ElecEng 2CF4
Assignment 4 Report 2

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EXERCISE #2: TRANSIENT 2ND DEGREE CIRCUIT

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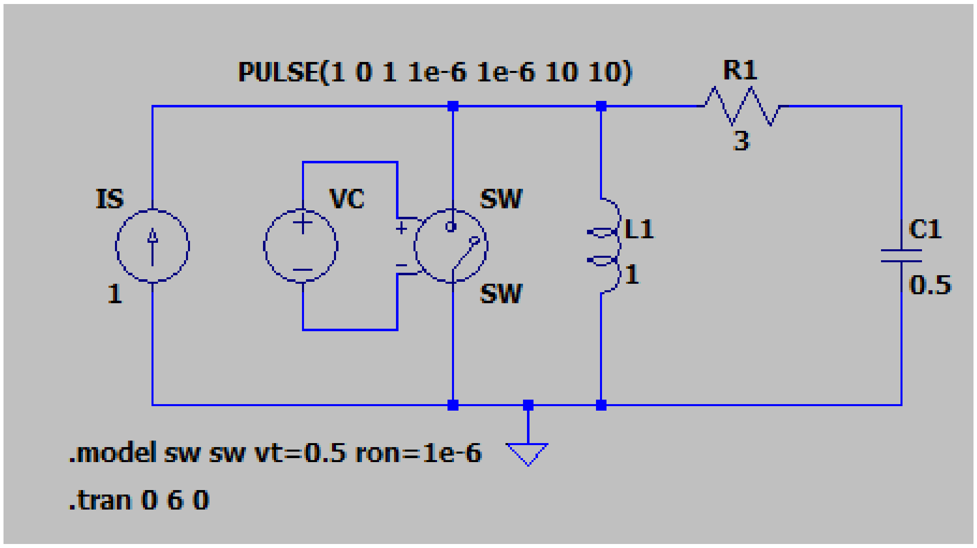
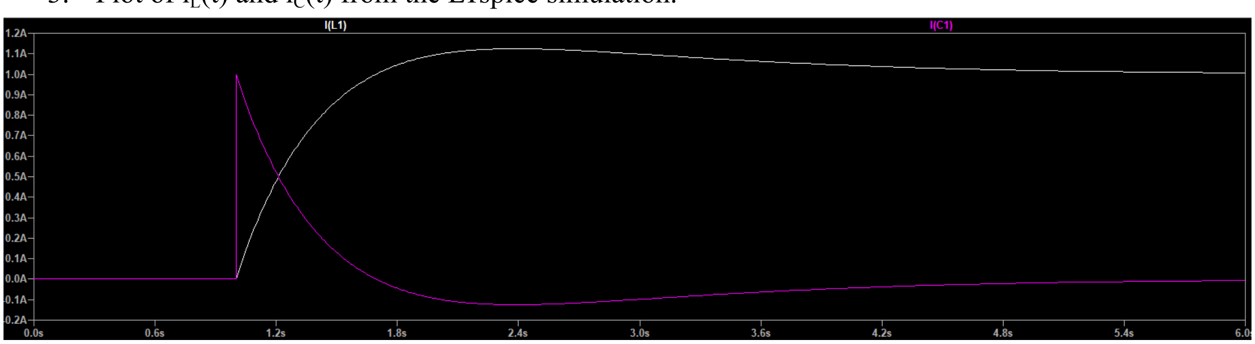
1. Circuit Schematic;



2. Spice netlist

```
* C:\Users\Josh\Documents\COMPENG\Y2S2\2CF3\Assignment4\Q2.asc
IS 0 N001 1
VC N003 N004 PULSE(1 0 1 1e-6 1e-6 10 10)
R1 N002 N001 3
C1 N002 0 0.5
SW 0 N001 N003 N004 SW
L1 N001 0 1
.model sw sw vt=0.5 ron=1e-6
.tran 0 6 0
.backanno
.end
```

3. Plot of $i_L(t)$ and $i_C(t)$ from the LTspice simulation.



4. Analytical solution for $i_L(t)$ and $i_C(t)$ based on the Laplace transform

Initial Conditions:

Capacitor Open circuit and Inductor short circuit

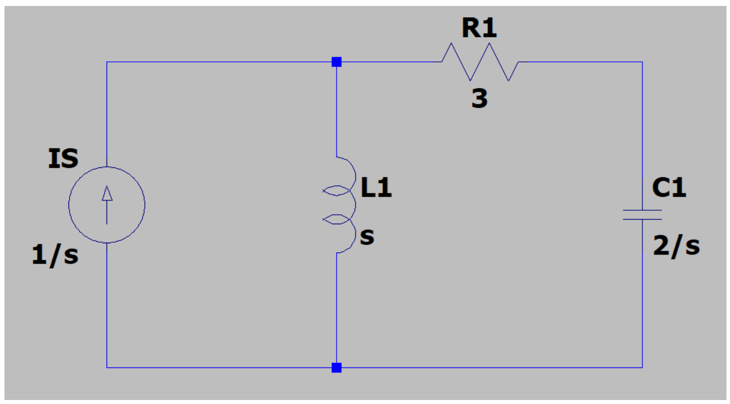
$I_{L, 0-}$ = 0A

$I_{C, 0}$ = 0V

Redrawing the circuit:

