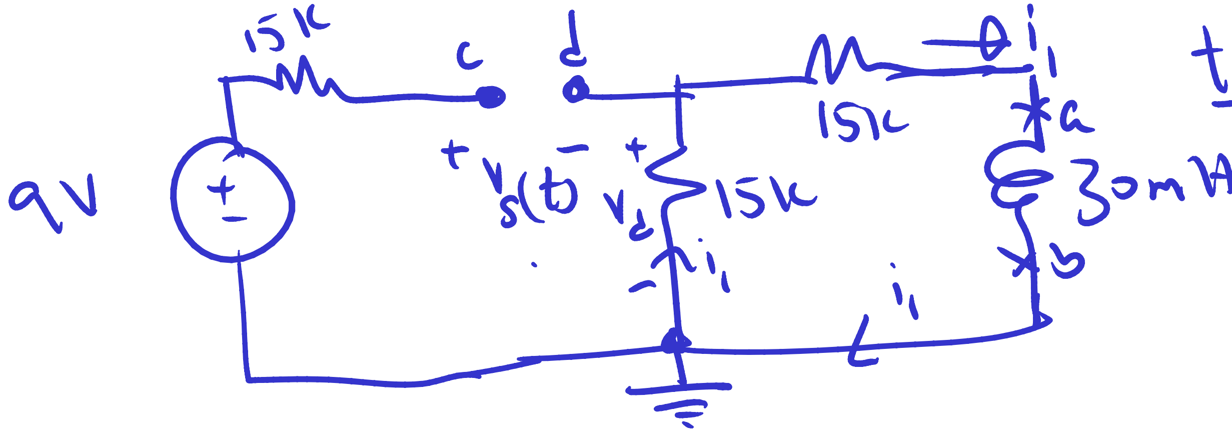
$$V_s(t) = V_{s_f} + (V_{s_i} - V_{s_f})e^{-t/\tau} \qquad \tau = L/R_{Th}$$



$$V_{s_f} = V_s(t \to \infty) = V_c(t \to \infty) - V_d(t \to \infty)$$

$$= 9 - 0 = 9$$

Problem 7.2 on p. 265

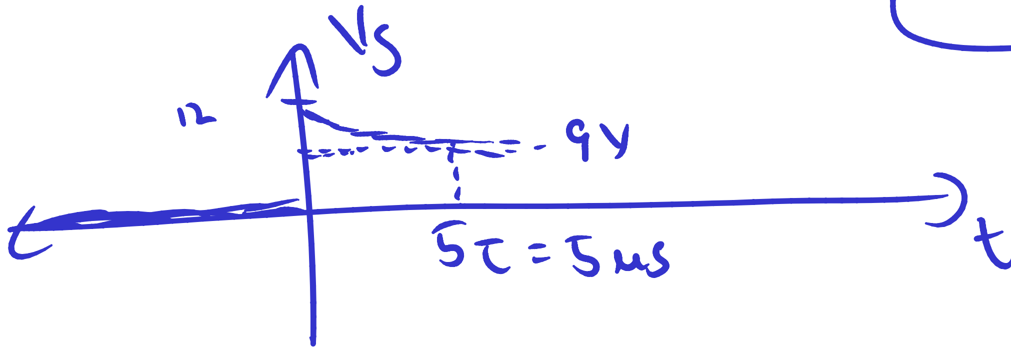


$t \to \infty$

$i_1(t \to \infty) \to 0$

(a) Find $V_s(t)$ [voltage across the switch for $t \geq 0$]?

