Home Assignment 5

IE1206 Embedded Electronics

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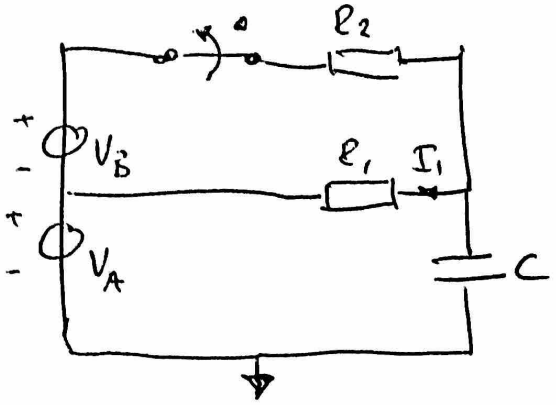
PROBLEM 1



$V_A = 1\ V$

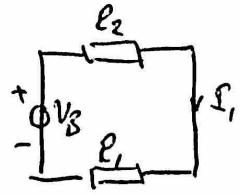
$V_B = 2\ V$

$R_1 = 1000\ \Omega$

$R_2 = 3000\ \Omega$

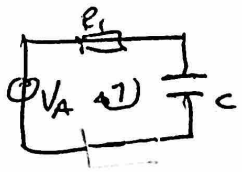
$C = 0.5\ nF$

$t < 0$



$I_1 = \frac{V_B}{R_1 + R_2} - I_1 \Rightarrow \frac{2}{1000+3000} = 0.5 \cdot 10^{-3}\ A = 0.5\ mA$

$0 < t < 5 \cdot 10^{-9}\ s$



$I = \left(V_c(\infty) + (V_c(0) - V_c(\infty)) \cdot e^{-\frac{t}{\tau}} \right) \cdot \frac{1}{\tau}$

$R_{TH} = R_1$

$\tau = R_{TH} \cdot C \Rightarrow 1000 \cdot 0.5\ nF = 0.5 \cdot 10^{-6}\ s$

$V_c(0) = -V_c + V_A + R_1 \cdot I_1 = 0 \Rightarrow V_c = 1 + 1000 \cdot 0.0005 = 1.5\ V$

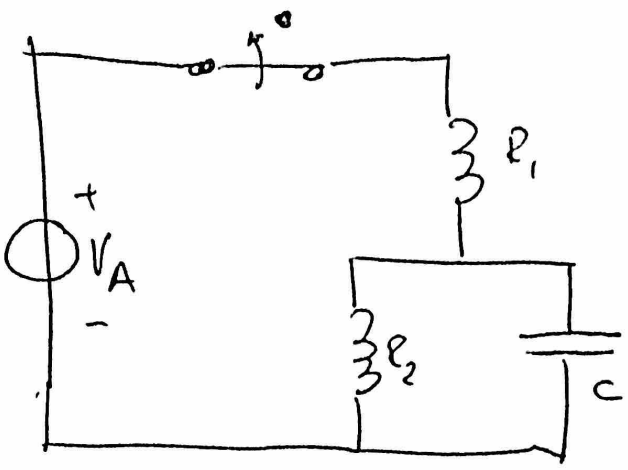
$V_c(\infty) = V_A = 1\ V$

$I = \frac{dv}{dt} \cdot e$

$I(5 \cdot 10^{-6}) = \left(\frac{(1-1.5) \cdot e^{\frac{-5 \cdot 10^{-6}}{0.5 \cdot 10^{-6}}}}{\tau} \right) - 0.5 \cdot 10^{-9} = 2.27 \cdot 10^{-8}\ A$

$0.5 \cdot 10^{-3} < I_1 < 2.27 \cdot 10^{-8}$

Problem 2



$V_A = 8\,V$

$R_1 = 10\,000\ \Omega$

$R_2 = 10\,000\ \Omega$

$C = 1\,nF$

$$V_c(0) = V_A \cdot \frac{R_2}{R_1 + R_2} \Rightarrow 8 \cdot \frac{10000}{10000+10000} = 4$$

$V_c(0) = 4\,V$

$V_c(\infty) = 0$

(A) $$E = \frac{C \cdot V^2}{2} \Rightarrow \frac{1nF \cdot 4^2}{2} = 8\,nJ$$

$P_c(0) = 8\,nJ$

(B) $R_{TH} = R_1 + R_2 = 20\,000\ \Omega$

$\tau = R_{TH} \cdot C \Rightarrow 20000 \cdot 1nF = 20\,us$

$$E = \frac{C \cdot V^2}{2} \Rightarrow V = \sqrt{\frac{2E}{C}}$$

$$\sqrt{\frac{2E}{C}} = V_c(\infty) + (V_c(0) - V_c(\infty)) \cdot e^{\frac{-t}{\tau}}$$

$$\sqrt{\frac{2 \cdot 1 \cdot 10^{-9}}{1 \cdot 10^{-9}}} = 0 + (4 - 0) \cdot e^{\frac{-t}{20 \cdot 10^{-6}}}$$

