Solution of ECE 300 Test 8 S11

1. Fill in the blanks below with numbers.

Before $t = 0$:
Switch is closed. Capacitor voltage and current are zero. R_2 is shorted out by the inductor and the switch so the voltage across it and the current through it are both zero. The voltage source is 10V. The current through R_1 is $10\text{V} / 4\text{k}\Omega = 2.5\text{ mA}$ and that is also the current through the inductor.

At time $t = 0^+$:

The switch opens and the inductor current and the capacitor voltage do not change. The current from the inductor must now flow through the capacitor. The voltage source is now 20 V. We can write and solve a nodal equation $\frac{v_2 - 20}{4000} + \frac{v_2}{9000} + \underbrace{i_L}_{2.5\text{ mA}} = 0 \Rightarrow 9v_2 - 180 + 4v_2 + 90 = 0 \Rightarrow v_2 = 6.9231\text{ V}$. Then $v_1 = 20 - 6.9231 = 13.0769\text{ V}$ and $i_1 = 13.0769\text{V} / 4000\Omega = 3.2692\text{ mA}$ and $i_2 = 6.9231\text{V}/9000\Omega = 0.7692\text{mA}$.

At time $t \to \infty$:

The capacitor is an open circuit and the inductor is a short circuit. There is no curren through either one. The only current flows through the two resistors and that is $20\text{V}/13000\Omega = 1.5385\text{ mA}$. $v_2 = v_C = 1.5385\text{mA} \times 9000\Omega = 13.846\text{ V}$. $v_L = 0$. $v_1 = 6.154$.

$$v_1(0^-) = 10\text{V} \quad v_2(0^-) = 0\text{V} \quad v_L(0^-) = 0\text{V} \quad v_C(0^-) = 0\text{V}$$
$$v_1(0^+) = 13.0769\text{V} \quad v_2(0^+) = 6.9231\text{V} \quad v_L(0^+) = 6.9231\text{V} \quad v_C(0^+) = 0\text{V}$$
$$v_1(\infty) = 6.154\text{V} \quad v_2(\infty) = 13.846\text{V} \quad v_L(\infty) = 0\text{V} \quad v_C(\infty) = 13.846\text{V}$$

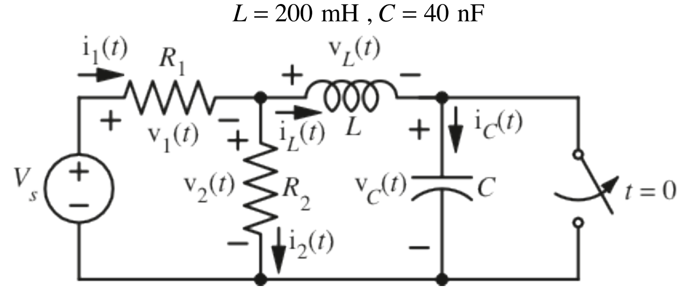
$$i_1(0^-) = 2.5\text{mA} \quad i_2(0^-) = 0\text{mA} \quad i_L(0^-) = 2.5\text{mA} \quad i_C(0^-) = 0\text{mA}$$
$$i_1(0^+) = 3.2692\text{mA} \quad i_2(0^+) = 0.7692\text{mA} \quad i_L(0^+) = 2.5\text{mA} \quad i_C(0^+) = 2.5\text{mA}$$
$$i_1(\infty) = 1.5385\text{mA} \quad i_2(\infty) = 1.5385\text{mA} \quad i_L(\infty) = 0\text{mA} \quad i_C(\infty) = 0\text{mA}$$

$$\alpha = \frac{R_{eq}}{2L} = \frac{4000\Omega \parallel 9000\Omega}{2(200\text{mH})} = 6923.1\ ,\ \omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{200\text{mH} \times 40\text{nF}}} = 11180\ ,\ \omega_d = \sqrt{\omega_0^2 - \alpha^2} = 8779$$

$$v_{Cf} = 13.846\text{ V}\ ,\ B_1 + 13.846 = 0 \Rightarrow B_1 = -13.846\text{ V}$$

$$-\alpha B_1 + \omega_d B_2 = \left.\frac{d v_C(t)}{dt}\right|_{t=0^+} = \frac{i_C(0^+)}{C} = \frac{2.5\text{ mA}}{40\text{ nF}} = 62500\text{ V/s} \Rightarrow B_2 = \frac{62500 - 6923.1 \times 13.846}{8779} = -3.7997\text{ V}$$