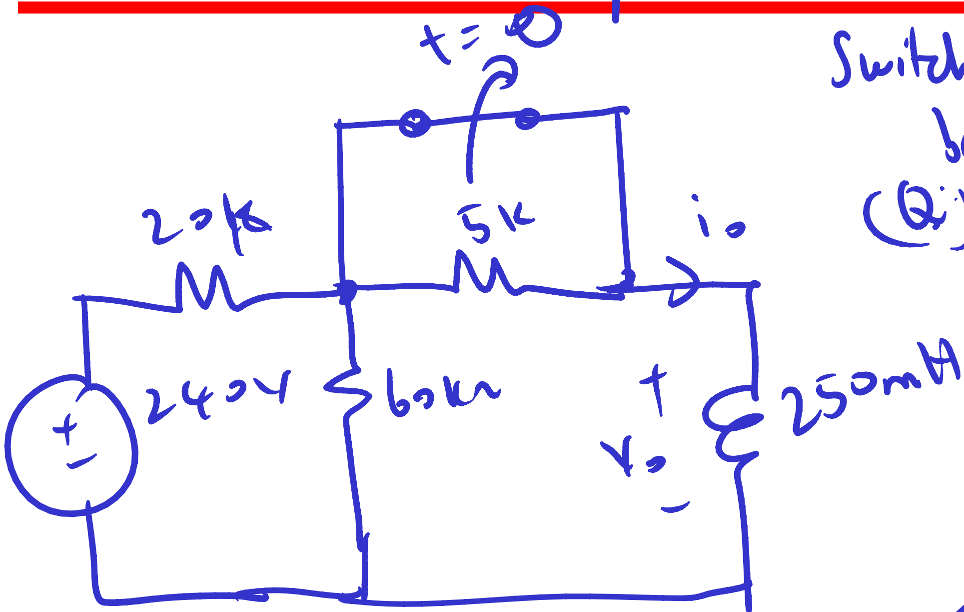
$$V_s(t) = 9 + (12-9)e^{-t/1\mu s} = \boxed{9 + 3e^{-\frac{t}{1\mu s}} u(t) \quad t \geq 0}$$



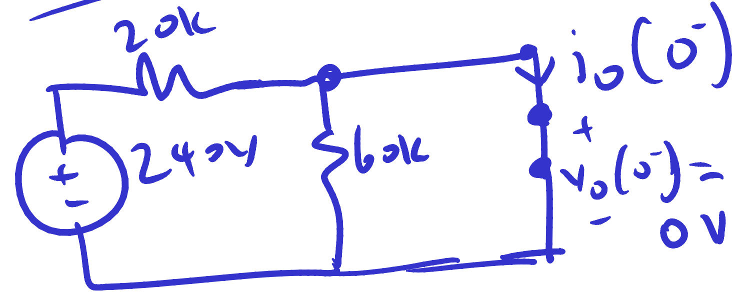
Problem 7.33 on p. 220

Switch closed for a long time before opening @ t = 0

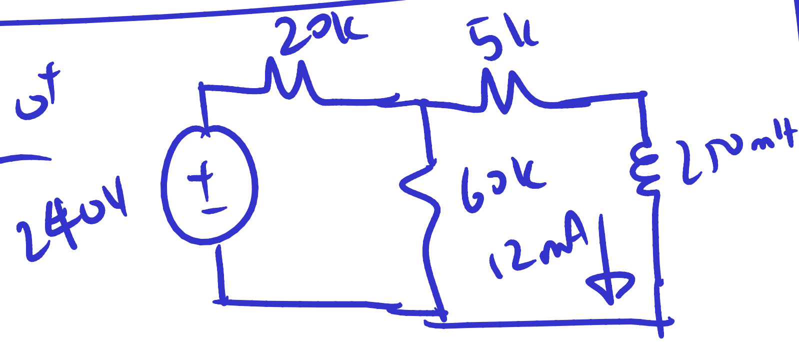
(Q:) Find $i_o(t)$, $v_o(t)$, $t \geq 0$.