$$i_C(t) = C\frac{dv_C(t)}{dt} \leftrightarrow I_C(s) = sCV_C(s) - Cv_C(0_-)$$

$$v_L(t) = L\frac{di_L(t)}{dt} \leftrightarrow V_L(s) = sLI_L(s) - Li_L(0_-)$$



I_L found with current division:

$$I_L(s) = \frac{1}{s}\left[\frac{R+\frac{2}{s}}{s+R+\frac{2}{s}}\right]$$

$$L^{-1}\{I_L(s)\}$$

$$= \frac{1}{s}\left[\frac{3+\frac{2}{s}}{s+3+\frac{2}{s}}\right]$$

$$L^{-1}\left\{\frac{3+\frac{2}{s}}{s+3+\frac{2}{s}}\right\} = 1 + e^{-t} - 2e^{-2t}$$

I_C found with current division:

$$I_C(s) = \frac{1}{s}\left[\frac{s}{R+\frac{s}{2}+s}\right]$$

$$= \frac{1}{s}\left[\frac{s}{3+\frac{s}{2}+s}\right]$$

$$L^{-1}\{I_C(s)\}$$

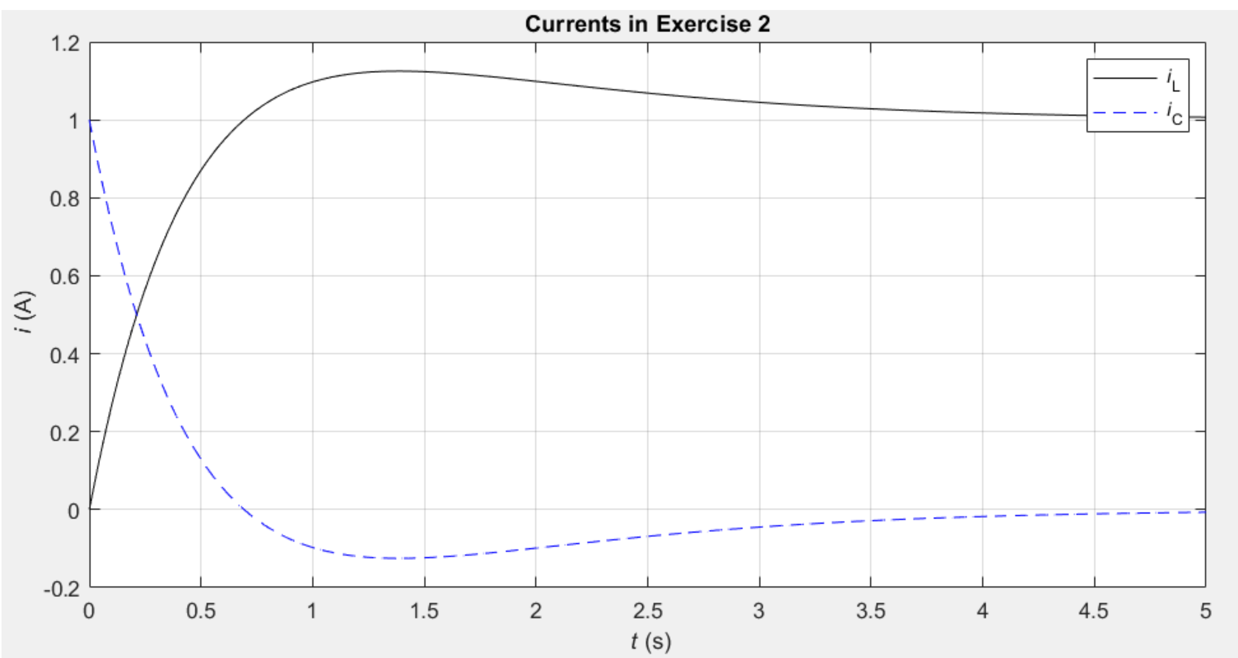
$$= -e^{-t} + 2e^{-2t}$$

Summary

$$I_L(t) = 1 + e^{-t} - 2e^{-2t}$$
$$I_C(t) = -e^{-t} + 2e^{-2t}$$

5. MATLAB source code and plot

```
clear all; close all;
t = linspace(0, 5, 1001); % vector of 1001 time samples from 0 to 5 s
iL = 1+exp(-t)-2*exp(-2*t);; % change this to the function iL(t) you found from Laplace analysis
iC = 2*exp(-2*t)-exp(-t); % change this to the function iC(t) you found from Laplace analysis
figure;
plot(t, iL,'-k') % plot curve in solid black line
hold on;
plot(t, iC,'--b') % plot curve in dash blue line
hold off;
grid on;
legend('{\it i}_L','{\it i}_C')
title('Currents in Exercise 2')
xlabel('{\it t} (s)');
ylabel('{\it i} (A)');
```



6. Does the LTspice simulation agree with the MATLAB plot of the theoretical results? Justify your answer.

The LTspice and MATLAB plots of $I_L(t)$ and $I_C(t)$ show the expected damped transient response of a second-order system. Features observed:

- Distinct time constants: Both simulations capture the fast and slow decay components in teh currents
- Overshoot and settling behavior: The curves transition smoothly towards steady-state values
- Phase relationship: LTspice confirmes that $I_C(t)$ and $I_L(t)$ follow the expected inverse relationship