$V_s = 10 + 10\,u(t)\text{ V}\ ,\ R_1 = 4\text{ k}\Omega\ ,\ R_2 = 9\text{ k}\Omega$
$L = 200\text{ mH}\ ,\ C = 40\text{ nF}$



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At time $t=0^+$:

The switch opens and the inductor current and the capacitor voltage do not change. The current from the inductor must now flow through the capacitor. The voltage source is now 10 V. We can write and solve a nodal equation $\frac{\text{v}_2-10}{4000}+\frac{\text{v}_2}{9000}+\underbrace{\text{i}_L}_{1.25\text{ mA}}=0 \Rightarrow 9\text{v}_2-90+4\text{v}_2+45=0 \Rightarrow \text{v}_2=3.4615\text{ V}$. Then $\text{v}_1=10-3.4615=6.5385\text{ V}$ and $\text{i}_1=6.5385\text{V}/4000\Omega=1.6346\text{ mA}$ and $\text{i}_2=3.4615\text{V}/9000\Omega=0.3846\text{mA}$.

At time $t\to\infty$:

The capacitor is an open circuit and the inductor is a short circuit. There is no curren through either one. The only current flows through the two resistors and that is $10\text{V}/13000\Omega=0.7692\text{ mA}$. $\text{v}_2=\text{v}_C=0.7692\text{mA}\times 9000\Omega=6.923\text{ V}$. $\text{v}_L=0$. $\text{v}_1=3.077$.

$$\text{v}_1(0^-)=5\text{V} \quad \text{v}_2(0^-)=0\text{V} \quad \text{v}_L(0^-)=0\text{V} \quad \text{v}_C(0^-)=0\text{V}$$
$$\text{v}_1(0^+)=6.5385\text{V} \quad \text{v}_2(0^+)=3.4615\text{V} \quad \text{v}_L(0^+)=3.4615\text{V} \quad \text{v}_C(0^+)=0\text{V}$$
$$\text{v}_1(\infty)=3.077\text{V} \quad \text{v}_2(\infty)=6.923\text{V} \quad \text{v}_L(\infty)=0\text{V} \quad \text{v}_C(\infty)=6.923\text{V}$$

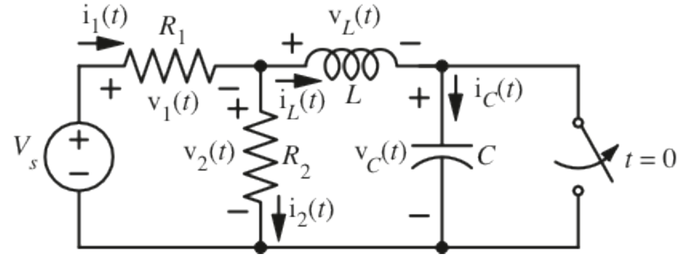
$$\text{i}_1(0^-)=1.25\text{mA} \quad \text{i}_2(0^-)=0\text{mA} \quad \text{i}_L(0^-)=1.25\text{mA} \quad \text{i}_C(0^-)=0\text{mA}$$
$$\text{i}_1(0^+)=1.6346\text{mA} \quad \text{i}_2(0^+)=0.3846\text{mA} \quad \text{i}_L(0^+)=1.25\text{mA} \quad \text{i}_C(0^+)=1.25\text{mA}$$
$$\text{i}_1(\infty)=0.7692\text{mA} \quad \text{i}_2(\infty)=0.7692\text{mA} \quad \text{i}_L(\infty)=0\text{mA} \quad \text{i}_C(\infty)=0\text{mA}$$

$$\alpha=\frac{R_{eq}}{2L}=\frac{4000\Omega \parallel 9000\Omega}{2(200\text{mH})}=6923.1,\ \omega_0=\frac{1}{\sqrt{LC}}=\frac{1}{\sqrt{200\text{mH}\times 40\text{nF}}}=11180,\ \omega_d=\sqrt{\omega_0^2-\alpha^2}=8779$$

$$\text{v}_{Cf}=6.923\text{ V},\ B_1+6.923=0 \Rightarrow B_1=-6.923\text{ V}$$

$$-\alpha B_1+\omega_d B_2=\left.\frac{d\text{v}_C(t)}{dt}\right|_{t=0^+}=\frac{\text{i}_C(0^+)}{C}=\frac{1.25\text{ mA}}{40\text{ nF}}=31250\text{ V/s} \Rightarrow B_2=\frac{31250-6923.1\times 6.923}{8779}=-1.8999\text{ V}$$