$t = 0^-$



$t = 0^+$



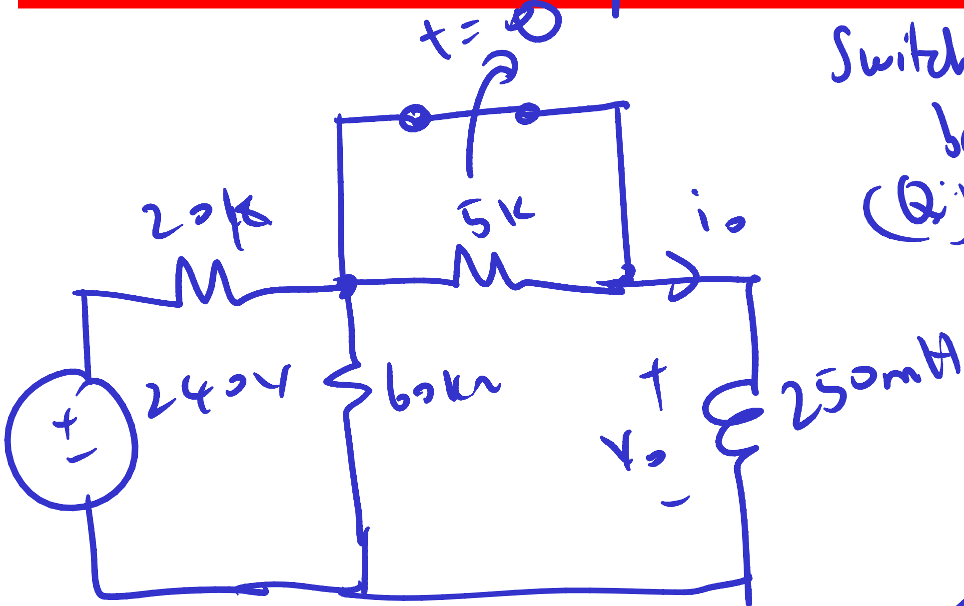
$i_o(0^-) = 12\ mA = \frac{240V}{20k}$

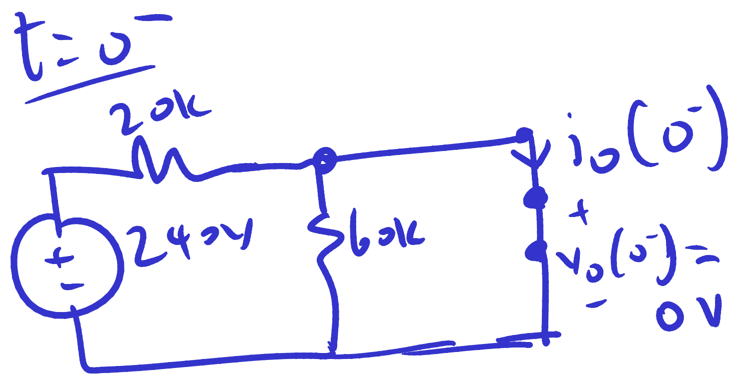
$i_o(t = 0^+) = 12\ mA = i_{o\,initial}$

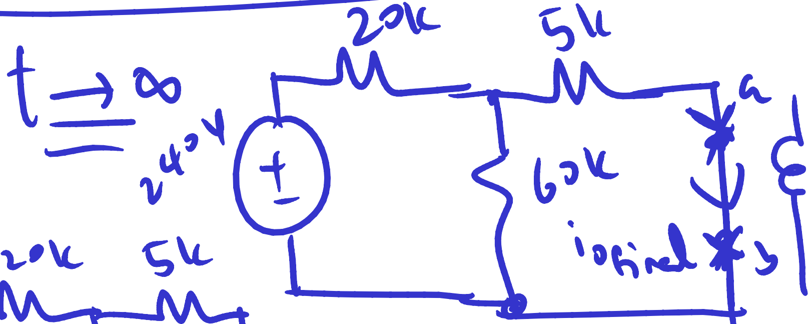
Problem 7.33 on p. 220

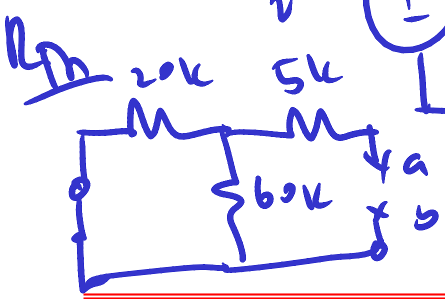
Switch closed for a long time before opening @ $t=0$

(Q:) find $i_o(t)$, $v_o(t)$, $t \geq 0$.









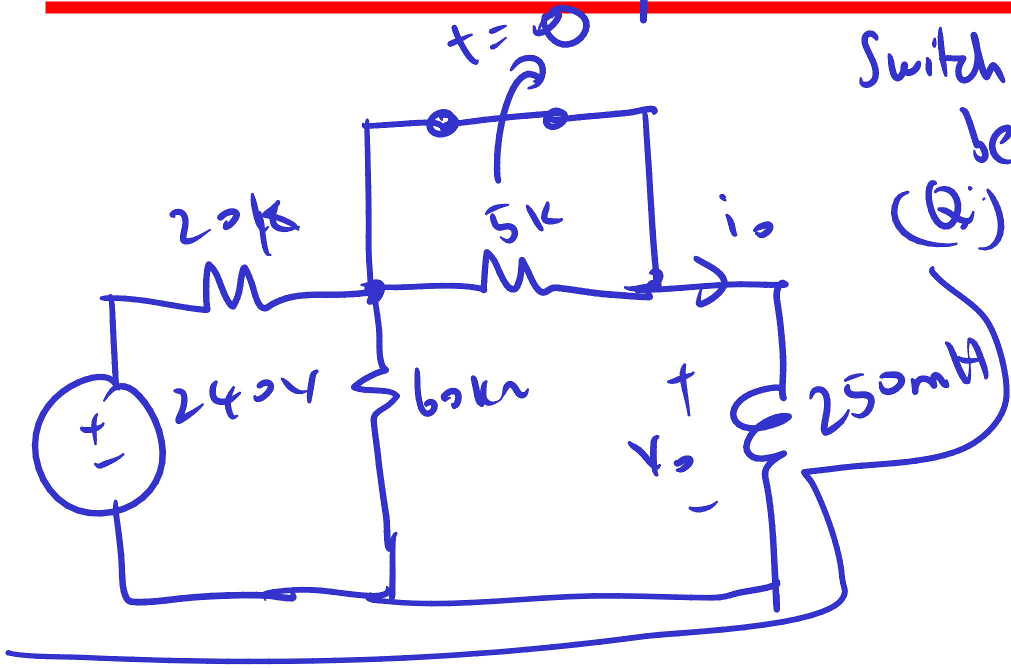
$$i_o(0^-) = 12\text{ mA} = \frac{240V}{20k}$$