$t = 20\,us$

$P_c(t = 0{,}00002) = 1\,nJ$

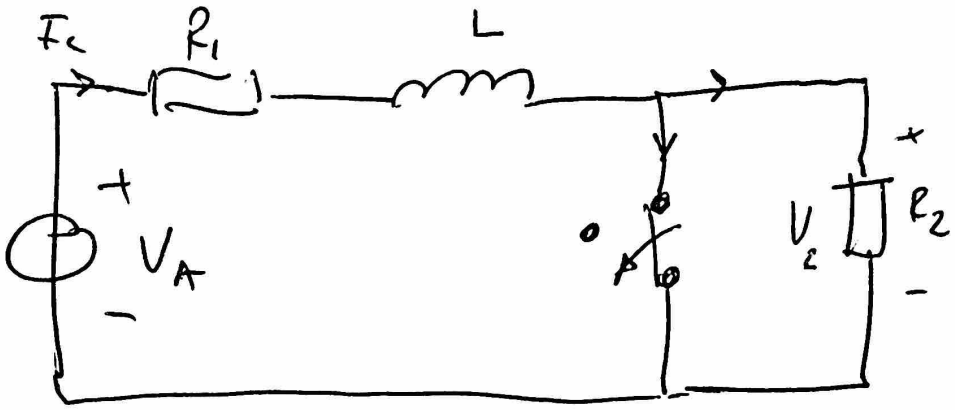
PROBLEM 3

$R_1 = 1000\ \Omega$

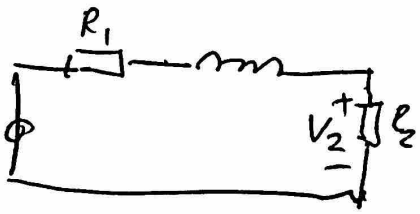
$R_2 = 100\,000\ \Omega$

$V_A = 10\ V$

$L = 0{,}001\ H$



$t > 0s \qquad I_L(t) = I(\infty) + \left(I_L(0) - I_L(\infty)\right) \cdot e^{-\frac{t}{\tau}}$



$\Rightarrow \quad I_L(\infty) = 0$

$R_{TH} = R_1 + R_2 \Rightarrow 1000 + 100000 = 101\,000\ \Omega$

$I_L(t=0)$

$t < 0s : \quad I_L = \frac{V_A}{R_1 + R_2} \Rightarrow \frac{10}{101\,600} = 90 \cdot 10^{-6} = 90\ mA$

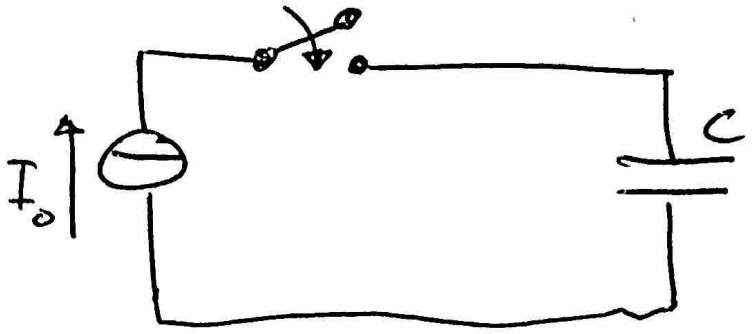
$\tau = \frac{L}{R_{TH}} = \frac{L}{R_{TH}} \Rightarrow \frac{0.001}{101000} = 9{,}9 \cdot 10^{-9} = 9{,}9\ ns$

$I_L(t) = \frac{V_A}{R_{TH}} \cdot e^{-\frac{t}{L/R_{TH}}}$

$V_{R_2} = -I_L \cdot R_2 = -\frac{V_A \cdot R_2}{R_{TH}} \cdot e^{-\frac{t}{\tau}} \Rightarrow \frac{-10 \cdot 100000}{101000} \cdot e^{\frac{-0}{90 \cdot 10^{-6}}} = -9.9\ V$

$V_{R_2}(t=0+) = 9{,}9\ V$

PROBLEM 5



$I_o = 0,061\ A$

$C = 0,000001\ F$

$Q = 0,001$

$$V_c(-2ms < t < 0) = 0\ v$$

$$V_c(0,002) = \frac{I}{C} \cdot t \Rightarrow \frac{0,001}{0,000001} \cdot 0,002 = 2\ v$$

$$V_c = 2\ v$$