$V_s=5+5\text{u}(t)\text{ V},\ R_1=4\text{ k}\Omega,\ R_2=9\text{ k}\Omega$
$L=200\text{ mH},\ C=40\text{ nF}$



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Before $t = 0$:
Switch is closed. Capacitor voltage and current are zero. R_2 is shorted out by the inductor and the switch so the voltage across it and the current through it are both zero. The voltage source is 20V. The current through R_1 is $20\text{V} / 4\text{k}\Omega = 5 \text{ mA}$ and that is also the current through the inductor.

At time $t = 0^+$:

The switch opens and the inductor current and the capacitor voltage do not change. The current from the inductor must now flow through the capacitor. The voltage source is now 40 V. We can write and solve a nodal equation $\frac{v_2 - 40}{4000} + \frac{v_2}{9000} + \underbrace{i_L}_{5\text{ mA}} = 0 \Rightarrow 9v_2 - 360 + 4v_2 + 180 = 0 \Rightarrow v_2 = 13.8462 \text{ V}$. Then $v_1 = 40 - 13.8462 = 26.1538 \text{ V}$ and $i_1 = 26.1538\text{V} / 4000\Omega = 6.5385 \text{ mA}$ and $i_2 = 13.8462\text{V}/9000\Omega = 1.5385\text{mA}$.

At time $t \to \infty$:

The capacitor is an open circuit and the inductor is a short circuit. There is no curren through either one. The only current flows through the two resistors and that is $40\text{V}/13000\Omega = 3.0769 \text{ mA}$. $v_2 = v_C = 3.0769\text{mA} \times 9000\Omega = 27.6921 \text{ V}$. $v_L = 0$. $v_1 = 12.308$.

$v_1(0^-) = 20\text{V}$	$v_2(0^-) = 0\text{V}$	$v_L(0^-) = 0\text{V}$	$v_C(0^-) = 0\text{V}$
$v_1(0^+) = 26.1538\text{V}$	$v_2(0^+) = 13.8462\text{V}$	$v_L(0^+) = 13.8462\text{V}$	$v_C(0^+) = 0\text{V}$
$v_1(\infty) = 12.308\text{V}$	$v_2(\infty) = 27.6921\text{V}$	$v_L(\infty) = 0\text{V}$	$v_C(\infty) = 27.6921\text{V}$

$i_1(0^-) = 5\text{mA}$	$i_2(0^-) = 0\text{mA}$	$i_L(0^-) = 5\text{mA}$	$i_C(0^-) = 0\text{mA}$
$i_1(0^+) = 6.5385\text{mA}$	$i_2(0^+) = 1.5385\text{mA}$	$i_L(0^+) = 5\text{mA}$	$i_C(0^+) = 5\text{mA}$
$i_1(\infty) = 3.0769\text{mA}$	$i_2(\infty) = 3.0769\text{mA}$	$i_L(\infty) = 0\text{mA}$	$i_C(\infty) = 0\text{mA}$

$$\alpha = \frac{R_{eq}}{2L} = \frac{4000\Omega \parallel 9000\Omega}{2(200\text{mH})} = 6923.1 \text{ , } \omega_0 = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{200\text{mH} \times 40\text{nF}}} = 11180 \text{ , } \omega_d = \sqrt{\omega_0^2 - \alpha^2} = 8779$$

$v_{Cf} = 27.6921 \text{ V}$, $B_1 + 27.6921 = 0 \Rightarrow B_1 = -27.6921 \text{ V}$

$$-\alpha B_1 + \omega_d B_2 = \left.\frac{d v_C(t)}{dt}\right|_{t=0^+} = \frac{i_C(0^+)}{C} = \frac{5 \text{ mA}}{40 \text{ nF}} = 125000 \text{ V/s} \Rightarrow B_2 = \frac{125000 - 6923.1 \times 27.6921}{8779} = -7.5994 \text{ V}$$

$V_s = 20 + 20\,u(t)$ V , $R_1 = 4$ kΩ , $R_2 = 9$ kΩ
$L = 200$ mH , $C = 40$ nF