$$= i_o(0^+)$$

$$\tau = L/R_{Th}, \quad R_{Th} = (20k \| 60k) + 5k$$

$$= 20k??$$

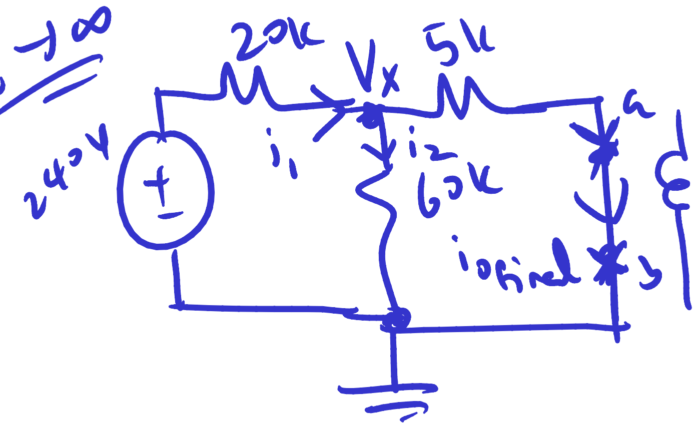
Problem 7.33 on p. 220



Switch closed for a long time before opening @ $t = 0$

(Q:) find $i_o(t)$, $V_o(t)$, $t \geq 0$.

$t \to \infty$



$$i_{o\,final} = \frac{V_x}{5k}$$

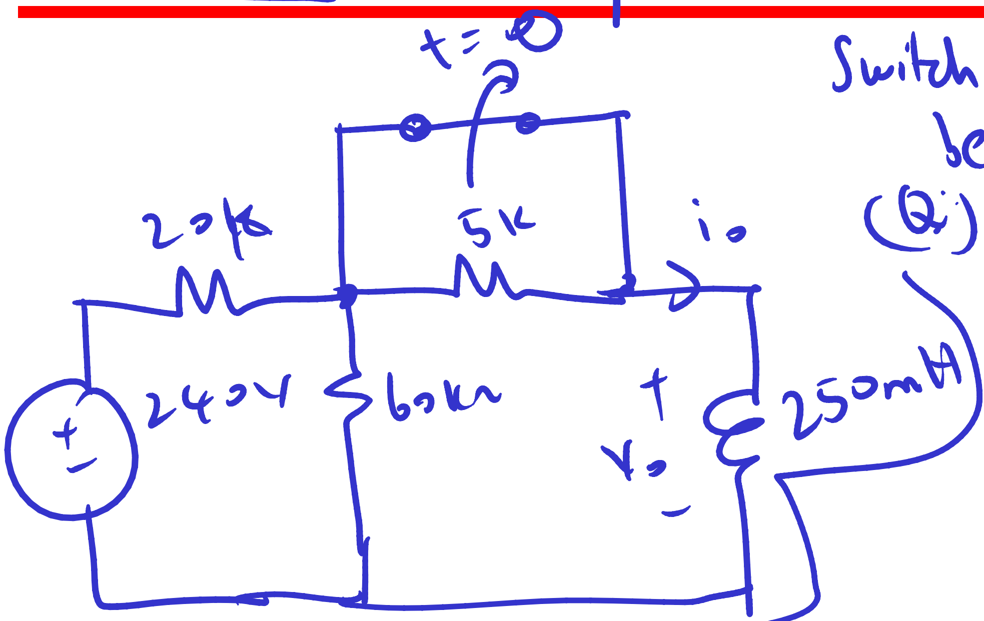
$$= \underline{9\,mA}$$

Nodal @ V_x: $\dfrac{240 - V_x}{20k} = \dfrac{V_x}{60k} + \dfrac{V_x}{5k}$

$\Rightarrow (240 - V_x)3 = V_x + 12V_x$

$\Rightarrow 3 \cdot 240 = 16V_x \Rightarrow V_x = \dfrac{240 \cdot 3}{16} = \underline{45V}$

Problem 7.33 on p. 220



Switch closed for a long time before opening @ t = 0

(Q:) Find $i_o(t)$, $v_o(t)$, $t \geq 0$.

$$i_{o_{initial}} = 12 \text{ mA}$$

$$i_{o_{final}} = 9 \text{ mA.}$$

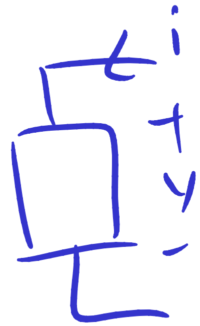
$$\tau = \frac{L}{R_{th}} = \frac{250\text{mH}}{20\text{k}} = 12.5\,\mu s$$

$$\therefore i_o(t) = i_{o_{final}} + (i_{o_{initial}} - i_{o_{final}})e^{-t/\tau}$$

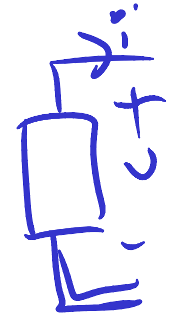
$$\boxed{i_o(t) = 9 + 3e^{-t/12.5\mu s} \text{ mA}}$$

$$v_o = L\frac{di_o}{dt} = L \times \left(3e^{-t/12.5\mu s} \times -\frac{1}{12.5\mu s}\right) \times 10^{-3} \text{ Volt}$$

Midterm Review (1) Power:



$p = vi$



$p = -vi$

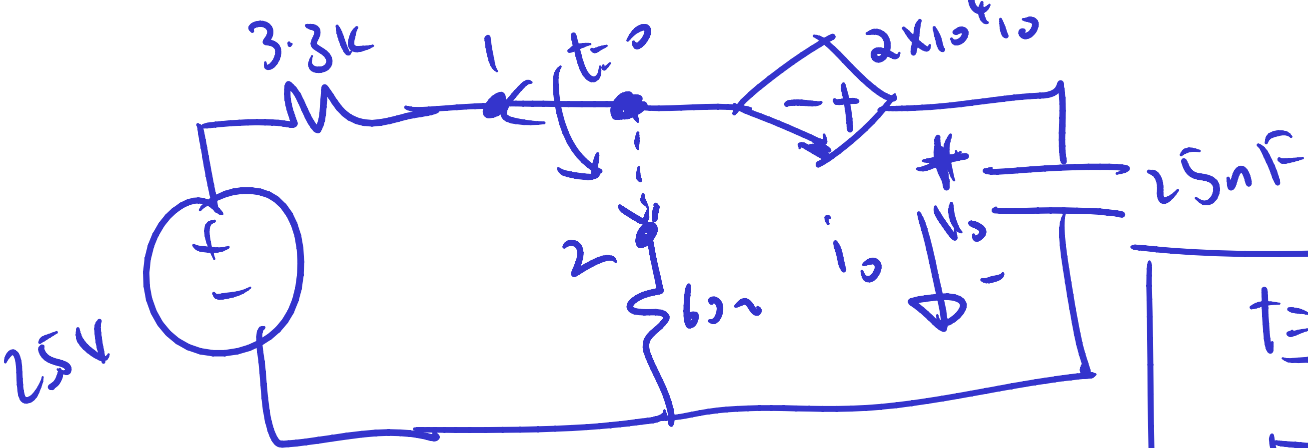
(2) KCL; KVL; $i = f(v)$ [i-v relationship]

(3) Nodal, Thevenin; Norton, superposition, source transforms, maximum power transfer.

(4) RC/RL

Problem 7.27 on p. 269

Switch is in position 1 for a long time before moving to position 2 @ $t=0$. Find $i_o(t)$ $\forall t \geq 0^+$

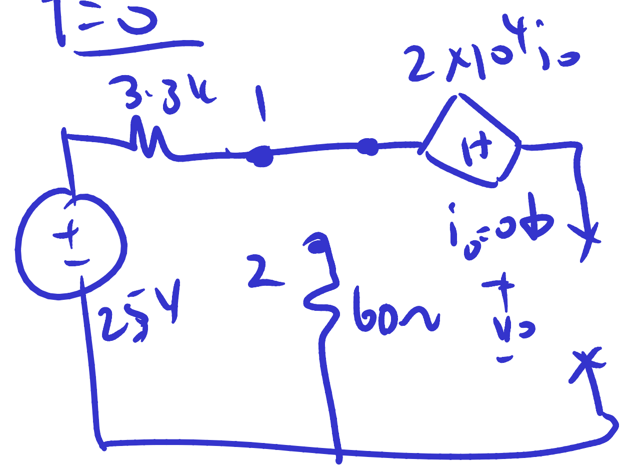


$$i_o = C\frac{dv_o}{dt}$$

$$V_o(t) = V_{o_f} + (V_{o_i} - V_{o_f})e^{-t/\tau}$$

$$V_{o_i} = V_o(0^+) = V_o(0^-) = 25V$$

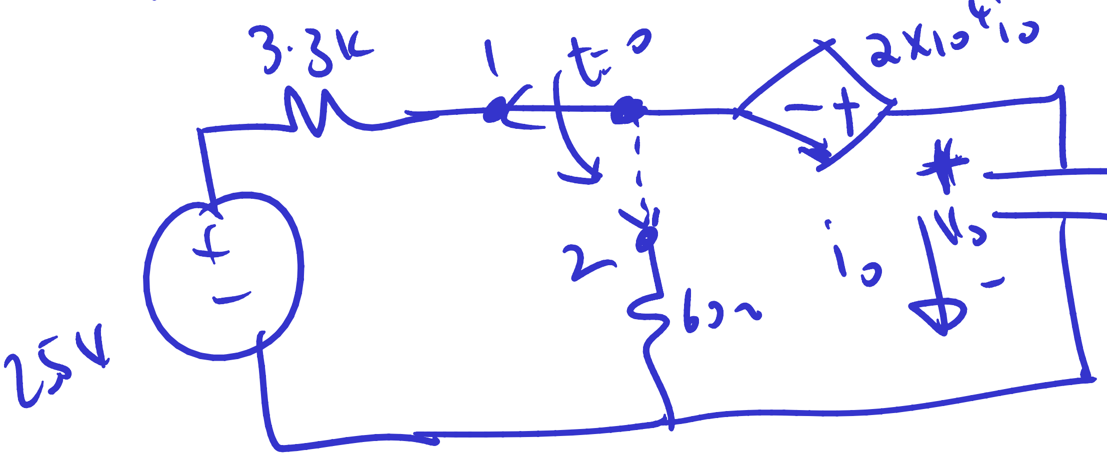
$\underline{t=0^-}$



$\underline{KVL}$: $V_o = 25V$

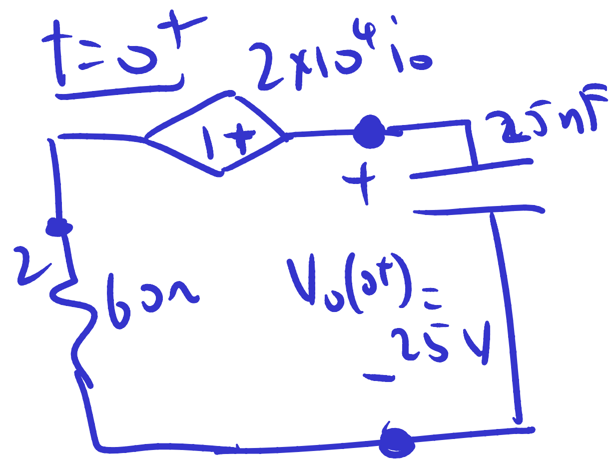
Problem 7.27 on p. 269

Switch is in position 1 for a long time before moving to position 2 @ $t=0$. Find $i_o(t)$ $\forall t \geq 0^+$



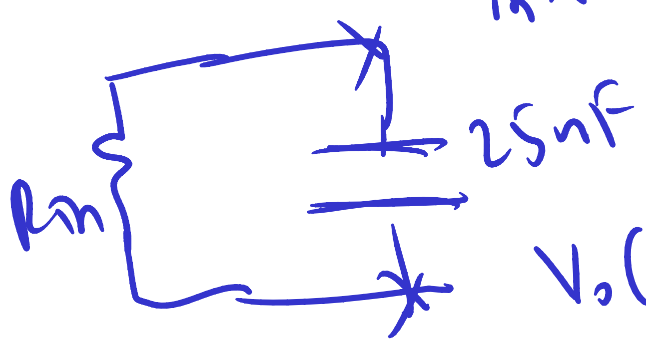
$$i_o = C\frac{dv_o}{dt}$$

$t=0^+$



$R_{Th} \approx 20k$

$t \to \infty$

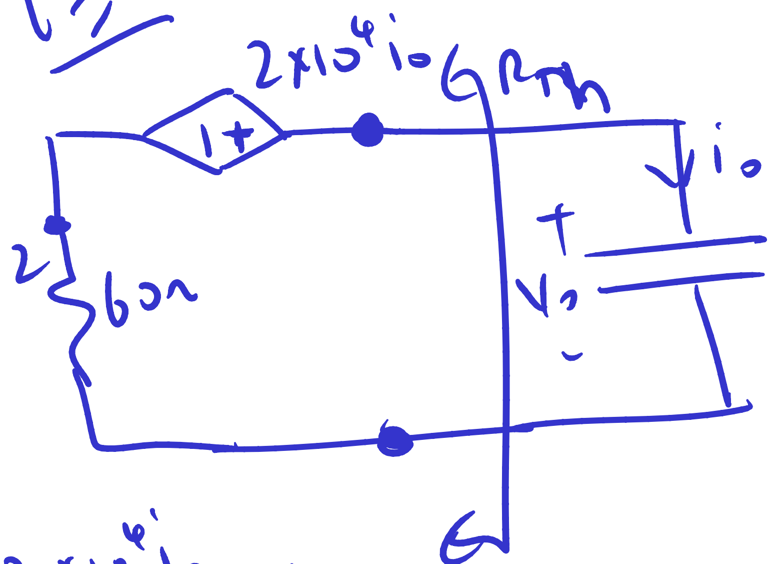


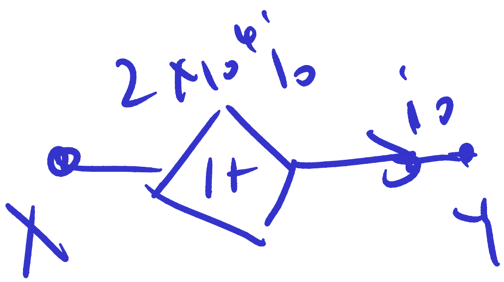
$V_o(t\to\infty) = V_{o_{final}} = 0\ V$

Problem 7.27 on p. 269

Switch is in position 1 for a long time before moving to position 2 @ t=0. Find $i_o(t)$ $\forall t \geq 0^+$

$t \geq 0$





$$i_o = C\frac{dv_o}{dt}$$

$$= C\frac{d}{dt}\left[v_{of} + (v_{oi} - v_{of})e^{-t/\tau}\right]$$

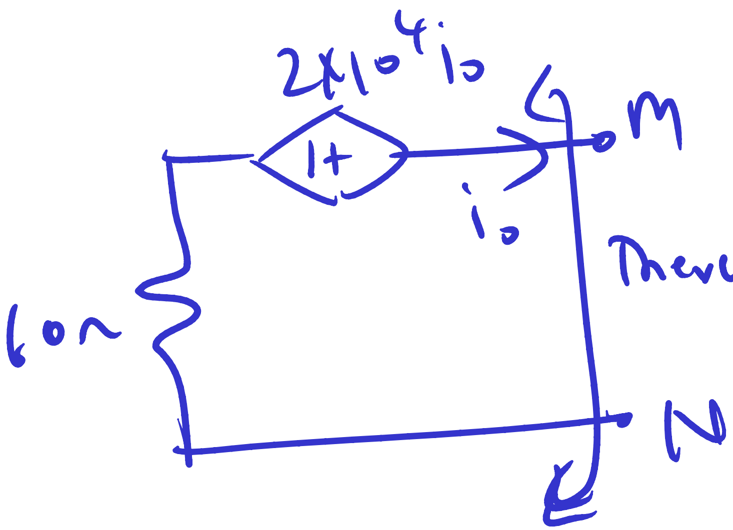
$$= C\frac{d}{dt}\left[25e^{-t/\tau}\right]$$

$$= \left[C.25e^{-t/\tau} \cdot -\frac{1}{\tau}\right]$$

Volts

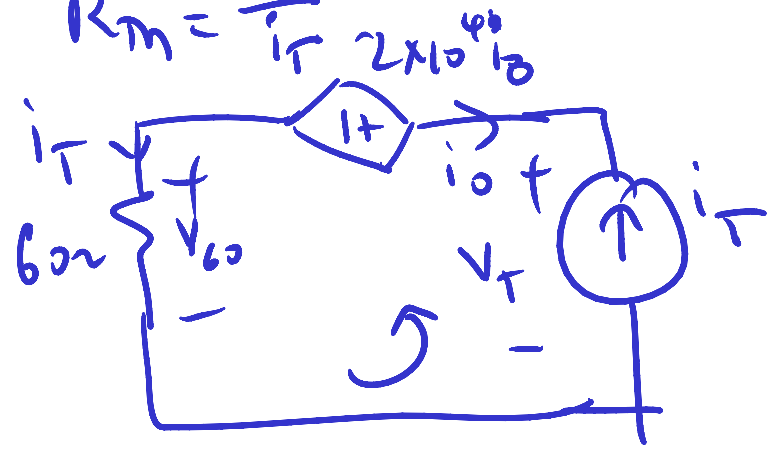
Problem 7.27 on p.269

Switch is in position 1 for a long time before moving to position 2 @ $t=0$. Find $i_o(t)$ $\forall t \geq 0^+$



Theven $\Rightarrow$ $V_{MN} = V_{oc} = 0V$

$R_{Th} = \frac{v_T}{i_T}$



KVL:

$$V_T - (2\times10^4 i_o) - V_{60} = 0$$

$$\Rightarrow V_T - (2\times10^4(-i_T)) - (60\, i_T) = 0 \Rightarrow v_T = 60 i_T - 2\times10^4 i_T$$

Problem 7.27 on p. 269

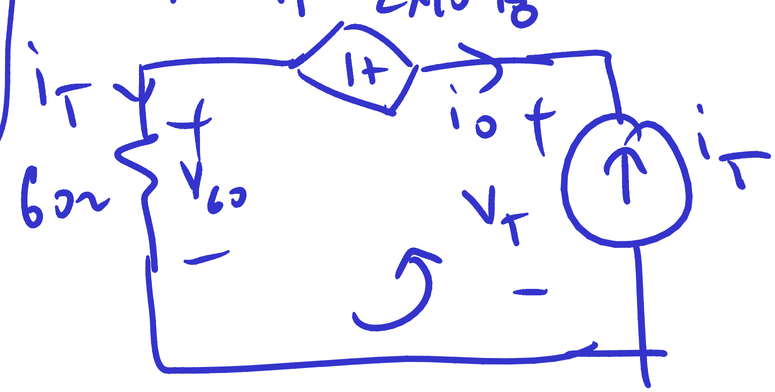
Switch is in position 1 for a long time before moving to position 2 @ $t=0$. Find $i_0(t)$ $\forall t \geq 0^+$

$\therefore R_{Th} = \dfrac{V_T}{i_T} \approx -20{,}000\,\Omega$

$\Rightarrow V_0 \to \infty,\ i_0 \to \infty$) next week, application to +ve feedback

$V_{MN} = V_{oc} = 0V$

$R_{Th} = \dfrac{V_T}{i_T}$



KVL:

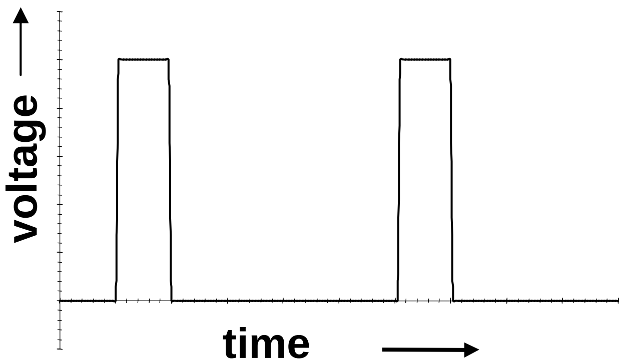
$$V_T - (2\times10^4 i_0) - V_{60} = 0$$

$$\Rightarrow V_T - (2\times10^4(-i_T)) - (60\, i_T) = 0 \Rightarrow V_T = 60 i_T - 2\times10^4 i_T$$

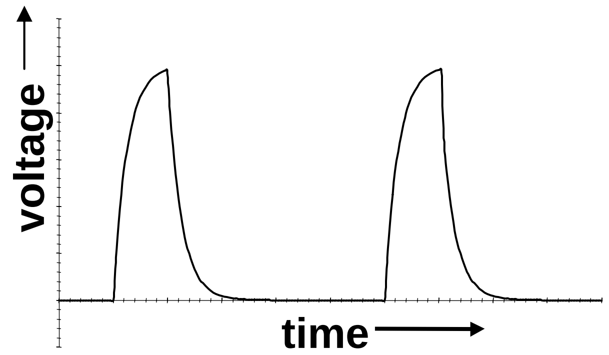
Digital Signals

We compute with pulses.

We send beautiful pulses in:



But we receive lousy-looking pulses at the output:



Capacitor charging effects are responsible!

- Every node in a real circuit has capacitance; it's the charging of these capacitances that limits circuit performance (speed)